Chapter 4 Environmental Consequences

4.1 Introduction

4.1.1 Overall Guidance for Analyzing Environmental Impacts

4.1.1.1 Issues Related to the Fire Management Plan

Issues related to the Fire Management Plan were identified through public and internal scoping and tribal consultations. These issues are summarized in Chapter 1 and Appendix B. Resource-specific issues are discussed under each impact topic in the following sections of this chapter.

4.1.1.2 Guiding Regulations and Policies Introduction

Overarching environmental protection laws and policies that guide development of this FMP FEIS/AEF include the NPS Organic Act (as amended), NEPA (including its amendments and implementing regulations), and the National Parks Omnibus Management Act of 1998. As discussed in Chapter 1 and Appendix A, the NPS Organic Act authorizes rules and regulations for use and administration of national park system areas, whose purpose is "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

NEPA requires Federal agencies to fully analyze environmental impacts when a planned, major Federal action could affect quality of the human environment. CEQ has established regulations that implement NEPA (40 CFR Parts 1500–1508), and the NPS has adopted procedures to comply with both NEPA and CEQ regulations. These procedures are detailed in Director's Order 12, Conservation Planning, Environmental Impact Analysis, and Decision-making and its accompanying handbook which state that the National Parks Omnibus Management Act of 1998 (PL 105-391) requires the Secretary of the Interior to continually improve NPS ability to provide state-of-the-art management, protection, and interpretation of and research on resources under its jurisdiction. Thus, park management decisions must be based on full and proper use of scientific study. Additionally, this Act states that in each case where an NPS action may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which resource studies were considered. Resource-specific regulations and policies are noted for each impact topic in sections of this chapter and detailed in Appendix A.

4.1.1.3 Management Objectives for the Proposed Fire Management Plan Introduction

Management objectives for the proposed Fire Management Plan are discussed in Chapter 1. Management objectives for each impact topic were used to guide analysis of environmental consequences and are discussed per impact topic in the following sections of this chapter.

4.1.2 Methodology for Analyzing Impacts Introduction

4.1.2.1 General Analysis Method

For each impact topic described in Chapter 3 (e.g. Biological Resources, Cultural Resources, Physical Resources, Wilderness Character, Sociological Resources, and Park Management and Operations), the following impact assessment methodology was followed.

- *Define Issues of Concern*
  - Based on public and internal scoping and tribal consultation for each resource topic
- *Identify Area of Potential Effect*
  - Resources, values, and visitor experiences in an area that could be affected

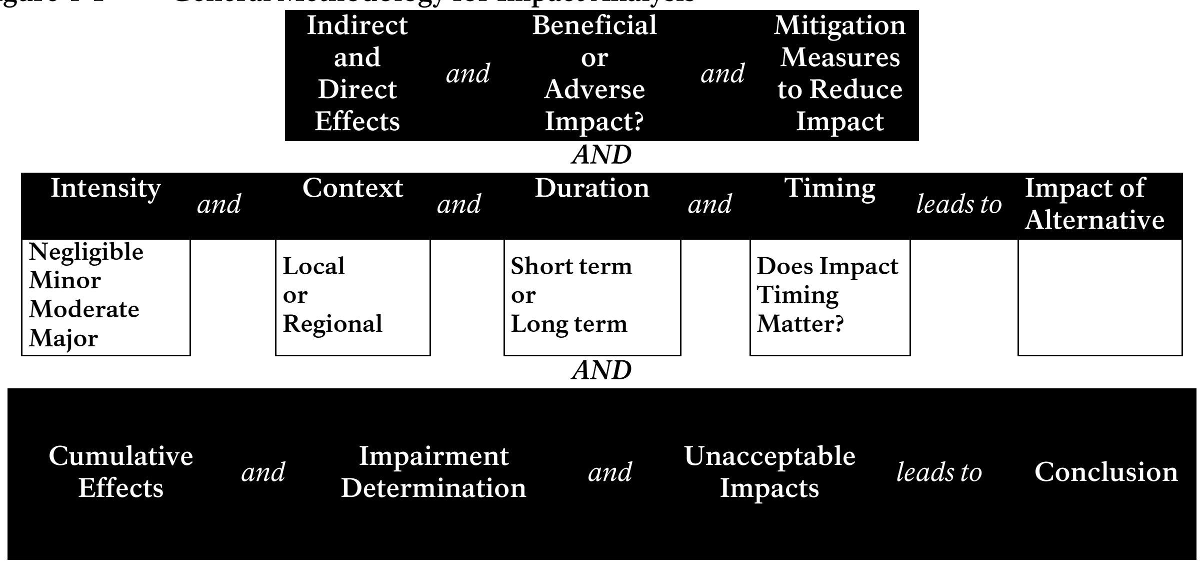
- *Identify Effects of Each Alternative*
  - This was accomplished in two ways, 1) by considering anticipated impacts of the alternatives on baseline or existing conditions as described for the No Action Alternative (Alternative 1), and 2) by comparing anticipated impacts of alternatives to a condition reasonably affected only by natural processes, because in many cases the No Action Alternative causes significant impacts on the environment. This does not imply comparisons to an idealized pristine condition that might have existed if humans had never affected the area. Rather, it is a condition that might have existed if humans had little effect on the environment, or if impacts of the No Action Alternative were reduced to negligible for all impact topics
  - Effects were characterized based on
    - **Direct and indirect effects**
      - A direct effect is caused by an action and occurs in the same time and place
      - An indirect effect is caused by an action but later in time or farther away, but still reasonably foreseeable
    - Whether effects would be **beneficial or adverse**
      - A beneficial effect is a positive change in resource condition or appearance, or a change that moves resources toward a desired condition (consistent with park purpose and management objectives)
      - An adverse effect is a change that moves the resource away from a desired condition or detracts from its condition or appearance
    - An impact's **intensity** or magnitude
      - Four impact intensity thresholds—negligible, minor, moderate, and major—are defined for each impact topic. Threshold values for these four intensity categories were developed based on Federal and state standards, consultation with regulators from applicable agencies, management objectives for the proposed FMP, public scoping, tribal consultations, and discussions with subject-matter experts
    - Impact **context**, primarily whether impacts would be regional or local, but also whether they would occur in a location sensitive or non-sensitive to such impacts
      - Generally, regional impacts are associated with one or several fire management units
      - Local impacts can vary from individual sites to fire management units
    - Whether effect duration is **short or long term**. Definitions of these terms vary by impact topic and are addressed in each of the following sections
    - If action **timing** contributes to impacts. An impact's exact time can be important, including sensitive time periods, time of day, how often the impact would occur, and seasonality
- *Identify Reasonable Mitigations* Mitigating measures were considered for each impact topic to reduce, avoid, or minimize impacts under each alternative. During impact analysis, additional mitigating measures were identified that would likely reduce impacts to each topic. Reasonable mitigations are those that could be implemented under conceivably foreseeable conditions and would not cause substantial adverse effects to other resources (cultural or natural or visitor experience)
- *Determine Whether an Impact Constitutes Impairment* The NPS is prohibited from impairing park resources and values by the NPS Organic Act. A determination of impairment is closely tied to resource impact analysis, consideration of the park's legislative mandates (purpose and significance), and resource management objectives as defined in the GMP or other relevant plans. The impact analysis includes any findings of impairment to park resources and values for each management alternative
- *Determine Cumulative Effects* Cumulative effects were determined by evaluating the alternative's incremental effect when combined with other past, present, or reasonably foreseeable future actions in and outside the area of potential effect (see Appendix G)

4.1.2.2 Tools Used to Analyze Environmental Consequences — Analysis Method

In addition to the methodology discussed above, several other tools were used to help predict impacts to physical and social environments. Some of these tools are presented below; others used for specific impact topics are discussed in the appropriate section.

Each alternative represents a set of management variables (prescribed, wildland fire-use, and suppression fire, and manual/mechanical thinning) that create a corresponding set of indicators (acres treated/year; acres treated/vegetation type). Analysis is based on how each alternative's variables and indicators interact with each other. Variables for each alternative are presented in Figure 4-1.

Figure 4-1 General Methodology for Impact Analysis



4.1.2.3 Incomplete or Unavailable Information — Analysis Method

DO-12 Handbook offers guidance on how to address data gaps in an environmental impact statement. If "such information cannot be obtained due to excessive cost or technical impossibility, the proposed alternative for decision will be modified to eliminate the action causing the unknown or uncertain impact or other alternatives will be selected." In the case where alternatives cannot be modified to eliminate unknown or uncertain potential impacts, the Handbook states that the NPS is required to address the following (in accordance with 42 CFR 1502.22). Incomplete or unavailable data are addressed per impact topic in each section of this chapter, and include

- Relevance of incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment
- A summary of existing credible scientific adverse impacts relevant to evaluating reasonably foreseeable significant adverse impacts
- An evaluation of such impacts based on theoretical approaches or research methods generally accepted in the scientific community

4.1.2.4 Assumptions — Analysis Method

Several assumptions were made in evaluating alternatives effects for the proposed FMP. These assumptions were applied to all impact topics unless otherwise noted. Resource-specific assumptions are discussed per impact topic in following sections of this chapter.

- *Analysis Period*
  - The analysis period addresses potential short- to long-term effects from the selected alternative
- *Analysis Area*
  - The analysis area includes Grand Canyon National Park, both Inner Canyon and all vegetative landscapes on North and South Rims

4.1.2.5 Impact Analysis — Analysis Method

Impact analysis uses tools and methodology discussed above to determine how each alternative would impact the environment and meet management objectives for each impact topic.

4.1.2.6 Cumulative Impacts — Analysis Method

Federal agencies must assess cumulative effects in an environmental impact statement. According to CEQ regulations (40 CFR 1508.7), cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions." Cumulative effects are considered for each alternative and are addressed per impact topic. Major past, present, and reasonably foreseeable future actions considered are listed in Appendix G.

4.1.2.7 Conclusions, Mitigations, Impairment Assessment, and Unacceptable Impacts Statement, and NPS EIS Requirements — Analysis Method

The conclusion for each impact topic summarizes all major findings in the impacts analysis for each alternative. As part of this summary, reasonable mitigations are identified when applicable for reducing or eliminating impacts, and their effect on the impact assessment is discussed.

The conclusion also includes a determination of whether the alternative is likely to cause park resource and value impairment. NPS Management Policies 2006 requires analysis of potential effects to determine if actions would impair park resources. The fundamental purpose of the national park system, as established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. NPS managers must always avoid or minimize, to the greatest degree practicable, adversely impacting park resources and values. However, laws do give management discretion to allow impacts when necessary and appropriate to fulfill park purposes, as long as the impact does not constitute impairment of affected resources and values.

Although Congress has given the NPS management discretion to allow certain impacts in parks, that discretion is limited by the statutory requirement that the NPS must leave park resources and values unimpaired, unless a particular law directly and specifically provides otherwise. Prohibited impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm park resource or value integrity, including opportunities that otherwise would be present for enjoyment of these resources or values. Whether an impact meets this definition depends on particular resources and values affected; impact severity, duration, and timing; the impact's direct and indirect effects; and cumulative effects of the impact in question, along with other impacts in existence. An impact to any park resource or value may constitute impairment, but an impact would be more likely to constitute impairment to the extent that it has a major or severe adverse effect on a resource or value whose conservation is

- Necessary to fulfill specific purposes identified in park establishing legislation or proclamation
- Key to park natural or cultural integrity or opportunities for enjoyment
- Identified as a specific goal in the park's GMP or other relevant NPS planning documents

Impairment may result from NPS activities in managing the park, visitor activities, or activities undertaken by concessioners, contractors, and others operating in the park. An impairment determination is made for each impact topic.

Unacceptable Impacts **Analysis Method**

In addition to impairment, unacceptable impacts are also considered in the analysis of alternatives. Although an action may not result in impairment, it could be determined unacceptable in the park's environment. Park managers must determine whether a project's associated impacts on park resources and values are acceptable. In its role as park resource steward, the NPS must ensure allowed park uses would not cause impairment of, or unacceptable impacts on, park resources and values.

Human activities in a park effect park resources or values, but do not mean the impact is unacceptable or that a particular use must be prohibited. Therefore, as defined in NPS Management Policies 2006, unacceptable impacts are impacts that, individually or cumulatively, would

- be inconsistent with a park's purposes or values, or
- impede attainment of a park's desired future conditions for natural and cultural resources as identified through the park's planning process, or
- create an unsafe or unhealthful environment for visitors or employees, or
- diminish opportunities for current or future generations to enjoy, learn about, or be inspired by park resources or values, or
- unreasonably interfere with park programs or activities, or an appropriate use, or the atmosphere of peace and tranquility, or the natural soundscape maintained in wilderness and natural, historic, or commemorative locations in the park, or NPS concessioner, or contractor operations or services.

Unacceptable impacts are discussed for each applicable resource for each alternative in this chapter. A statement to summarize results of this evaluation is included in an unacceptable impacts statement at the end of the environmental consequences section for each applicable resource in this chapter.

Unavoidable Adverse Impacts, Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-term Gain, and Irreversible/Irretrievable Commitments of Resources

These topics described below are discussed at the end of the alternative analysis section for each resource impact topic.

- *Unavoidable Adverse Impacts* Environmental consequences that cannot be avoided, whether by implementing mitigation measures or changing the nature of a proposed action. Thus, unavoidable adverse impacts would persist throughout the action's duration
- *Loss in Long-Term Availability Or Productivity Of the Resource To Achieve Short-Term Gain* Are any long-term management possibilities or park resource productivities traded for immediate use of the land?
- *Irreversible/Irretrievable Commitments of Resources* An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation, and could not be reused or recovered during the plan's lifespan

4.2 IMPACTS ON BIOLOGICAL RESOURCES

4.2.1 Vegetation

4.2.1.1 Guiding Regulations and Policies **Vegetation**

Overarching laws considered in management of Vegetation, include

- National Park Service Organic Act of 1916
- National Environmental Policy Act of 1969
- National Parks Omnibus Management Act of 1998
- Healthy Forest Restoration Act of 2004

The Organic Act directs parks to conserve scenery and natural objects unimpaired for future generations. The NPS interprets this to mean that native vegetation, ecosystems, and watersheds should be perpetuated as part of GRCA's legacy for current and future generations.
NPS Management Policies 2006 direct park managers to understand, maintain, restore, and protect the inherent integrity of park natural resources, processes, systems, and values. The NPS will try to maintain all components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of plant and animal species native to those ecosystems.
Management Policies 2006 state the NPS will maintain all native plants as part of the natural ecosystem by

- Restoring native plant populations in parks when extirpated by past human-caused actions
- Minimizing human impact on native plants, communities, ecosystems, and processes that sustain them
- Preventing exotic species introduction into units of the national park system, and remove, when possible, or otherwise contain, individuals or populations of these species already established

4.2.1.2 Management Objectives — Vegetation

As stated in Chapter 1, Purpose and Need for Action, the goal and objective for the proposed FMP related to Vegetation is
Goal 2 Restore and maintain park ecosystems in a natural, resilient condition

- Maintain ecosystems that are within the range of desired conditions (see Chapter 2) through natural processes within policy constraints
- Restore ecosystems that are not within the range of natural variability to desired conditions (see Chapter 2) and maintain them through natural processes within policy constraints
- Set priorities for treatment activities based on site-specific information including: departure from natural fire return intervals, desired conditions (see Chapter 2), and other relevant factors

4.2.1.3 Methodology for Analyzing Impacts — Vegetation

Tools Used To Analyze Effects

Fire Behavior Prediction Models

FlamMap and FARSITE fire-behavior prediction models were used in vegetation analysis. Both programs are used by the NPS, USFS, and other Federal and state land management agencies.

FlamMap is a fire-behavior mapping and analysis program that computes potential fire behavior characteristics (e.g. spread rate, flame length, fireline intensity) over the entire landscape for constant weather and fuel-moisture conditions. FlamMap models fire behavior as if each landscape pixel were ignited simultaneously. FlamMap was run for the entire GRCA landscape for four different weather scenarios (50th, 80th, 90th, and 97th percentiles) defined in Table 4-2.

FARSITE is a fire-growth simulation model. It uses spatial information on topography and fuels along with a given set of fire-weather conditions. It computes wildland fire growth and behavior for long periods of time under heterogeneous conditions of terrain, fuels, and weather.

Spatial changes in fuel conditions resulting from prescribed fire and manual or mechanical treatments were modeled for each alternative. It was infeasible to model spatial effects of wildland fire-use fires or suppression wildland fires; therefore, all fire behavior prediction outputs from FARSITE and FlamMap do not include potential effects from these two fire management activities.

Tools Used To Analyze Effects **Vegetation**

Departure from Historic Fire Regimes

Desired conditions for Vegetation described in the affected environment (Chapter 3) are based on historic fire regimes. Impact thresholds are based on departure from historic fire regimes (and associated fuels, vegetation composition, and structure). To conduct the analysis of departure from historic fire regimes by alternative it was necessary to map historic fire regimes. This analysis focuses on both a quantitative and qualitative review to assess departure.

The quantitative review incorporated fire frequency analysis with the park atlas of fire history, and summary of fire severity monitoring since 2000. Categories of departure from historic fire regime were applied based on the number of fires since 1910. This approach was applied to assign departure from historic fire regimes for current conditions. Proportions of different severities (unburned, low, moderate, high) were summarized by vegetation type and fire category (prescribed, fire use, suppression).

Other aspects of fire regimes were reviewed qualitatively. Fire regimes are often described in terms of frequency (fire return interval) and severity (National Fire Plan Fire Regime Condition Classes shown in Table 4-1), but other aspects of fire regimes may be as important, particularly spatial patterns. This spatial aspect of fire regimes may include fire extent as well as spatial complexity, or patchiness (Sugihara et al. 2006). Fire severity was also reviewed qualitatively based on potential fire behavior predictions and burn plan prescriptions, and prescribed burn weather monitoring. These qualitative aspects of historic fire regime departure were addressed in the impacts section for each alternative in the analysis of their trend toward or away from departure from historic fire regime.

Table 4-1 National Fire Plan Fire Regime Condition Classes and Definitions

National Fire Plan Fire Regime Condition Class	Frequency (in years)	Severity
I	0-35	Low
II	0-35 years	High
III	35-100+	Mixed
IV	35-100+	High
V	greater than 100	High

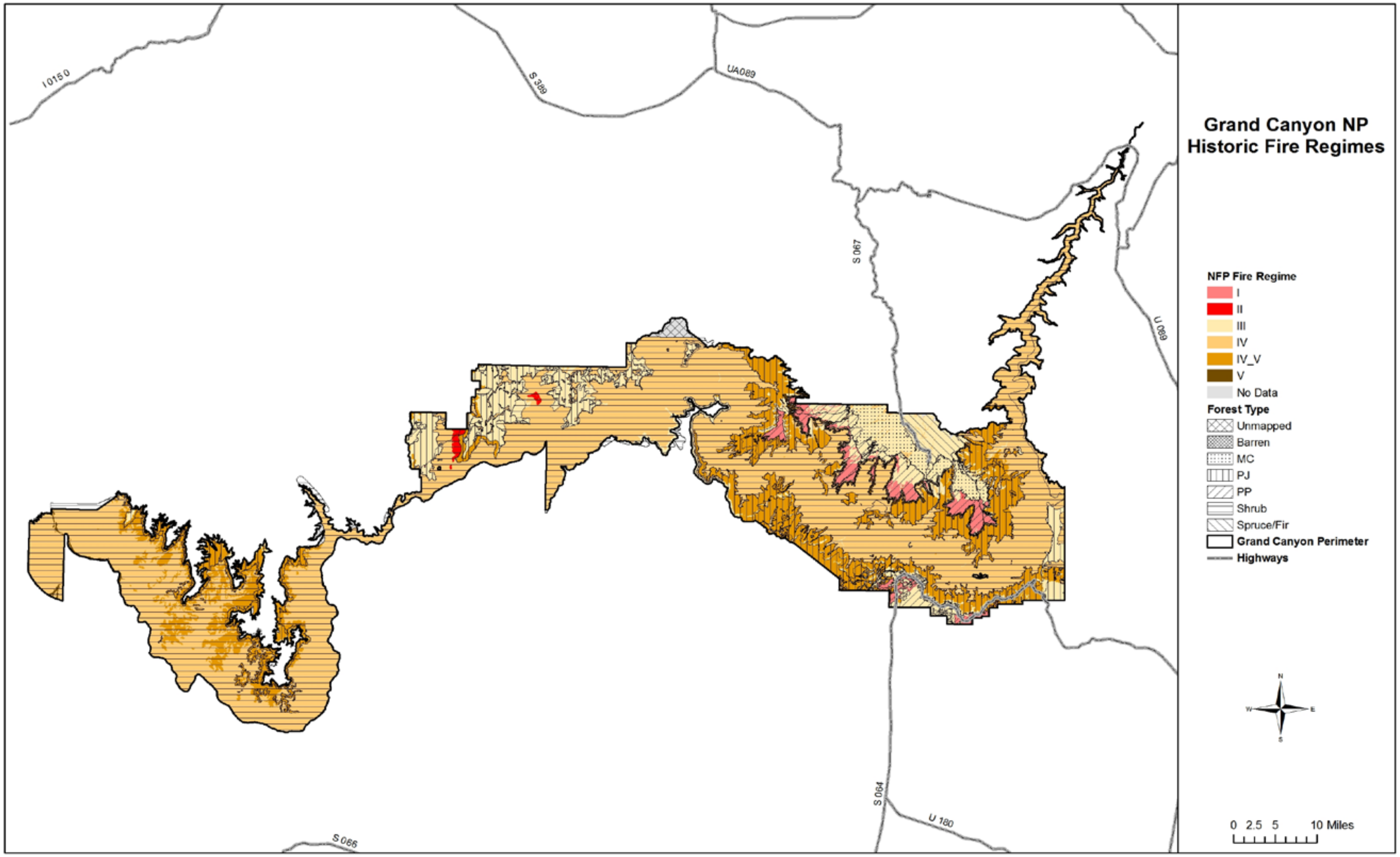
Map 4-1 displays historic fire regimes considered in this analysis. Fire regime classes are defined in frequency and severity as noted in Table 4-1. Map 4-1 also shows GRCA vegetation types.

The vegetation type with greatest departure from historic fire regime, based on fire frequency data only, is mixed-conifer on North Rim. As estimated, 42% of the mixed-conifer vegetation type is currently at high level of departure from historic fire regimes (Figure 4-2). This is consistent with treatment history (limited prescribed and wildland fire-use fire) and modeling by Fulé et al. (2004) on past, present, and future canopy fuel conditions for North Rim. The ponderosa pine vegetation type is in low (47%) or low/moderate (29%) departure from historic fire regime as a result of extensive burning in this vegetation type in the past 25 years.

Spruce-fir areas are generally classed as moderate (45%) or low/moderate (38%) departure from historic fire regime. Even though most of this vegetation type has not had a fire in the last 100 years, the historic fire regime in this type is highly variable and more likely to have moderate/long return intervals (Fulé et al. 2003a). The piñon-juniper type varies in departure level depending on historic fire-regime class. Overall 68% is currently classed as low/moderate departure, and 29% at moderate/high departure.

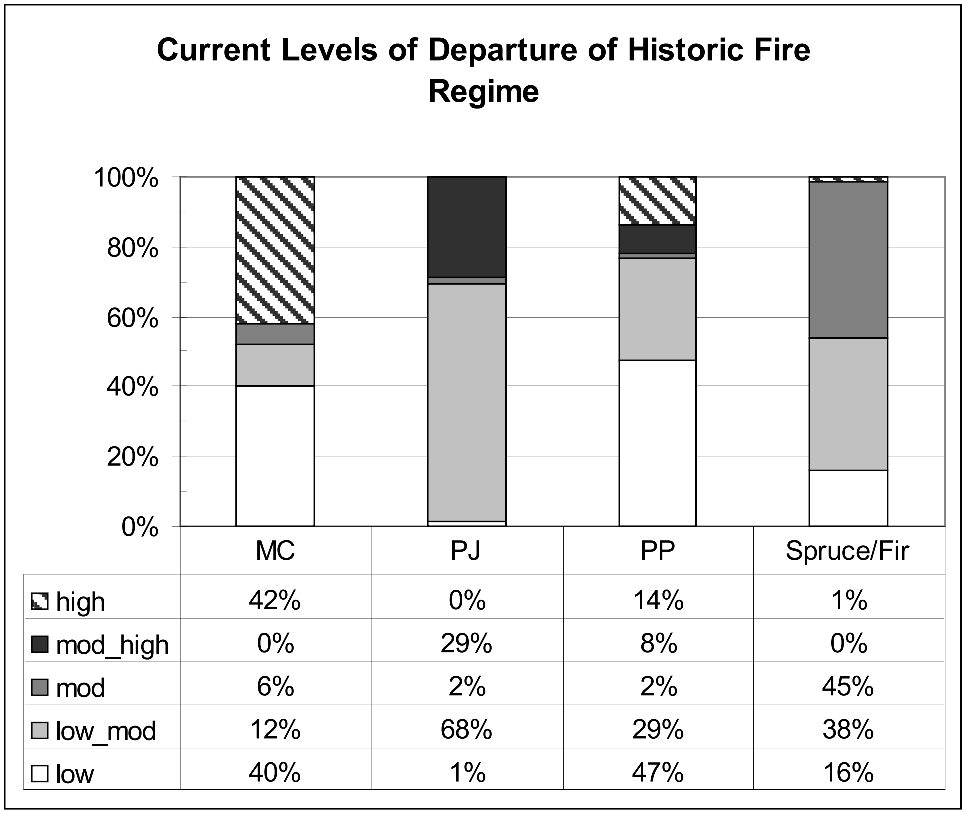
Tools Used To Analyze Effects **Vegetation**
Effects to Vegetation Composition, Structure, and Fuels

Fire-effects monitoring data and fire severity mapping from GRCA were used to project fire effects related to the proposed FMP.



Map 4-1 GRCA Historic Fire Regimes

Figure 4-2 Summary of 2007 Levels of Historic Fire Regime Departure by Vegetation Type



	MC	PJ	PP	Spruce/Fir
high	42%	0%	14%	1%
mod_high	0%	29%	8%	0%
mod	6%	2%	2%	45%
low_mod	12%	68%	29%	38%
low	40%	1%	47%	16%

Tools Used To Analyze Effects **Vegetation**
Fire Effects Monitoring

Fire effects monitoring data includes pre- and post-fire data collected since 1990. Data collected includes understory and overstory vegetation and surface fuels. Data collection was stratified by major vegetation type. Not all vegetation types have been sampled with the same intensity. Ponderosa pine and mixed-conifer vegetation types have been most extensively sampled; piñon-juniper has some samples; and spruce-fir has a very limited number. Data collected were immediately pre- and post-fire, after one year, two years, five years, and ten years. Numbers of post ten-year samples are limited for all vegetation types.

Tools Used To Analyze Effects **Vegetation**
Fire Severity Mapping

GRCA is among the first Federal units to use and widely apply vegetation fire severity maps using protocols developed by the USGS. GRCA fire severity mapping has occurred since 2000, and is now an interagency effort that spans DOI and USFS managed lands. For most fires, extensive ground-truthing at one year post-fire has been conducted. This information was used to interpret remote-sensing based maps of changes from pre- to post-fire conditions. GRCA has used FIREMON composite burn index field sampling methodology (http://www.landfire.org/media/la_final.pdf), with slight modifications.

Five severity categories are mapped: unburned, low, low/moderate, moderate/high, and high. In general, both high and moderate/high categories include high levels of tree mortality (greater than 80%). The high category also has more needle or foliage consumption in crowns and less immediate post-fire cover from fallen scorched foliage. The moderate/high category may have extensive sprouting response of understory species, aspen, and/or Gambel oak and may also have strong understory annual development (Huisinga et al. 2005). There is partial foliage and fine materials consumption on above-ground vegetation. This is in contrast to the high category where all foliage and fine materials on above-ground vegetation is consumed. The low category is non-lethal to dominant vegetation; dominant vegetation structure is unaltered. Vegetation scorching is limited to three feet or less from the ground up. Most foliage and twigs remain intact. Tree mortality in the low category is undefined but expected to be less than 10% in the overstory. The moderate/low category is most variable and least defined. There is partial scorching of foliage and fine materials on above-ground vegetation and some overstory mortality. There is minimal consumption of foliage and fine materials on above-ground vegetation. The mortality pattern in the moderate/low category is best described as mixed (see Chapter 3) with various proportions of intermixed low and high mortality. Unburned burn severity category is not burned.

Because severity mapping has been used over a relatively short time, data and/or assumptions were used to project fire severity by vegetation type and fire type.

Wildland Fire-use Fire Predictions Tools Used To Analyze Effects Vegetation

There is no reasonable way to predict exactly where wildland fire-use fires will occur or under which weather conditions. Location depends on ignition (lightning). Spread and effects are dependent on fuel type, topography, where ignition occurs, and weather conditions under which the fire burns. However, it is important to have some means to assess impacts of wildland fire-use fires that goes beyond broad, qualitative inferences. This analysis used historic ignition patterns with potential fire behavior to predict likely locations and effects of potential wildland fire-use fires by major vegetation type. This approach included assessing lightning-ignition densities and projecting wildland fire-use acres across the landscape proportionate to the amount per dominant vegetation type that occurred in the past.

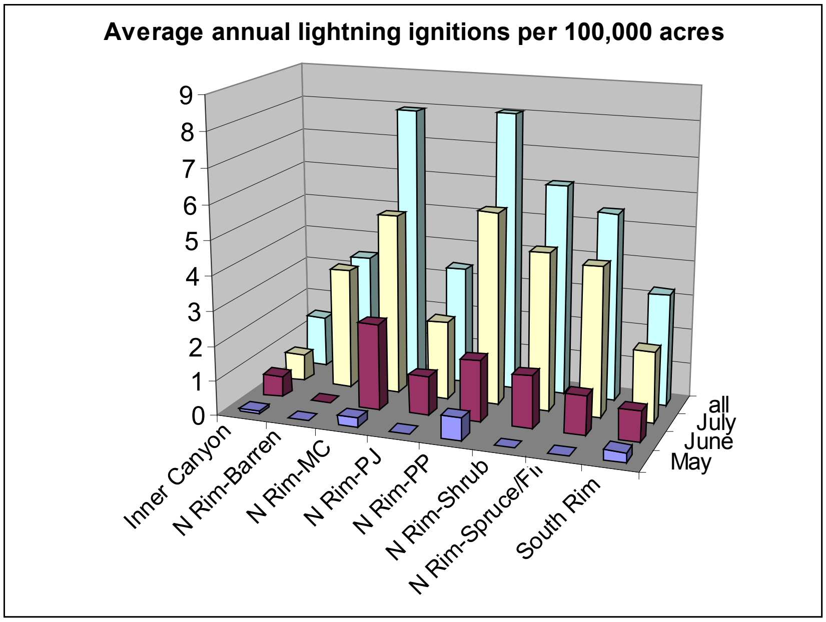
To address potential wildland fire-use fires location, lightning ignition history across the landscape was examined. This analysis focused on pre-monsoon ignitions during May, June, and July, since more fire-use fires are initiated during these months. Calculations were made on ignition density (number per 100,000 acres) per year by major vegetation type and location, and an average yearly density was calculated. The analysis was completed for each month separately, as well as together. Figure 4-3 shows average annual lighting ignitions per 100,000 acres May through July in various GRCA locations and vegetation types. Each month was examined separately because in some vegetation types, such as spruce-fir, there are fewer lightning-ignited fires early in the year (when conditions are relatively wetter and cooler from later snow melt and higher elevation) than others, such as ponderosa pine.

As Figure 4-3 shows, very few lightning ignitions occur in May, a few more occur in June, with the majority in July during monsoon season. It is important to note how ignition-number distribution varies by major vegetation type and location (Inner Canyon, South Rim, North Rim). Ignitions starting earlier in the year are likely to burn longer as wildland fire-use fires cover more area and produce greater varieties of fire severities. In May, most ignitions occur in ponderosa pine. According to the historical lightning-ignition data, there are none to very few ignitions in the Inner Canyon or spruce-fir vegetation type. In June, ignition density is still relatively low compared to July, but encompasses all areas that may have wildland fire-use fires.

The effect of potential wildland fire-use fires was assessed in a three-fold process. First, to assess the effect on departure from historic fire regime and fire type, a quantitative process was applied. Secondly, the potential severity pattern (distribution amongst low to high fire regime classes) was inferred based on fire severity history (since 2000, when severity mapping commenced) by vegetation type, location, and proposed treatment amount. Thirdly, predicted fire behavior results were used to infer expected fire behavior and resulting severity, by major vegetation type, for each alternative.

For the quantitative analysis, acreage expected to burn as wildland fire-use fire (as described by each alternative in Chapter 2) was proportionately applied to ponderosa pine and mixed-conifer vegetation types based on patterns since 1993. Average proportions of 57% in ponderosa pine and 20% in mixed-conifer were applied (Fites 2007). Some limited wildland fire use may occur in piñon-juniper stands occurring in small patches in other types managed for wildland fire use, such as ponderosa pine on Powell Plateau. Where wildland fire use occurs in piñon-juniper, monitoring would be prioritized to meet the objective of gaining a better understanding of piñon-juniper fire ecology. Since there is no data on fire-use fires in spruce-fir, effects of potential fire-use fires in this type were determined qualitatively.

Figure 4-3 Pre-Monsoon and During Monsoon (July) Lightning-Ignition Densities by Major Vegetation Type and Location (Inner Canyon, North Rim, South Rim)



Abbreviations for categories of combined vegetation type and location are:
N Rim= North Rim, MC=mixed-conifer, PJ=piñon-juniper, PP=ponderosa pine

4.2.1.4 Impact Thresholds — Vegetation

Alternatives were evaluated by looking at vegetation, fuel structure, and composition. The analysis considered effects on vegetation and fuels in the context of historical disturbance characteristics (fire regimes) observed over time and over different landscape parts and desired conditions. Because plant species number is so immense they have been grouped into broad vegetation categories having similar fire regimes for the purpose of this analysis. Broad vegetation groups are described in Chapter 3.

Type of Impact

Adverse Moves the system outside or away from the natural range of variability and desired conditions for vegetation (structure, composition, fuel characteristics, and ecosystem processes)

Beneficial Moves the system inside or toward the natural range of variability and desired conditions for vegetation (structure, composition, fuel characteristics and ecosystem processes)

Intensity

Negligible Imperceptible or undetectable effects on vegetation

Minor	Slightly perceptible and local effects
Moderate	Apparent change in plant community structure, composition, or fuels resulting in a change in fire's role on a small scale
Major	Substantial change in plant community structure, composition, or fuels representing a change in fire's role, ecological function, vegetation type, or fire-return interval on a landscape scale
Context	
Regional	Regional impacts affect a widespread area (generally greater than 40%) of a single vegetation and/or fuel type, and/or multiple fire regimes in and adjacent to GRCA
Local	Local impacts confined to a landscape of similar vegetation or fire regime and generally affect less than 35% of type
Duration	
Short Term	Effects can be reversed or neutralized in one or two fire-return intervals
Long Term	Requires three or more fire-return intervals to reverse or neutralize effects
Timing	Vegetation is generally more sensitive to impacts during the growing season and drought

4.2.1.5 Mitigation of Effects — Vegetation

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description and are addressed in other sections of this Chapter.

The 2006 Draft NPS Invasive Species Action Plan (NPS 2006d) provides a framework for implementing prevention, early detection and rapid response, control, education, research and restoration activities for invasive species on park lands.

The Fire Management Program can contribute to prevention and control of invasive species in the following ways.

- Locate control lines, helispots, fire camps, and other soil-disturbing fire management activities to minimize damage to biological resources
- Inspect helispots, staging areas, incident command posts/base camps, etc., periodically; and minimize exotic species introduction
- Use Minimum Impact Suppression Techniques to reduce disturbances to soil and vegetation
- Clean fire vehicles, equipment, and clothing in compliance with parkwide policy as determined by the upcoming Exotic Plants Management Plan
- Procure certified weed-seed-free mulching materials and native plant seed used in fire rehabilitation operations

4.2.1.6 Cumulative Impact — Vegetation

The area considered important for cumulative impacts to historical fire regimes and vegetation structure and composition encompasses adjacent areas outside park boundaries. This includes the area north of GRCA that comprises the remainder of the Kaibab Plateau and the area south that includes ponderosa pine forests on the Kaibab National Forest.

Actions in the Park **Cumulative Impact** **Vegetation**

Cumulative effects to fire regimes from other past or planned actions in GRCA would be very limited, except for past prescribed fires and wildland fire-use fires included in the analysis of fire behavior and departure of historic fire regimes. An action that would have an additional beneficial effect is the Cross Corridor Fire Protection Project (NPS 2003a) whose purpose is to upgrade existing water distribution systems connected to the Trans-Canyon Pipeline to delivery the volume and pressure needed to supply fire sprinkler and hydrant systems at four sites along the Corridor area trails.

Actions in Areas Surrounding the Park **Cumulative Impact** **Vegetation**

Other actions in areas surrounding GRCA that influence effects to fire regimes and vegetation composition and structure are prescribed fire, mechanical treatments, wildland fire-use fires and wildfires. The Kaibab National Forest has completed or planned numerous treatments that reduce hazardous fuel loads and restore fire regimes.

Projects south of GRCA would play a role in cumulative effects to fire regimes and vegetation structure and composition in the park. There have been a number of prescribed fires, mechanical thinning treatments and wildland fire-use fires just south of the park boundary. Since prevailing winds are from the southwest, fires on the Tusayan District, Kaibab National Forest, have potential to travel into GRCA.

North of GRCA, the Kaibab National Forest has also planned and implemented similar projects. Since prevailing winds are from the southwest, fires on the park have potential to travel into the North Kaibab District, Kaibab National Forest (See Appendix G).

4.2.1.7 Longer-term Effects and Climate Change Vegetation

Areas left untreated for 40 years would trend toward adverse effects to fire regimes and vegetation composition and structure. Simulations of changes in North Rim ponderosa pine, mixed-conifer, and spruce-fir forest types by Fulé et al. (2004) 2000 to 2040 suggest continued crown fuel accumulation and increase in crown fire potential. This effect is likely exacerbated by predicted climate change.

Recent analysis of fire extent and climate during the last 35 years revealed a trend in increasing incidence of large, high severity fires since the mid-1980s (Westerling et al. 2006). A positive correlation was found between increased fire incidence and warmer years, and there has been an increase in fire season length. It is likely that forest or vegetation types that have experienced fuel accumulations and increased vegetation density from fire suppression are more sensitive to climatic variability—less resilient to fires during droughts and warmer years when fire behavior is most intense. In the face of climate change, it is uncertain whether the same or different vegetation would grow back following high severity fire. There is some unknown probability for some type conversion from forest to non-forest in areas burned with high severity since tree establishment may be more difficult. On the other hand, areas with scattered, old ponderosa pine among younger or mature fir and spruce indicate they may have become established during hotter, drier past climates. So a cumulative effect of climate change may be re-establishment of old-growth ponderosa pine in mixed-conifer or spruce-fir sites where it currently exists as remnants of past warmer, drier climate.

Changes in plant communities can also be expected from future climate change, as individual species respond to large and small scale changes in temperature and precipitation, the fertilizing effect of increased atmospheric carbon dioxide, and changing patterns of inter-specific competition (Shafer et. al 2001). This document can not address the sweep of ongoing scientific investigations into potential change particulars. Many future scenarios have been developed and modeled in the attempt to quantify future climate change (Solomon et.al 2007). At this time, the models are not sufficiently precise to address increases in temperature and water stress over the relatively short duration of the planning period in an area as small as GRCA as applied to particular species or habitats, although work of this nature is underway (Cole, no date). There is also uncertainty regarding how past fire suppression effects will influence regeneration of high altitude forests in the park regardless of climate change (Fulé et.al 2004, p. 246) that would further complicate meaningful predictions. Considered over a broad scale, restoring proper ecosystem functions can remove additional environmental stressors on species and allow them to better adapt to climate change. Burn plan prescriptions, go/no-go decisions, and real-time fire modeling rely on current meterological conditions and fuel characteristics, which reflect the uneven progression of longer-term changes. These planning and decision-making processes are an example of short-term adaptive management followed by the fire program. As additional scientific information becomes available at a useful temporal, spatial, and/or ecological scale, it would also contribute to the longer-term adaptive management process through annual program reviews and revisions to the Fire Management Plan. See 2.6.4.

4.2.1.8 Assumptions Made for Modeling Vegetation Fire Behavior

Typically for fire behavior modeling and predictions, one or several sets of representative weather conditions are used as model inputs. Most often, a set of conditions is developed from analysis of weather station data during a specified time, expressed as a percentile. Fire season extent is typically used. For this analysis two different fire seasons were defined and weather percentiles computed as inputs. The pre-monsoon fire season was defined as May through July. Post-monsoon weather was defined as August through September for initial analysis but later restricted to September. Weather percentiles are based on sorting a weather variable from lowest to highest for a defined time and taking the value where a certain percent (such as 90) of weather conditions are lower. This was done individually for temperature, humidity, and wind and results combined for the range of weather percentiles chosen. Four different weather percentiles were chosen to represent a range of fire-weather conditions. These included: 97^{th} percentile for very high weather conditions, 90^{th} for high, 80^{th} for moderate, and 50^{th} for low.

Originally, both pre- and post-monsoon weather conditions were planned for fire-behavior prediction modeling. However, after examining test fire behavior model outputs, results did not vary enough among different weather scenarios to warrant modeling both. Similarities were greatest for 90^{th} and 97^{th} percentile weather conditions. The decision was to focus on pre-monsoon conditions for this analysis since this is when moderate/high fire behavior is most likely. Live vegetation moisture levels (foliar moisture) are typically greater post-monsoon rains, and may result in lower fire intensity or severity effects. It was also felt that fire severity monitoring encompassed both pre- and post-monsoon weather conditions and could be used in with fire-behavior simulations to accurately capture impact range.

Table 4-2 Weather Conditions Used for Fire Behavior Prediction Modeling*

Location (N or S Rim)	Weather Percentile	Minimum Temperature (°F)	Maximum Temperature (°F)	Maximum Humidity (%)	Minimum Humidity (%)	Wind Speed (mi/hr)	Wind Direction (degrees)
Pre-Monsoon (May – July)							
North and South Rim	97**	60	95	21	2	20	245
North and South Rim	90	50	90	27	4	7	245
North and South Rim	80	48	86	31	6	5	245
North and South Rim	50	43	79	43	10	3	245
Post-Monsoon (September)							
North Rim	90	50	87	38	6	5	240
South Rim	90	48	94	54	5	5	225

*Table based on summaries from Bright Angel, Lindberg Hill, and Dry Park remote automated weather stations (RAWS) for North Rim; and Tusayan and Bright Angel for South Rim. Wind speeds for the 97th percentile were based on those observed during the Outlet Fire
**Restricted to six days in June to obtain more typical daily averages for all individual weather indicators including temperature, humidity, and wind

Interpreting potential fire-behavior outputs at a given weather percentiles necessitates considering how often those conditions would likely occur. Average number of days per year during pre-monsoon months, at each weather percentile, provides reasonable information to infer likelihood of how often each weather percentile condition would occur. This is particularly important related to potential impacts from wildland fire-use and suppression fires. Table 4-3 shows, on average, the pre-monsoon 97th percentile weather conditions occurred two to three days per year; 90th percentile weather conditions occurred four to ten days per year; 80th percentile weather conditions occurred five to nine days per year. These estimates are based on a weather percentile analysis of a fire-weather index, the spread component. Spread component is calculated from wind, and one-hour and live-fuel moisture. The one-hour fuel moisture integrates information on humidity and temperature.

To assess potential impacts to departure from historic fire regime, acres that would be burned as wildland fire use were applied in proportion to the area in each departure class. When potential wildland fire-use acres fell in a low/moderate or moderate departure class, it was assumed the acres moved to a low departure class. Further, when potential wildland fire-use acres fell into a high or moderate/high departure class, it was assumed those acres moved into a moderate departure class after the fire-use fire. Where potential wildland fire-use acres occurred in areas already in the low departure class, it was assumed those acres would stay in the low departure class.

Table 4-3 Average Number of Days per Year at Different Fire Weather Percentiles, Pre-Monsoon May through July

Pre-Monsoon Weather percentile	Average Number of Days per Year by Weather Station Name/Location		
	Bright Angel	Dry Park	Lindbergh Hill
97th	2	3	3
90th	4	9	10
80th	5	6	9

Assumptions Made for Modeling **Vegetation**
Changes in Departure from Historic Fire Regimes from Wildland Fire Use or Suppression Fires

Potential departure changes from uniformly high severity fire managed as suppression fire were not assessed quantitatively because there was no reasonable way to predict where these fires might occur. Changes were reviewed qualitatively.

Assumptions Made for Modeling **Vegetation**
Changes in Potential Fire Behavior from Wildland Fire-use Fires

When potential wildland fire-use acres fell in areas predicted to burn as crown fire, it was assumed those acres would move into surface fire type in the next burning cycle. Further, if potential fire-use acres fell in areas predicted to burn as surface fire, those areas remained as surface fire.

4.2.1.9 Incomplete and/or Unavailable Information Vegetation
Fuel Accumulations in Untreated Areas

In areas not scheduled for treatment, fuels would accumulate at various rates, depending on vegetation type and density. Fire-effects monitoring data clearly show surface fuel accumulations after ten years; however, data were limited in number of plots and did not encompass all vegetation types and conditions. Data also did not include measures necessary to estimate crown fuels (canopy base height and canopy bulk density), since they were designed primarily to measure fire effects changes. Existing data were not considered adequate to accurately predict fuel condition changes. The Forest Vegetation Simulator model does provide predictions of surface and crown fuel accumulations over time, but this portion of the model is limited and results uncertain, particularly for surface and ladder fuels. Therefore, changes in fuel conditions in untreated areas were discussed qualitatively. They were not incorporated in FARSITE and FlamMap fire-behavior predictions. Expected changes in fire behavior due to qualitative predictions in fuels were described qualitatively.

Incomplete and/or Unavailable Information **Vegetation**
Location of Wildland Fire-Use or Suppression Fires

It was not feasible to model spatial effects of wildland fire-use or suppression fires; therefore, all fire-behavior prediction outputs, including those from FARSITE and FlamMap, do not include potential effects of wildland fire-use or suppression fires.

Incomplete and/or Unavailable Information **Vegetation**
Fire Effects Monitoring Data

Data from the GRCA fire-effects monitoring program represent a programmatic sampling approach, i.e., they are not designed to sample an individual fire or other fire treatment, but rather overall effects of all projects. Sampling has been stratified by pre-fire vegetation types based on dominant species. These types reflect expected differences in fire patterns and responses to fire. Effects for a given vegetation type would also vary depending on fire type—and with resulting different fire severities. There has been no stratification of monitoring data into different fire severities; therefore, data presented in this analysis are combined outputs of all fire severities sampled.

Monitoring data did not include measurements of tree crown characters that would allow evaluation of responses in canopy base height or canopy bulk density; therefore, interpretations of how crown fuels change with prescribed fire were based on inferences from tree density by diameter class results.

Limited data were available on fire effects on vegetation understory (herbs and grasses) composition and structure. Fire-effects monitoring data for the understory are limited to species presence and absence;

therefore, effects are discussed generally in the context of historic fire regimes and inferred understory vegetation responses.

Incomplete and/or Unavailable Information **Vegetation**
Fuels Data

GRCA had two different surface-fuel layers: one prepared by Regional Office, and another modified version prepared by GRCA Fire Staff. Both surface fuel layers were based on vegetation layer, mostly large polygons; therefore, data are limited in characterizing the finer-scale pattern of surface fuel variation and potential fire behavior. There has been no formal accuracy assessment of either layer.

The only available crown fuel layer was incomplete for piñon-juniper and, as a result, some areas of piñon-juniper were characterized as a high fuel load, intensely burning surface fuel type. This resulted in over-prediction of fire behavior in most weather conditions. Surface fuels were modified for use in combination with LANDFIRE crown fuels to obtain expected bi-modal behavior.

The crown fuel layer available at GRCA did not encompass the entire park and had not been updated for fires since 1999; therefore, LANDFIRE crown fuel data were evaluated. These data provided reasonable levels compared to published canopy fuel conditions (Fulé et al. 2004) and in tests with the fire behavior model, produced predicted fire behavior consistent with observations and expected patterns.

There are no fuels inventories in WUI. As a result, fire behavior predictions in this area were qualitative.

4.2.1.10 Impact Analysis **Vegetation**
Effects Common To All Alternatives
Departure from Historic Fire Regimes

Fire intensity, type, and severity are three important fire regime components; however, another often overlooked component is spatial pattern (Sugihara et al. 2006). Spatial complexity, or patchiness of different fire intensities and resulting effects (or severity), is a key aspect of spatial pattern that can differ between prescribed, wildland (suppressed) and wildland fire-use fires. Many suppressed wildland and prescribed fires tend to have lower spatial complexity since suppression fires tend to occur during very high fire-weather conditions and, as a result, tend to burn more uniformly at high intensity, and prescribed fires normally burn in a very short time at a more even, lower intensity. Wildland fire-use fires tend to have higher spatial complexity (Fites-Kaufman and Noonan-Wright *in review*) since they tend to burn for longer periods. Changes in fire behavior (spread rate and intensity) from day to night and across changes in daily weather create a wider variety of post-burn intensities and spatial patterns of effects. Because of this, it is assumed most wildland fire-use fires that occur during this planning period would cause a major, beneficial trend toward restoration of historic spatial complexity in fire and vegetation structure and composition. However, there is also the probability with wildland fire-use and suppression fires that they can generate more uniform spatial patterns of high severity when burning during extreme weather conditions. Whether this would be an adverse or beneficial impact and the degree of certainty regarding the conclusion on impact type depends on vegetation type. There is a high to moderate level of certainty that large patches of uniformly high severity fire did not occur in the ponderosa pine type. This is most likely the same for mixed-conifer forests where high severity patches were more likely than in ponderosa pine, but were generally thought to be small to medium in size. In the spruce-fir and piñon-juniper types there is a high level of uncertainty about occurrence, frequency, and extent of uniform, large patches of high severity.

Effect of prescribed fires on spatial complexity varies with ignition pattern. In general, prescribed fire spatial complexity is more limited than wildland fire-use fire because they burn in shorter timeframes. Ignition pattern may also cause more uniform spatial patterns, although not always. Prescribed fires implemented with strip firing tend to be more uniform. Prescribed fires implemented over a short period for operational reasons, or to minimize length of smoke exposure, tend to be more uniform. In general, prescribed fires proposed during this planning period would cause a moderate, beneficial trend toward restoration of historic spatial complexity in fire and vegetation structure and composition. GRCA Fire Staff are experimenting with different prescribed-burn strategies that would result in a major, beneficial trend in spatial complexity similar to wildland fire-use fires. This would include ignition patterns where spots are ignited on ridges, and fires allowed to move slowly down hills over a longer period.

Effects Common to All Alternatives **Vegetation**
Vegetation Composition, Structure, Fuels and Severity

Fire behavior is a product of the environment in which the fire is burning. Topography, fuel, weather, and the fire itself interact to influence how fire moves across a landscape. In most vegetation communities, time alters potential fire behavior through accumulation of different fuel size classes, or fuel removal through structure or physiological state of vegetation/fuel. As GRCA's forest stands grow older, availability of different vegetation structure to fire spread changes potential fire behavior and resulting fire effects. As Agee states in *Fire Ecology of Pacific Northwest Forests*, 1993: *Today's plant communities reflect species assemblages in transition, each reacting with different lag times to past changes in climate, and each migrating north or south, up or downslope. Many species have not closely coevolved with the other species they are found growing with today, because of differential rates of migration over past millennia. Each species, however, may have coevolved for much longer periods with particular processes associated with it.*

The concepts of vegetation emergence, growth, aging, and renewal are included in cycles interrupted at various times by various disturbance agents such as insects, disease, vegetative harvest, fire, wind, or other factors. Evaluating burn severity in GRCA can take place at various scales and time frames and lead to different end points in assessing impacts to park resources and values. Descriptive terminology is used to articulate a variety of aspects of a process, like fire moving across a landscape, but in renewable landscape ecology the positive or negative value determination may only apply to one aspect of the process or individual perception of the resulting impacts to a favored resource. For example, in assessing site-specific data from GRCA mixed-conifer stands (Bunn 2009) it appears a wide range of attributes can be described for fire effects to vegetation structure in mixed-conifer stands. These range from little change in forested structure to small scale loss of overstory trees in all size classes. In higher burn severity patches, data show a resulting increase in snags, and no net change of woody debris on the ground as fire-killed trees fell and replaced woody debris consumed in fire events. In these patches average understory species richness did not change; however, average plant cover increased dramatically following fire. So although an area is described as having high burn severity, the cycle of vegetation response continues, renewing forested characteristics at different life stages. Influences on today's vegetation communities also influence resulting processes and consequent vegetation structure.

Based on monitoring data collected at GRCA since 1993, conclusions were reached on potential effects to vegetation types from fire. Not all vegetation types have been monitored, since not all have experienced prescribed fire (spruce-fir), or monitoring is limited (piñon-juniper, mixed-conifer). For these vegetation types (spruce-fir, piñon-juniper, mixed-conifer) conclusions were also based on potential fire predictions and fire ecology of dominant species. These conclusions would be applicable to all alternatives in areas treated with fire.

Effects Common to All Alternatives **Vegetation**
Ponderosa Pine **Vegetation, Composition, Structure, and Fuels**

Considerable prescribed burning and wildland fire use have occurred in the last 25 years in GRCA ponderosa pine forests. As a result, over three-quarters (76%) of the ponderosa pine type is currently at low or low/moderate departure from historic fire regimes (Map 4-1).

As shown in Table 4-4, severity patterns in the ponderosa pine type (since 2000, when severity mapping commenced) indicate most fires (wildland fire-use, prescribed, suppression) result in less than 20% moderate/high or high severity.

Based on historical monitoring data, fire severity was projected for all three fire categories. Monitoring data was the sole basis of determining averages for projected fire severity in the ponderosa pine vegetation type. Ponderosa pine had the greatest number of fires monitored in comparison with other vegetation types. Table 4-5 provides a summary of the average percentage, by fire severity level, that would burn in each fire type. These averages were used in determining fire severity impacts for all alternatives.

Table 4-4 One-Year Post-Fire Severity Data by Fire Category (Prescribed, Wildland Fire Use, Suppression) and Fire Name in Ponderosa Pine*

Fire	Proportion Burned by One-year Post-fire Severity Class					
	Unburned	Low	Moderate /Low	Moderate /High	High	Area (acres)
Fire-Use Fire						
Big	3%	74%	20%	3%	0%	306
Grama	10%	84%	6%	0%	0%	306
Quartz	5%	18%	68%	8%	0%	426
Rose	15%	64%	14%	5%	1%	3064
Swamp	4%	70%	23%	2%	0%	2697
Powell	20%	74%	5%	1%	0%	2671
Poplar WFU	1%	44%	36%	16%	2%	1086
Vista	5%	31%	34%	25%	6%	118
Tower	5%	82%	12%	1%	0%	3877
Suppressed Wildland Fire						
Poplar	14%	69%	14%	3%	0%	1786
Long Jim III	7%	38%	28%	19%	8%	128
Outlet	20%	47%	24%	8%	1%	496
Prescribed Fire						
Long Jim III	21%	54%	15%	5%	5%	956
Outlet	8%	40%	35%	13%	5%	1083
Walhalla	19%	56%	21%	4%	1%	2940

*One-year post-fire severity from fire use, suppression, and prescribed fire in the ponderosa pine type. Data were generated using standard remote sensing (LANDSAT) and extensive field plot data. Severity is based on the FIREMON Composite Burn Index, incorporating effects to all vegetation layers and soil. High and moderate/high categories have high (greater than 80%) overstory tree mortality.

Table 4-5 Projected Fire Severity by Fire Category in Ponderosa Pine

Severity Level	Fire Category		
	Prescribed Fire	Wildland Fire Use	Suppression Fire
unburned	16%	8%	14%
low	51%	60%	51%
low/mod	23%	24%	22%
mod/high	7%	7%	10%
high	3%	1%	3%

As a whole, alternatives effects include both continued movement toward the natural range of variability where fire treatments are proposed (beneficial effect) and away from the natural range of variability, where no treatments would occur (adverse effect). Effects vary by alternative due to treatment acreage proposed. Rate of fuel accumulations in untreated areas is not known precisely, but monitoring data indicates there can be substantial increases in surface fuels ten years after a burn.

Past monitoring data indicates that post-prescribed and wildland fire-use fire surface-fuel conditions are substantially reduced (42 to 47% of pre-burn levels). Monitoring data also indicate that tree densities, particularly of smaller diameter (1 to 5.9-inch dbh) and medium diameter (5.9 to 15.8-inch dbh) trees, still exceed desired conditions in many areas treated once. There is a trend toward reduction in small and medium tree densities, particularly after a second burn treatment. After the second burn, small tree densities were reduced to 47% of pre-burn levels on South Rim sites. North Rim effects are more difficult to interpret since there is a high degree of variability among plots, and a limited number of plots (two) that have burned twice. There is a marked reduction in tree seedlings after the first year of burning; however, where Gambel oak or aspen occur, in subsequent years total seedling density can increase greatly due to sprouts from these species. Conifer seedling densities remain low during the first ten years after burn treatment. Although there can be recruitment flushes in a single year, these seedlings apparently do not survive, and in following years densities are again greatly reduced. Research by Fulé and Laughlin (2007) confirm density reductions in ponderosa pine sites through burn treatments.

Although understory and midstory tree densities have not reached desired conditions based on monitoring data, overall canopy base heights are higher as a result of prescribed and wildland fire-use fires to date. There is no direct information from monitoring data to calculate changes in canopy base height, but GRCA fire staff observe that crown fires are less likely to initiate or be sustained in much of the treated ponderosa pine type where surface-fuel loading and tree-sapling densities are low. Low surface fuel loading and lower tree sapling densities would create lower fire intensities and flame lengths, thus decreasing the chance of fire reaching canopies of larger trees.

Since fires burned frequently in the historic fire regime, it is assumed that understory species' response to current and planned fires are within the natural range of variability. The exception would be where invasive exotic plants are present or increase in presence. See 4.2.3 for a detailed analysis.

Monitoring data indicates that after ten years, surface fuels have accumulated to approximately 70% of pre-burn conditions. Understory shrub-stem density and Gambel oak sprouts also increase after five to ten years in monitored South Rim ponderosa pine sites. Tree seedlings show marked increases after ten years in some North Rim ponderosa pine sites as well. Data indicate that after approximately ten years, ponderosa pine type fuels begin to accumulate beginning a trend away from historic fuel conditions and an increase in potential fire behavior. Rate of trend after ten years is unknown due to monitoring data lack beyond ten years. Based on existing data, beneficial effects from fire treatments for all alternatives would be short term since the proposed treatment schedule is for a ten-year period and beneficial effects begin to trend away from historic fuel conditions after ten years.

In conclusion, predicted and observed fire behavior on sites re-burned within ten years of treatment (prescribed fire, wildland fire use) indicate they would burn primarily as surface fires under most, if not all, fire weather conditions. Monitoring data results, in combination with predicted fire behavior, indicate fire treatments (prescribed fire or wildland fire use) result in a trend in fuels, vegetation, and fire regime toward desired conditions and natural range of variability for the ponderosa pine type during the first ten years. After ten years, there is a trend toward fuel accumulation and increased fire behavior.

Prescribed and wildland fire-use fires effects to ponderosa pine vegetation composition and structure would trend toward the natural range of variability. Species that occur in this type are adapted to frequent fire historically and, based on observed and predicted fire behavior, the majority of this vegetation type is near or within the natural range of variability. Prescribed and wildland fire-use fires would have moderate to major, beneficial, short-term effects in the ponderosa vegetation type.

Given current fuel conditions (three-quarters of the vegetation type is currently at low or low/moderate departure from historic fire conditions) and predicted fire behavior (mostly surface fire) in the ponderosa pine vegetation type, it is assumed fires chosen to be suppressed would generally be contained rapidly under most weather conditions. It is assumed that wildland fire-use fires that ignite in ponderosa pine forests would have a low probability of burning at high intensities or with much crown fire. The exception would occur where ponderosa pine is in a high departure from historic fire conditions (14% of the vegetation type), including in the WUI where some treatment has occurred but not extensively, particularly around structures.

Effects Common to All Alternatives **Vegetation**
Mixed-Conifer **Vegetation, Composition, Structure, and Fuels**

When compared to the ponderosa pine vegetation type, GRCA mixed-conifer vegetation type has experienced less fire in the last 25 years. Presently, an estimated 40% of mixed-conifer type is at low departure from historic fire return interval. As noted in Chapter 3, this vegetation type was thought to have burned with low (Fire Regime Class I) to mixed fire severity (Fire Regime Class III). There is less known about historic fire regimes in mixed-conifer than ponderosa pine; therefore, less certainty in assessing trends toward the natural range of variability. Further, mixed-conifer includes a gradient of types from overlap with ponderosa pine at lower elevations and with spruce-fir type at higher elevations. As noted in Table 4-6 fire severity mapping since 2000 indicates that prescribed fires are primarily burning at low or moderate/low fire severity classes (with less than 2% in moderate/high or high classes). This is based on limited information from one prescribed fire. Expected fire behavior for prescribed fires would be less than the predicted potential fire behavior (from FlamMap) because predictions are based on an assumption of headfire (that part of the fire that moves with the wind and upslope) and prescribed fires are implemented with backing fire (that part of the fire that moves against the wind and downslope) or patchy fire. Backing or patchy fires burn at lower intensities and spread rates than head fires.

Table 4-6 One-Year Post-Fire Severity Data by Fire Type and Name in Mixed-Conifer*

	Proportion Burned by One-year Post-fire Severity Class					
Fire	Unburned	Low	Moderate /Low	Moderate /High	High	Area (acres)
Fire Use						
Big	1%	47%	37%	15%	0%	141
Bright	6%	25%	23%	34%	13%	710
Vista	2%	57%	29%	8%	4%	3495
Poplar WFU	1%	28%	23%	29%	19%	5745
Suppression						
Outlet	12%	22%	24%	31%	11%	1962
Poplar	9%	69%	18%	4%	0%	3077
Prescribed Fire						
Walhalla	12%	56%	31%	1%	0%	210

*One-year post-fire severity from fire use, suppression, and prescribed fires in the mixed-conifer type. Data were generated using standard remote sensing (LANDSAT) and extensive field plot data. Severity is based on the FIREMON Composite Burn Index, incorporating effects to all vegetation layers and soil. High and moderate/high categories have high (greater than 80%) overstory tree mortality.

Wildland fire-use fire effects are more varied, with levels of moderate/high or high severity ranging from 12 to 48% for fire severities by individual fires in this vegetation type. In summary this means that the average severities for the entire forest of mixed conifer would be within the reference conditions. This is within the range of variability of estimated historic distribution for fire severities in this vegetation type, which had a mixed or moderate severity pattern historically. The Poplar and Vista fire-use fires severity pattern was at the high end of the natural range of variability. The two suppression fires (Outlet and Poplar) also displayed a variety of fire severity in mixed-conifer vegetation. Although proportions of high severity for wildland fire-use and suppression fires are not outside the range of historic distribution of fire severity in this vegetation type, patches of high severity may be larger than what occurred historically, when vegetation and fuels were more heterogeneous and less continuous.

Monitoring data was deemed insufficient to represent averages of projected fire severity for every fire category (prescribed, wildland fire use, suppression). A combination of existing monitoring data, knowledge of existing fuel conditions, and/or expected fire behavior were considered in determining representative fire severity level by fire category (Fites 2007). Average wildland fire-use severity levels for four different fires were used for fire-use fires. Only two recent suppression fires have had severity mapping, and out of these severity levels, data for the Outlet Fire were used since it represents the higher end of weather conditions most likely to coincide with suppression fires. Limited area from a portion of one prescribed fire had severity mapping; this was considered unrepresentative. Severity levels for prescribed fire were based on professional judgment on existing fuels, vegetation conditions, and historic fire patterns in this vegetation type. Under these conditions, fire behavior predictions for mixed-conifer treated areas would vary from 64 to 82% surface fire depending on the alternative (Tables 4-13, 4-17, 4-20, 4-23 display surface-fire projections for each alternative). Assuming all crown fire area would result in high or moderate/high fire severity, this would result in 18 to 36% high or moderate/high severity depending on alternative. As noted earlier, predictions are based on an assumption of head fire; reduced crown fire levels and severity are expected under the backing or patchy fire patterns applied in prescribed burns. Table 4-7 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type, except Alternative 1 where Mexican spotted owl constraints require low intensity fire for fire treatments (low intensity is defined as overstory tree mortality and amount of high severity limited to less than 15% of the area).

Table 4-7 Projected Fire Severity by Fire Category in Mixed-Conifer

	Fire Category		
Severity level	**Prescribed fire**	**Fire use**	**Suppression**
Unburned	20%	3%	12%
Low	20%	39%	22%
Low/moderate	30%	29%	24%
Moderate/high	20%	20%	31%
High	10%	9%	11%

As with ponderosa pine, there is no detailed information on historic levels of surface fuels, small tree, or seedling densities. Monitoring data for mixed-conifer vegetation shows both surface fuels and tree densities have similar responses to that described for ponderosa pine.

There is a marked reduction in surface fuels (to nearly 50% of pre-burn levels) and litter and duff depth (greater than 66% of pre-burn levels) with prescribed and wildland fire-use fires. After ten years, surface fuel levels have increased to near pre-burn levels but after a second treatment they are reduced again. Due to the relatively high productivity level of mixed-conifer forests, fuels would accumulate faster than ponderosa pine vegetation type. Based on this information, there would be a beneficial effect of prescribed and wildland fire-use fires on surface fuels in the mixed-conifer vegetation type since surface fuels are reduced. Also, vegetation type would trend toward natural range of variability, where the majority of fires in mixed-conifer vegetation type are thought to be mixed, meaning there would be a more mosaic pattern of surface and crown fire (mostly passive crown fire) and resulting fire severity.

GRCA monitoring data shows small (1 to 5.9 inch dbh) and medium diameter (5.9 to15.8 inch dbh) tree densities are reduced 30 to 50% after prescribed burn or wildland fire-use fires but still exceed desired conditions. Similarly, after treatments, trees in the 15.8 to 35.9 inch diameter class exceed desired conditions. Conifer seedlings show decreased densities, particularly those burned twice. This indicates that future conifer-stem density would be reduced by repeated fire, resulting in longer-term achievement of desired conditions in tree density (some open stands). Aspen sprouts show marked increase the second year after the first fire, but decline after a second fire. Overall, with prescribed fire and wildland fire-use fire treatments, data indicate a trend toward desired condition of more open stands.

In monitoring plots, shrub stem densities show a marked decrease in the first year post-fire but rapidly recover and increase in subsequent years. The increase is particularly evident in New Mexico locust, snowberry, and *Ceanothus* species. Since there is little to no information available on historic understory vegetation patterns, it is assumed that any fire effects on understory vegetation during this planning period would be similar to those historically, and a beneficial fire effect on understory vegetation in the mixed-conifer vegetation type.

Reductions in surface fuels, in combination with decreased tree density, particularly in the understory, indicate fire would be less intense and more like historic patterns in treated areas. There would be a beneficial effect of prescribed and wildland fire-use fires on fuels in the mixed-conifer vegetation type under most weather conditions. An exception would be at the 97th weather percentile. Under these conditions, fires would be more intense, and fire effects more uniformly severe in previously untreated mixed-conifer forests. The number of days per year when these conditions would occur is limited to several days on average (Table 4-2); therefore, likelihood is not great. But fires have burned in mixed-conifer in these conditions previously, as when the Outlet prescribed fire was converted to a suppression fire and encompassed 1,960 acres of which 42% was high or moderate/high severity. On rare occasions when this might occur in previously untreated mixed-conifer stands, fire behavior and effects would be at the high end of the natural range of variability for mixed-conifer vegetation. Large patches of high or moderate/high severity may result and exceed sizes that would have occurred most often historically, because historically, forest structure was more of a mosaic of densities and areas of reduced fuel loads. Spatial complexity is less likely to be within or trend toward the natural range of variability from wildland fire-use fires that burn during 97th percentile weather conditions. Limited recent wildland fire-use fires in this vegetation show they are at the high end of the natural range of variability for a mixed severity regime in proportion of area burned at different severity levels.

It is assumed fires would be more difficult to suppress in untreated mixed-conifer areas during high or very high weather conditions due to high fuel levels and predicted fire behavior. Many untreated areas are predicted to have at least passive crown fire during high or very high (90th or 97th percentile) weather.

Effects Common to All Alternatives — Vegetation
Spruce-Fir — Vegetation, Composition, Structure, and Fuels

In the past, there have been no planned prescribed fires in the spruce-fir vegetation type. The Outlet Fire was a prescribed fire in ponderosa pine that escaped into spruce-fir. This escape occurred when winds increased dramatically, entering into 97th percentile weather conditions. Of this fire, 69% burned as moderate/high to high severity in the spruce-fir vegetation type (Table 4-8). Overall, severity has been higher in fires in spruce-fir than in mixed-conifer or ponderosa pine. This is in part due to fire ecology of this vegetation type. Spruce trees have thin bark and are not resistant to fire of most intensities. Both spruce and subalpine fir have branches that extend to the ground, making them more susceptible to burning at all fire intensities or flame lengths.

Prescribed and wildland fire-use fires under weather conditions less than very high (less than 97th percentile), would likely burn with a moderate/high spatial complexity (patchiness of different fire intensities), given the patchy nature of fuels. This is particularly the case on flatter landscape portions in spruce-fir vegetation, where soils are shallow and rocky and fuels discontinuous. On slopes, where more soil has accumulated, there are higher and more continuous fuel levels, particularly on more mesic north- or east-facing slopes. Fires on these slopes would likely burn in a more uniform spatial pattern. These slopes are also more likely to retain higher fuel moistures longer than other areas. In addition, severity patterns for prescribed burns would be expected to vary greatly depending on ignition pattern. Strip burning, as applied in ponderosa pine, would likely lead to more uniformly high severity effects. Spot ignitions, particularly on ridges as planned by fire staff, would likely lead to more of an effect mosaic.

Because there is limited monitoring data in spruce-fir (Table 4-8), a combination of existing monitoring data, knowledge of existing fuel conditions, and/or expected fire behavior were considered in determining representative fire severity level by fire category (Fites 2007). For suppression fires, severity levels from the Outlet Fire are most representative of fires that burn in 97th percentile weather conditions, which are most likely associated with larger suppression fires. Since there have been no prescribed fires in the spruce-fir type, severity levels were based on those projected for mixed-conifer. A higher level of unburned area was projected due to greater area with sparsely vegetated patches on plateau surfaces, and higher levels of high severity because spruce and fir fire ecology would result in higher tree mortality. Table 4-9 provides an average percent summary, by fire severity level, that would burn in each fire type. Similar to that described above for mixed-conifer, projected spruce-fir severity levels for prescribed fire would be different for Alternative 1 based on MSO habitat constraints. For Alternative 1, it is assumed prescribed fires would only be implemented if less than 15% moderate/high or high severity would result.

Table 4-8 One-Year Post-Fire Severity Data by Fire Category and Name in Spruce-Fir

	Proportion Burned by One-year Post-fire Severity Class					
Fire	Unburned	Low	Moderate /Low	Moderate /High	High	Area (acres)
Fire Use						
Bright	9%	15%	27%	47%	3%	126
Suppression						
Outlet	4%	10%	16%	38%	31%	5057
Poplar	62%	38%	0%	0%	0%	88

One-year post-fire severity from fire-use and suppression fires in the spruce-fir type. There have been no prescribed burns. Data were generated using standard remote sensing (LANDSAT) and extensive field plot data. Severity is based on the FIREMON Composite Burn Index, incorporating effects to all vegetation layers and soil. High and moderate/high categories have high (greater than 80%) overstory tree mortality.

Table 4-9 Projected Fire Severity by Fire Category in Spruce-Fir

	Fire Category		
Severity Level	Prescribed Fire	Fire Use	Suppression
Unburned	30%	30%	4%
Low	10%	10%	10%
Low/moderate	20%	20%	17%
Moderate/high	20%	20%	38%
High	20%	20%	31%

Fire-effects monitoring data are limited in the spruce-fir type because prescribed fires have not historically been planned in this vegetation type.

Based on existing monitoring data, reductions in downed woody fuels, litter, and duff depth were high following prescribed and suppression fires. Surface fuel levels dropped from 14 to 16 tons per acre to less than five tons per acre. This would result in a significant decrease in potential fire behavior (intensity and likelihood of crown fire). After five years, surface fuel levels increased to over ten tons per acre, presumably due to indirect effect of smaller trees killed by fire that subsequently fell.

Based on this limited data, small diameter (1-5.9-inch dbh) tree densities are reduced to 93% of pre-burn levels. Medium (5.9-15.8 inch dbh) and larger (greater than 15.8-inch dbh) tree densities did not change significantly and remain above desired condition levels. Conifer seedlings are much reduced from over 600 seedlings/acre pre-burn to less than 100 seedlings/acre after burning. Number of aspen seedlings, presumably sprouts, increases dramatically to over 850 stems/acre the second year after the burn.

Shrub densities declined dramatically (25,000 stems per acre to 2,000 stems per acre) in one plot in the spruce-fir vegetation type, but in plots in the Outlet Fire, stem densities steadily increased over time, reaching more than 4,000 stems per acre five years after the fire. This response on the Outlet Fire is due to a high number of fire-tolerant species, such as sprouters and heat-stimulated germinators (*Ceanothus*).

It is believed fire suppression would be difficult in spruce-fir given lack of access and safety zones and continued fuel accumulations in absence of treatment. Fire spread predictions were simulated through FARSITE (in Thompson Canyon, GRCA). Based on model runs (See Appendix F), under pre-monsoon high (90^{th} percentile) or very high (97^{th} percentile) weather conditions, fire would spread readily through most of the spruce-fir. Under high (90^{th} percentile) weather conditions, an estimated 46% of the spruce-fir type would burn as crown fire.

There is a high level of uncertainty in predicting amount of wildland fire-use or suppressed fire in spruce-fir. Although fuels are generally sufficient to carry fire readily during high or very high weather conditions, historical lightning ignitions in spruce-fir have been less dense than in mixed-conifer or ponderosa pine (Figure 4-3). Fire season is shorter in the spruce-fir vegetation type compared with other GRCA vegetation types, especially on northerly slopes where moisture is retained longer (Hiatt 2006) During mild (50^{th} percentile) and moderate (80^{th} percentile) weather conditions, fire spread would be limited in flatter areas and other sites with shallow, rocky soils, since fuels are discontinuous and patchy. Spread would be slower and fire size smaller but, as noted earlier, still difficult to suppress. In addition, given the dominant species' (spruce) thin bark and low crowns fire effects during any fire type would likely be more severe (more tree mortality). The greatest fire pattern difference under different weather scenarios would be spatial pattern.

Overall, fire effects under most weather conditions would result in a patchy or complex spatial pattern of fire behavior and severity resulting in a beneficial trend toward the natural range of variability. Under high (90^{th} percentile) or very high (97^{th} percentile) weather conditions, there is a moderate to high level of uncertainty whether fire patterns would be within, or trend toward, the natural range of variability. It is likely that historically some fires did burn under very high conditions in the spruce-fir type. The patchier nature of most fires and relatively longer fire-free intervals on at least more mesic slopes would lead to larger patches of high severity fire during very high weather conditions, similar to what researchers (Fulé et al. 2003a) surmised from park fire history and vegetation reconstructions. How large these patches were or how often they occurred is unknown.

Effects Common to All Alternatives **Vegetation**
Piñon-Juniper **Vegetation, Composition, Structure, and Fuels**

The piñon-juniper type is varied. In Chapter 3, three piñon-juniper subtypes were described including savanna, woodland, and forest. Tree density, understory vegetation type, and amount range from: open, with a well developed understory (savanna); to denser, with varied understory (woodland and forest).

Information on location, amount, and condition of the three piñon-juniper subtypes is limited, restricting analysis by subtype.

Historically, little prescribed burning occurred in GRCA piñon-juniper vegetation. Prescribed burning that has occurred has been primarily low severity (Table 4-10). Wildland fire-use and suppression fires have generally only touched on smaller portions of the piñon-juniper vegetation type. The Powell fire-use fire affected the most piñon-juniper (834 acres) and burned in a predominately low/moderate severity pattern with 17% of area unburned. For portions of other fire-use fires that entered smaller portions of piñon-juniper, there is a mixed pattern of fire severity, with similar representation in low, moderate/low, and moderate/high severity fire classes. Suppression fires, particularly the Outlet, had the greatest proportion of high severity. The Outlet Fire burned during high wind conditions, conditions typically required for piñon-juniper to burn at high severity.

For prescribed fires, average of severity levels was used from monitoring data. Because only a small amount of wildland fire-use fire is proposed in any alternative for this vegetation type, no projections were made for fire severity. Outlet Fire data were believed representative for suppressed fires; therefore, severity levels from this fire were used in projecting suppressed fires. Table 4-11 is a summary of average percentage, by fire severity level, expected to burn in each fire type.

Table 4-10 One Year Post-Fire Severity Data by Fire Type and Fire Name in Piñon-Juniper

	Proportion Burned by One-year Post-fire Severity Class					
Fire	Unburned	Low	Moderate /Low	Moderate /High	High	Area (acres)
Fire Use						
Powell	17%	53%	23%	7%	0%	834
Rose	17%	36%	27%	20%	1%	67
Swamp	1%	34%	40%	23%	1%	143
Tower	11%	60%	20%	9%	0%	34
Suppression						
Long Jim	7%	32%	35%	19%	6%	97
Outlet	4%	15%	34%	46%	2%	236
Prescribed Burn						
Outlet prescribed fire	32%	52%	17%	0%	0%	820
Walhalla prescribed fire	66%	32%	2%	0%	0%	32
Long Jim prescribed fire	49%	2%	7%	39%	3%	723

One-year post-fire severity from fire use, prescribed burn, and suppression fires in piñon-juniper. Data were generated using standard remote sensing (LANDSAT) and extensive field plot data. Severity is based on the FIREMON Composite Burn Index, incorporating effects to all vegetation layers and soil. High and moderate/high categories have high (greater than 80%) overstory tree mortality.

Table 4-11 Projected Fire Severity by Fire Type in Piñon-Juniper

	Fire Type		
Severity level	Prescribed fire	Fire use	Suppression
Unburned	36%	limited treatment proposed	4%
Low	47%	limited treatment proposed	14%
Low/moderate	10%	limited treatment proposed	34%
Moderate/high	4%	limited treatment proposed	46%
High	3%	limited treatment proposed	2%

GRCA monitoring data on vegetation and fuels changes are limited to one site in the piñon-juniper woodland subtype. Monitoring data indicates there are limited effects of prescribed fire on piñon-juniper vegetation composition and structure except for surface fuels. This has also been observed in piñon-juniper areas outside GRCA. With typically sparse understory vegetation and surface fuels, it is difficult to carry fire across piñon-juniper vegetation without high winds.

Based on data, litter and duff are reduced to 63% of pre-fire levels. Surface fuels are reduced to 67% of pre-fire levels immediately post-fire, but increase to 80% or more of pre-fire levels at years two and five. Only one plot out of 13 had a second fire, and showed substantially lower surface fuel levels (13% of pre-fire tons per acre).

Monitoring data shows no change in tree density from prescribed burning, as implemented to date. Tree seedlings showed little change after years one and five. Shrub stem densities initially decreased to approximately 74% of pre-fire densities; increased to approximately 120% at year two; and decreased to approximately 60% at year five. As noted earlier, only one plot had been burned twice, and it is not clear if it is representative, but data from this plot are similar to data taken five years after the first burn.

Substantial decreases in snakeweed and rubber rabbitbrush stem densities occurred immediately after years one and five post-fire. For unknown reasons, density increases at two years post-fire, but apparently these stems do not survive at five years. Data may not be representative of normal conditions, but for the one plot with a second burn, there is a slightly higher density level of these species than pre-treatment.

Because there are few fire history studies, a moderate to high level of uncertainty exists on historic fire regimes in the piñon-juniper type. Therefore, there is a high level of uncertainty on effects of alternatives on piñon-juniper. In piñon-juniper areas where vegetation mapping indicates presence of understory grasses, shrubs, or intermixed ponderosa pine, it is likely fire was more prevalent historically due to presence of surface fuels (see piñon-juniper savanna and woodland in Chapter 3.1.15). Departure from historic fire regime is likely low to moderate/low in piñon-juniper sites, with only 31% thought to be moderate/high departure from fire suppression. Without treatment, it is assumed these areas would continue to trend toward increased departure from historic fire regime. Effects of alternatives in non-treatment areas would trend away from natural range of variability, but how much is uncertain, given uncertainty about historic fire regimes.

Effects of prescribed fire in the piñon-juniper type have been limited to date based on monitoring results described above. Data show a decrease in surface fuels but not tree density. Though fire regime is poorly understood, this could indicate a trend toward the natural range of variability and desired conditions for surface fuels in the WUI where treatments have occurred and are being proposed in the action alternatives. Tree density shows limited to no change with prescribed fire to date. Manual and/or mechanical treatments are expected to be more effective in reducing tree density in piñon-juniper. It is unknown which areas in the piñon-juniper type have increased in tree density or how much from historic patterns. It is assumed tree density decreases would result in a trend toward the natural range of variability, but since fire regime is poorly understood, there is a moderate to high level of uncertainty.

For all alternatives, there are limited proposed prescribed fire treatments in this vegetation, but primary actions planned in the piñon-juniper type are monitoring, research, and adaptive management, which might include limited but negligible wildland fire use to improve understanding of ecological processes and functions. These actions would have indirect, beneficial, long-term, and regional effects on piñon-juniper by reducing uncertainty regarding historic fire regimes, vegetation structure, and composition.

Effects Common to All Alternatives **Vegetation**
Montane-Subalpine Grassland **Vegetation, Composition, Structure, and Fuels**

There are no proposed prescribed fire treatments in montane-subalpine grasslands (meadows) for any alternative. It is unlikely this type would burn very often during wildland fire-use fires based on past fire observations. However, as stated in Chapter 3.1.1.6, there likely was a fire effect on the grassland-forest boundary. From the alternatives, prescribed fire and wildland fire-use fires would occur around grasslands; therefore, fires that burn from surrounding areas into grasslands could affect vegetation.

Little is known about historic fire regime in grassland vegetation; therefore, there is high uncertainty on effects of alternatives on departure from historic fire regime. Observations in grassland-forest boundary areas burned during prescribed or wildland fire-use fire indicate there can be tree mortality in the boundary. This could result in grasslands expansion. There have also been areas where, after more intense fires, aspen sprouts surfaced farther into grasslands than existed prior to fire. Since fire occurred historically in adjacent forest vegetation types, it is assumed effects of prescribed or wildland fire-use fires in adjacent forest types would have a beneficial, moderate, local, long-term effect on fire regimes and vegetation composition and structure in grasslands, concentrated in the grassland-forest boundary.

Effects Common to All Alternatives **Vegetation**
Below the Rim **Vegetation, Composition, Structure, and Fuels**

Below the Rim is not an vegetation type, but is included as a separate entity for this analysis because this location has different fire patterns (than above the rim) important to wildlife and archeological resources.

No treatments are proposed Below the Rim in any alternative; but lightning and rolling material from rim fires occasionally ignite fires Below the Rim. As shown in Figure 4-3, lightning ignition densities are low Below the Rim. In addition, most ignitions result in limited fire spread due to very sparse or patchy and discontinuous fuels. Below North Rim some extensive Gambel oak patches intersperse with individual or small conifer patches such as ponderosa pine. These areas can sustain fire spread over larger areas, especially on drier south- or west-facing aspects. Fire extent would still be relatively limited due to limited fuel. Fires would be difficult to suppress in these locations due to difficulty fighting fire Below the Rim.

In areas that burn Below the Rim, fire severity would likely be mixed, as is thought to have occurred historically. Mixed severity patterns Below the Rim are projected because of patchy and variable vegetation and fuel conditions that occur(ed) currently and historically. Much of the area Below the Rim, where fires have and are likely to occur, are in piñon-juniper vegetation. There are also pockets of mixed-conifer and larger patches of scattered ponderosa pine over dense layers of Gambel oak. Fires tend to burn more intensely and result in greater severity on steep slopes. Most areas Below the Rim are steep; however, given fuel discontinuity, a patchy pattern of widely varying severities, including unburned areas, is most likely. Most areas Below the Rim where vegetation does occur have lower productivity and, as a result, fuel accumulations are more limited. This limited fuel accumulation, in addition to steep slopes, means that even though fires may be higher intensity due to steep slopes, fire spread is likely to be rapid with little concentration of heat for long periods. These fire behavior characteristics would cause relatively low severity effects to soils and surface and overstory vegetation, but moderate/high severity effects to understory and midstory vegetation. Gambel oak and New Mexico locust are two prevalent species, and both resprout vigorously after fires. Overall, fire effects Below the Rim would result in a trend toward the natural range of variability and be beneficial, moderate, and local.

Effects Common to All Alternatives **Vegetation**
South Rim **Vegetation, Composition, Structure, and Fuels**

Inventory data is lacking to assess specific potential WUI fire behavior and effects. It is assumed that proposed manual, mechanical, and/or prescribed fire treatments from the alternatives would result in reduced fire behavior that would minimize WUI fire ignition and spread. It is assumed that treatments would result in flame lengths less than four feet, conditions that limit spotting potential into or from the WUI, and very low to no ignition potential. It is assumed that within at least a 30-foot area around structures, the amount of shrub decadence and surface fuels would be limited. It is assumed that tree canopy base height would be mostly greater than 12 feet and that shrubs and trees would be widely spaced, limiting fire's ability to spread from crown to crown (active crown fire).

4.2.1.11 Alternative 1 No Action Vegetation

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same suppression level of approximately 20,050 acres; 58,500 acres treated through prescribed fire (primarily in ponderosa pine and mixed-conifer FMUs); 55,000 acres treated through wildland fire use; and 400 acres manually treated (primarily in piñon-juniper habitat). Manual treatment description includes chainsaws use with cut vegetation chipped, piled, or otherwise disposed of on or offsite. For a full description of Alternative 1 see Chapter 2.

Direct and Indirect Effects Alternative 1 Vegetation
Treatment Types and Amounts/Fire Ponderosa Pine

A large portion of the ponderosa pine vegetation type is proposed for treatment with prescribed burning in Alternative 1 (41%). There is a high probability that during the planning period, most if not all (70 to 100%) of the ponderosa pine vegetation type would receive treatment given the acreage proposed for treatment through prescribed fire and wildland fire use (based on data since 1980, it is assumed 53% of wildland fire-use fire acres would be in the ponderosa pine vegetation type). In the current condition, the majority of this vegetation type (80%) would generally meet conditions suitable for wildland fire-use fires (predominately surface fire) under constraints imposed by MSO habitat mitigation measures. It is assumed, at most 13% of suppression fire acres would be in ponderosa pine vegetation type. This amounts to approximately 2,600 acres or 4% of this vegetation type. The amount is based on historical averages in the past 25 years. Suppression fires in this type would be readily contained in most locations and conditions due to the high level of past and planned treatments.

Fire Behavior Alternative 1 Vegetation
Ponderosa Pine

Table 4-12 is a summary of predicted fire behavior in the ponderosa pine vegetation type in proposed prescribed fire treatment areas, determined through FlamMap, based on several weather conditions. To meet mitigation measures requiring low fire intensities for prescribed fire, weather conditions would generally have to be no greater than 90th percentile. Under 90th weather percentile conditions, 96% of fire would burn as surface fire, and 4% would be passive crown fire (individual tree torching), and no active crown fire (fire spreading from crown to crown). Other conditions are used by GRCA to determine success in meeting the low intensity mitigation measure requirement, such as observed fire behavior during test burns and burn implantation.

Table 4-12 Predicted Fire Behavior in Prescribed Fire Treatment Areas in Ponderosa Pine during Various Weather Conditions

	Weather Percentile			
Fire Type	50th	80th	90th	97th
Active Crown	0%	0%	0%	14%
Passive Crown	1%	1%	4%	12%
Surface Fire	99%	99%	96%	74%

Specific fire behavior during wildland fire-use fires is not feasible to predict because it is unknown where or during which weather condition such fires will burn. Wildland fire-use fires would burn during a variety of weather conditions, potentially including all weather percentiles. Under all but the 97^{th} weather percentile, nearly all (greater than 95%) of the ponderosa pine type is predicted to burn as surface fire. Suppression fires, and a small but unknown percentage of wildland fire-use fires, would more likely burn at 97^{th} percentile weather. Fire behavior under this weather for fire-use fire and suppression fires is predicted to be 20% crown fire.

Fire Severity **Alternative 1** **Vegetation**
Ponderosa Pine

Table 4-5 summarizes predicted direct effects to fire severity by fire category in ponderosa pine vegetation. Because of past treatments in this vegetation type, the majority of fire severity levels would be low to low/moderate (73% for suppressed fires, 74% for prescribed fires, 84% for wildland fire-use fires) and a much smaller percentage would be high to moderate/high fire severity levels (13% for suppressed fires, 10% for prescribed fires, 8% for wildland fire-use fires).

Predicted Fire Regime and Fire Behavior after Planning Period **Alternative 1** **Ponderosa Pine** **Vegetation**

Figure 4-4 displays that direct effect to departure from historic fire regime (after the planning period) would trend toward the natural range of variability with at least 78% reaching a low level and an additional 12% reaching low/moderate levels. The 78% was estimated based on the assumption that 57% of wildland fire-use acres would occur in ponderosa pine (average since 1980). Based on historical data, probability of lightening strikes in ponderosa vegetation is high (Figure 4-3). Given 76% of the ponderosa vegetation type is currently low or low/moderate departure from historic fire conditions, wildland suppression fires in the ponderosa pine type would facilitate wildland fire-use application (low likelihood of crown fire and mitigation-measure compliance requiring low intensity fire for wildland fire-use fires). 57% of wildland fire-use acres expected to occur in ponderosa pine could be a conservative estimate.

The direct effect from this alternative to predicted fire behavior would be primarily low to low/moderate (94%) fire intensity surface fire, with less than 6% crown fire (Figure 4-5) after proposed prescribed fire and manual treatments, and projected wildland fire-use fires (after the planning period). Based on monitoring data discussed earlier, and predicted changes in fire behavior, direct and indirect effects from all fire categories (prescribed, suppression, and wildland fire-use fires) would result in continued trends toward natural range of variability in fire behavior in ponderosa pine vegetation.

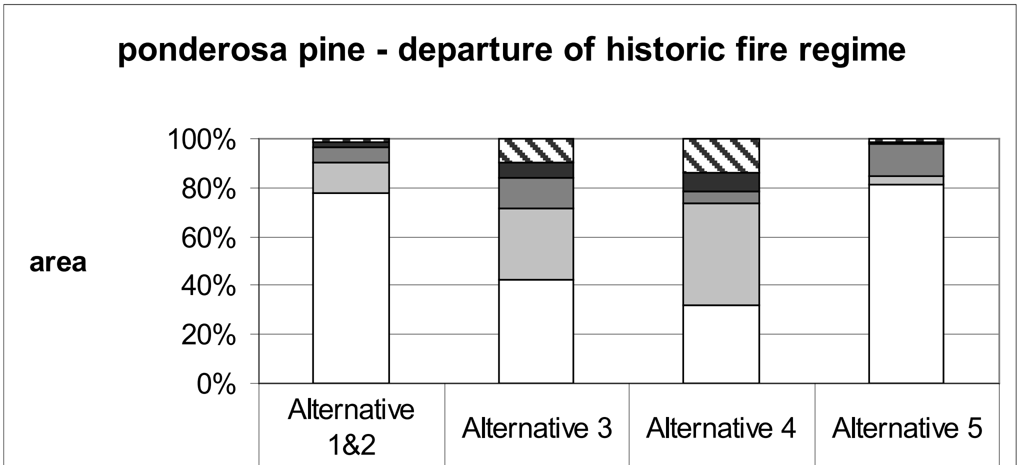
In addition, areas burned under wildland fire use would display beneficial direct impacts to fire regime's spatial complexity element, with spatial complexity at or trending toward natural range of variability.

Implementing this alternative would have direct beneficial, major, short-term, regional impacts to departure from historic fire regime.

Vegetation Composition and Structure after Planning Period **Alternative 1** **Ponderosa Pine** **Vegetation**

Impacts to vegetation composition and structure would be similar to those described for fire regime: beneficial, major, regional. Although monitoring across all post fire severity conditions show there are still sites that do not meet desired conditions for medium and understory tree density in this vegetation type, there are density reductions that are evident, particularly after a second treatment. Since the majority of the ponderosa pine landscape has been treated in the last 25 years, many treatments in Alternative 1 would be the second or third treatment event. There are evident reductions in ponderosa and two-needle piñon seedlings from prescribed fire treatments in South Rim ponderosa pine sites. This would lead to future trends of decreased stand density, since there is less recruitment. Where white fir has expanded into ponderosa pine on North Rim, monitoring indicates that one fire entry substantially reduces white fir seedling density, but fir seedling density can subsequently increase to even higher levels than pre-fire treatment. A second fire treatment reduces or removes all white fir seedlings and only ponderosa pine seedlings survive. The effect on tree seedling composition away from white fir would have a direct, long-term, beneficial impact on tree species composition. As noted earlier, a high proportion of ponderosa pine would be getting a second or third treatment (either prescribed or wildland fire-use fire), which would be a trend toward the natural range of variability in tree density and composition.

Figure 4-4 Predicted Historic Fire Regime Departure for Ponderosa Pine for All Alternatives after the Planning Period*



	Alternative 1&2	Alternative 3	Alternative 4	Alternative 5
high	2%	10%	14%	1%
mod_high	2%	6%	8%	1%
mod	6%	13%	5%	13%
low_mod	12%	29%	42%	4%
low	78%	42%	32%	81%

*Predicted historic fire regime departure for ponderosa pine, including proposed prescribed fire and estimated wildland fire use. Predictions do not include potential effects of suppression fires. Wildland fire use is assumed to be equally distributed in the ponderosa pine type. The proportion of fire-use acres applied to ponderosa pine out of the total proposed was based on the average since 1980 (57%).

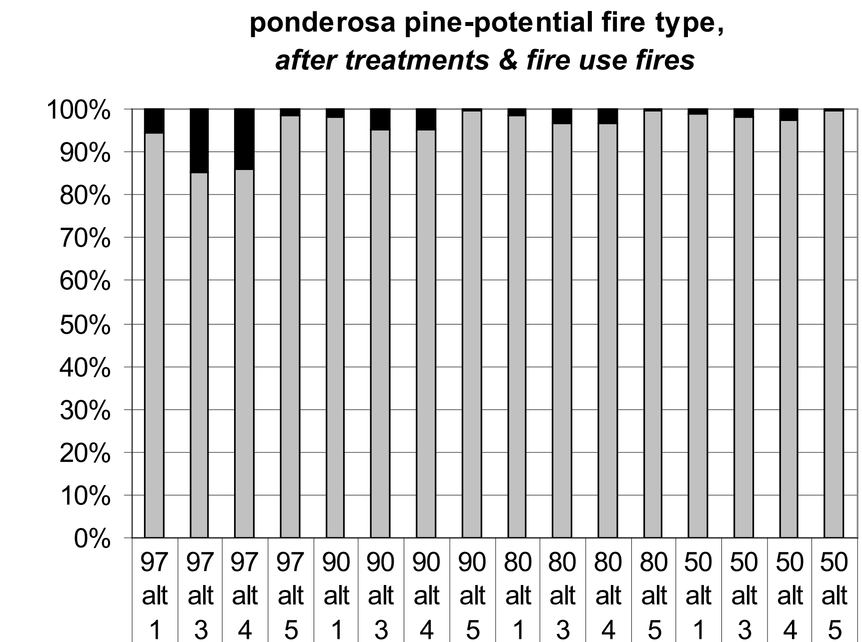
Historic patterns of understory vegetation are not easy to reconstruct; therefore, trends toward the natural range of variability are uncertain. Monitoring data shows status quo or increases in shrub-stem densities of species with a medium or high fire tolerance. Monitoring data on herbaceous, grass, or grass-like understory is limited to species presence and absence. It is assumed there would be a trend toward the natural range of variability in understory vegetation structure and composition when fire regime trends toward the natural range of variability. The exception would be with any invasions or increases in exotic plants or invasive species. See 4.2.3 for more detail on potential impacts from invasive exotic plants.

Based on monitoring data discussed earlier and predicted changes in fire behavior and understory fuels, direct and indirect effects from all fire categories (prescribed, suppression, and wildland fire-use) would result in continued trends toward natural range of variability in surface fuel, understory vegetation, and understory and midstory tree densities in the ponderosa pine vegetation type. Overall, effects to vegetation composition and structure would be beneficial, major, long term, and regional.

Insects/Pathogens/Drought **Alternative 1** **Vegetation**
Ponderosa Pine

As noted earlier, potential impacts would be a beneficial trend toward the natural range of variability in vegetation composition and structure and fire regime. Treatments that would reduce seedling and small tree densities would increase overall stand drought tolerance and indirectly result in a trend toward insect/pathogen levels within the natural range of variability. It is uncertain whether the magnitude of this indirect effect would be moderate or major, since the majority, if not all, of the vegetation type would receive treatment. Prescribed fires result in some mortality and reduction in tree density that would increase resilience to drought, insects, and pathogens, but amount would vary with fire intensity. Most prescribed fires are low/moderate intensity and have a moderate beneficial, short-term impact on tree density and resilience to drought, insects, and pathogens. A longer-term beneficial trend toward desired tree densities and increased resilience would result from seedling mortality, reducing future tree densities. Wildland fire-use fires that burn under conditions of more variable fire intensities would result in greater tree density reductions. Wildland fire-use fires have potential to have major, beneficial, indirect effects.

Figure 4-5 Predicted Fire Behavior (by Fire Type: Surface or Crown Fire) after Implementation of Prescribed Fire and Wildland Fire-use Fires, Based on FlamMap Projections*



	97 alt 1	97 alt 3	97 alt 4	97 alt 5	90 alt 1	90 alt 3	90 alt 4	90 alt 5	80 alt 1	80 alt 3	80 alt 4	80 alt 5	50 alt 1	50 alt 3	50 alt 4	50 alt 5
■ crown	6%	15	14	2%	2%	5%	5%	0%	2%	3%	3%	0%	1%	2%	3%	0%
□ surface	94	85	86	98	98	95	95	10	98	97	97	10	99	98	97	10

*The y-axis is percent of area. Projections for Alternative 2 are nearly identical to those for Alternative 1 and therefore are not shown separately. Projected wildland fire-use fires were based on applying 57% of the total projected amount, which is the average proportion of wildland fire-use fire that has occurred in the ponderosa pine type.

Areas that burn under lower fire intensities in prescribed or wildland fire-use fire would have a moderate, beneficial, indirect effect (fewer tree and seedling mortality). There may be a short-term, minor, adverse, indirect effect in untreated areas and areas burned at low intensity because medium-sized tree density would remain higher than desired conditions and natural range of variability (causing water stress to trees). Under these conditions, this may indirectly lead to levels of drought resilience and insect /pathogen levels outside the natural range of variability. Overall, the relatively high level of wildland fire-use fire should result in a higher likelihood of mixed fire intensity that would likely reduce medium tree density and increase the trend toward natural range of variability in insect/pathogen levels and drought resilience. These effects, in combination with reductions in seedling and small-tree density, would be long term. Therefore, overall indirect impacts would be beneficial, moderate, long term, and regional.

Mixed-Conifer Alternative 1 Vegetation
Treatment Types and Amounts

Currently, 42% of the mixed-conifer type is in a high level of departure from historic fire regimes. More than half (57%) of the mixed-conifer type is proposed for treatment with prescribed fire in Alternative 1. Of that, almost all areas currently in a high level of departure are planned for treatment with prescribed fire. In addition, 20% of wildland fire-use acres are estimated to occur in the mixed-conifer vegetation type (based on averages from data since 1980). These additional treatment acres could also be in the area of high level of departure from historic fire regimes. However, there is uncertainty as to how much of the proposed prescribed burns and wildland fire-use fire would be implemented in mixed-conifer given mitigation constraints developed as part of the Alternative description for MSO habitat. Although 20% of wildland fire-use acres have historically occurred in the mixed-conifer type, for Alternative 1 it is more reasonable to assume that, at most, 5% of wildland fire-use acres would be applied in mixed-conifer (7% of the mixed-conifer vegetation type) because of fire behavior predictions indicating that under many weather conditions more than 15% of the area would burn as crown fires. Further, it is uncertain if all proposed prescribed fire treatments would be implemented due to these constraints. For this analysis, it is assumed planned prescribed fire treatments could be implemented using careful application of test burns and ignition patterns, but there is uncertainty whether there would be sufficient weather conditions to implement all proposed acres.

After the life of the plan, due to the high area proportion proposed for treatment in the mixed-conifer type, it is anticipated there would be smaller-sized suppression fires. Until full implementation of this alternative is completed, suppression fires would be expected to increase in size due to expected difficulty in suppression success. This vegetation type is the most productive and experiences greatest rates of fuel accumulations. Based on GRCA suppression fire history over the past 25 years, it is assumed 34% of suppression fire acres will be in mixed-conifer for this analysis. This amounts to approximately 6,800 acres or 18% of this vegetation.

Fire Behavior Alternative 1 Vegetation
Mixed-Conifer

Table 4-13 summarizes predicted fire behavior, determined through FlamMap, based on several weather conditions for prescribed-fire treatment units. To comply with the mitigation measure requiring low intensity fires for prescribed fire, weather conditions would typically have to be no greater than 50th percentile, or ignitions would need to be applied in patterns to minimize increased fire intensity. Assuming 50th weather percentile conditions, fire predictions (assuming head fires) show 72% of the fire would burn as surface fire and 28% would be passive crown fire (individual tree torching) and no active crown fire (fire spreading from crown to crown).

However, these predictions assume higher intensity head fire while prescribed fires are applied as lower intensity backing or patchy fires with objectives of less than 15% of the area burnt as high severity fire. In mixed-conifer, high severity fire generally results from crown fire. Therefore, the projected area burned as higher intensity crown fires is expected to be less than 15%.

For wildland fire-use (Table F-5, Figure F-1), fires would burn under more variable weather conditions, primarily at the 90th weather percentile or less. Based on the current potential fire behavior, 60% of the mixed-conifer type would burn as surface fire during 90th percentile weather conditions, 62% at the 80th weather percentile, and 76% during half or more of the fire season (50th percentile). Crown fire would vary from 24% at the 50th percentile weather to 40% at the 90th percentile weather. These projections for the 50th weather percentile are at the high end for those conditions; if areas burned under 40th percentile weather conditions or less, less crown fire would be expected. It is uncertain which weather conditions would occur during wildland fire-use fires. It would depend on weather at ignition and during the fire's course. Given MSO habitat mitigation constraints, it is assumed very few wildland fire-use fires, if any, would be implemented in mixed-conifer prior to application of planned prescribed fires in the planning period.

Table 4-13 Predicted Fire Behavior from Prescribed Fire Treatments in Mixed-Conifer Based on Various Weather Conditions*

	Weather Percentile			
Fire Type	50th	80th	90th	97th
Active Crown	0%	0%	0%	27%
Passive Crown	28%	42%	45%	28%
Surface Fire	72%	58%	55%	44%

*Data does not incorporate mitigation measures developed to address MSO habitat. It is assumed when mitigations are incorporated, amount of crown fire at the 50th weather percentile would decrease to 15% or less, or burns would not be implemented

Predicted fire behavior from prescribed and wildland fire-use fires would be within the historic range of variability under most weather conditions (90th weather percentile or less). However, if prescribed and wildland fire-use fires occur in current MSO habitat mitigation constraints, with restricted high severity patches (15% or less), then overall severity distribution of these fires would be outside the natural range of variability. Historically, this vegetation type had a mixed severity fire regime which included a variable and often higher proportion (cumulatively) of high severity fire than 15%. Given MSO habitat mitigation constraints, it is assumed GRCA would avoid wildland fire-use fires in this type that might include anything greater than 30th weather percentile conditions. Predicted suppression fires in this vegetation type would most likely burn under 50th or greater weather percentile conditions. Depending on extent of area burned under 50th or greater weather percentile conditions, impacts could be beneficial or adverse. Suppression fires that burn as crown fires could cover large areas. Larger areas would result in a moderate to major adverse impact with a trend away from the natural range of variability. Impacts would be long term but most likely local since it is unlikely that all the mixed-conifer area susceptible to crown fire would burn as crown fire during 97th weather percentile conditions. Based on weather data in this vegetation type there are only three days on average per year in these weather conditions (Table 4-13).

Fire Severity Alternative 1 Vegetation Mixed-Conifer

Table 4-7 projects fire severity by fire category in mixed-conifer vegetation for each alternative. However, these data are based on averages of historical data, and for analysis purposes it is assumed that MSO mitigation measures will be met. Past evaluation of MSO mitigation measures has been across all fires in a year and not based on multi-year averages by specific fire type. Therefore, although multi-year averages for each specific fire type exceed MSO mitigation measures, in reality, when averaged annually across all fires, mitigation measures have been met. For this analysis, levels of high severity fire are presumed lower than those shown in Table 4-7 presuming MSO mitigation measures can be met.

In summary, fire severity levels in mixed-conifer would be higher than expected in ponderosa pine vegetation. Fire severity varied depending on fire category. Presuming MSO habitat mitigation measures are met, unburned, low and low/moderate would be 85% in prescribed fire or wildland fire-use fire, and 58% in suppression fire; high to moderate/high would be 15% in prescribed fire and wildland fire-use fires; and 42% in suppression fire. There is some uncertainty whether moderate/high and high severity effects could be limited to 15% in mixed-conifer during prescribed fires. This is because greater fuel accumulations occur in this type than in any other in GRCA (Fulé et al. 2004). These severity projections for wildland fire-use fires and prescribed fires would be at the low end and primarily outside the natural range of variability for this type.

Historically, the mixed-conifer type burned as mixed severity, which generally includes more than 15% high severity cumulatively over time and across a landscape. There would be some beneficial impact from any fire in this type in moving toward a reduced likelihood of uniformly high severity fire. But overall, the impact would be adverse, moderate, short term, and regional. Some portion of suppression fires are within the natural range of variability for the historic regime of mixed severity for this type. These fires would result in a beneficial, moderate, local, short-term impact. There is possibility for an adverse, moderate to major, local impact from suppression fires that burn at 97th weather percentile conditions. The amount of high severity fire could be greater during these conditions and may exceed the natural range of variability in extent given the more uniformly higher density vegetation in the mixed-conifer type compared to historic conditions. There is some evidence that extensive high severity fire may have occurred in some of the mixed-conifer type historically, but frequency and extent of these types of fire events are unknown (Fulé et al. 2003a). For prescribed fires, if MSO habitat mitigation measures are met, severity levels would be at least partially outside natural range of variability, at least in the short term. Historically, mixed-conifer is thought to have had a mixed severity pattern, which means that over the long term, typically 20% or more of the area would burn at high severity. If mitigation measures are not met, and there is more than 15% high fire severity in prescribed fires, then prescribed fires would be within the natural range of variability.

Predicted Fire Regime and Fire Behavior after Planning Period **Alternative 1 Mixed-Conifer** **Vegetation**

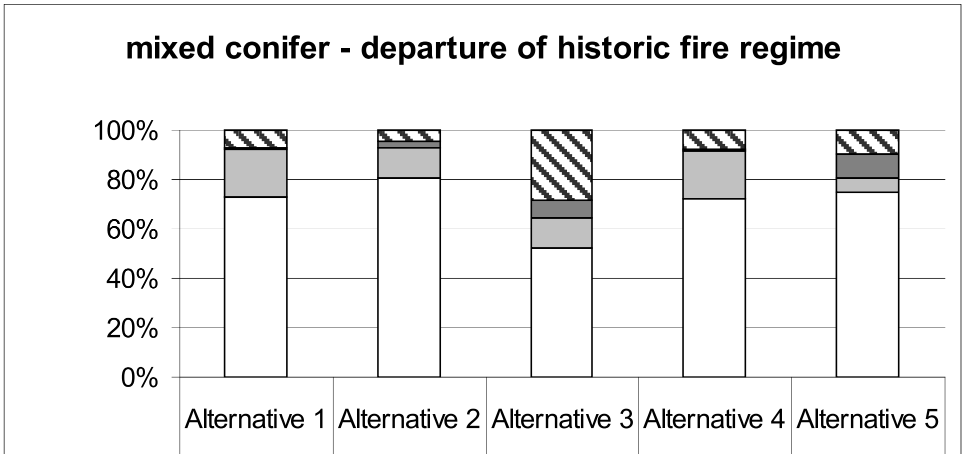
After implementation of the proposed plan with prescribed and estimated wildland fire-use fire, 73% of the mixed-conifer type would be in low-departure level; an additional 19% would be at a low/moderate departure level from historic fire regime (Figure 4-6). Generally, effects from past wildland fire-use fires in mixed-conifer have fallen within the natural range of variability for fire severity, with a mixed pattern of low, moderate, and high severity. Some past wildland fire-use fires have burned partially during 97th weather percentile conditions and have had a level of moderate/high or high severity near the upper limits of the natural range of variability. Likelihood of a higher proportion of high severity effects from future wildland fire-use fire would be reduced after Alternative 1 implementation. However, if MSO habitat mitigation measures are followed, then wildland fire-use fires would be very limited or absent, and at lower limits or more likely outside the natural range of variability because high severity fire patches would be limited to 15% of the area or less. Virtually all the area currently at a high level of departure from historic fire regime, with associated higher fuel loads and potential for crown fire, would be treated with prescribed fire. Fuel loads would be reduced, and potential for crown fire reduced, after prescribed fire.

Before fire treatment activities proposed with this alternative, 47% of mixed-conifer treated would be crown fire under very high (97th percentile) weather conditions. After prescribed fire and manual treatments, and projected wildland fire-use fires (planning period), proportion of crown fire under these weather conditions is predicted to decrease to 33% (Figure 4-7). Wildland fire-use fire would result in decreased surface fuels and increased canopy base height, reducing potential for future crown fire. In areas burned under wildland fire-use fires there would be a beneficial trend toward the natural range of variability in the spatial complexity aspect of fire regimes. But given MSO habitat mitigation constraints, it is unlikely these beneficial impacts would be realized, or they would be very local.

New prescribed fire prescriptions developed for mixed-conifer would result in more variable spatial patterns (limited ignitions on ridges versus uniform strips across unit). Therefore, there may be a beneficial impact of prescribed fire on fire regime spatial complexity. Feasibility of this prescription for varied locations in mixed-conifer and resulting level of fuels reduction and severity are unknown. Effect of prescribed fire on spatial complexity would likely be beneficial but minor and local. It is uncertain whether the full amount of proposed prescribed fire would be implemented due to MSO habitat mitigation measures which narrow the burning window.

After the planning period, likelihood of acres burned as wildland suppression fires in mixed-conifer is lower in Alternative 1 due to extensive areas planned for prescribed fire. Areas treated with prescribed fire would reduce fuel loads and crown fire potential. However, access is limited in much of the mixed-conifer type and it is possible that suppression or wildland fire-use fires under weather conditions that lead to intense fire behavior would be difficult to contain. Overall, prescribed fire would result in lower levels of suppression fire acres.

Figure 4-6 Predicted Fire Regime Departure for Mixed-Conifer for all Alternatives after the Planning Period*



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
high	7%	5%	29%	8%	10%
mod_high	0%	0%	0%	0%	0%
mod	1%	2%	7%	0%	10%
low_mod	19%	13%	12%	20%	6%
low	73%	80%	53%	72%	75%

*Predicted historic fire regime departure for mixed-conifer including proposed prescribed and estimated wildland fire-use fire. Predictions do not include potential effects of suppression fires. Wildland fire use was assumed to be equally distributed in the mixed-conifer type. Proportion of fire-use acres applied to mixed-conifer out of the total proposed was based on the average since 1980 (20%), except for Alternative1 where, due to MSO habitat mitigation measures, it was reduced to 5%.

There would be a potential moderate, adverse effect from suppression fires.

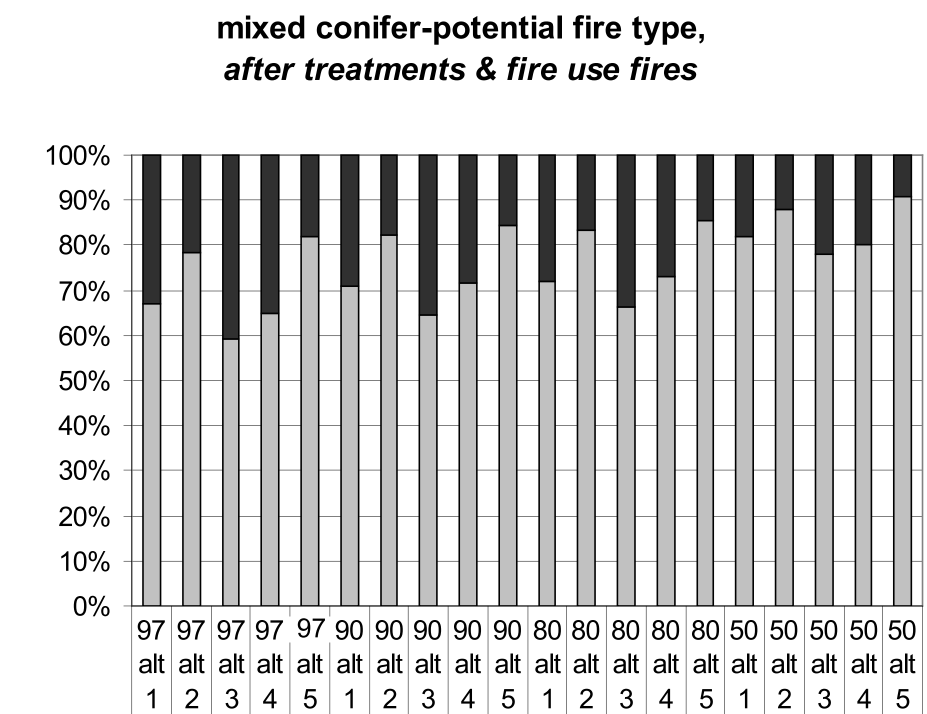
Overall, after Alternative 1 implementation, there would be a beneficial, moderate, short-term, regional impact to fire regimes. This impact would primarily be from prescribed fires, since it is assumed that few if any acres of wildland fire use would be implemented.

Vegetation Composition and Structure after Planning Period | **Alternative 1 Mixed-Conifer** | **Vegetation**

Overall effect would be a beneficial, regional impact since more than 57% of mixed-conifer would be treated, and the trend shown in fire-effects monitoring data and impacts to fire regimes analysis is movement toward the natural range of variability and desired conditions. This effect would be moderate and short term since tree densities and surface fuels would be reduced (based on monitoring data), but limited due to MSO habitat mitigation constraints, limiting fire intensity and tree mortality.

Anticipated effects to understory would be similar to those for ponderosa pine. Although limited information exists on historic understory vegetation structure and composition, it is assumed that a trend toward lower overstory tree densities and fire restoration would lead to a beneficial change in vegetation understory. Monitoring data shows that native shrubs respond positively to fire. Research by Huisinga et al. (2005), on understory flora after an intense prescribed fire, showed twice as much plant cover and greater species richness than unburned sites. Less than 1% cover of invasive exotic plant species occurred. These beneficial impacts would be limited due to MSO habitat mitigation constraints, which limit prescribed and fire-use fires to low intensity.

Figure 4-7 Predicted Fire Behavior (by Fire Type: Surface, or Crown Fire) after Implementation of Prescribed and Wildland Fire-Use Fires, Based on FLAMMAP Projections*



	97 alt 1	97 alt 2	97 alt 3	97 alt 4	97 alt 5	90 alt 1	90 alt 2	90 alt 3	90 alt 4	90 alt 5	80 alt 1	80 alt 2	80 alt 3	80 alt 4	80 alt 5	50 alt 1	50 alt 2	50 alt 3	50 alt 4	50 alt 5
crown	33	22	41	35	18	29	18	35	29	16	28	17	34	27	15	18	12	22	20	9
surface	67	78	59	65	82	71	82	65	71	84	72	83	66	73	85	82	88	78	80	91

*The y-axis is percent of area. Projections for Alternative 2 are nearly identical to those for Alternative 1 and therefore not shown separately. Projected wildland fire-use fires were based on applying 20% of the total projected amount, the average proportion of wildland fire-use fire that has occurred in the ponderosa pine type.

Insects/Pathogens/Drought Mixed-Conifer **Alternative 1** **Vegetation**

Similar to ponderosa pine, there is expected to be a moderate, long-term, regional, beneficial impact to level of insects, pathogens, and drought response. Lower stem densities and increased spatial complexity would result in greater mixed-conifer forest resilience.

Spruce-Fir Treatment Types and Fire Amount **Alternative 1** **Vegetation**

Only one treatment is proposed in the spruce-fir type, in a narrow strip along the northern park boundary, encompassing 19% of the spruce-fir vegetation type. The proposed treatment includes manual and prescribed fire treatments. Wildland fire-use fires could occur in this vegetation type although, to date, all ignitions in this type have been suppressed. Spruce-fir fires have been suppressed due, in part, to USFS concerns about fires going northeast into an area with critical fish habitat. Once proposed treatments are conducted along the northern border, likelihood of fire-use fires going beyond GRCA's boundary would be greatly reduced. However, given air quality and MSO habitat mitigation constraints, current fuel and vegetation conditions, and projected fire behavior under all weather conditions, it is unlikely that any wildland fire-use fires would be allowed in this vegetation type under Alternative 1. GRCA fire staff predict wildland fire suppression would be difficult given lack of access and safety zones and continued fuel accumulations in absence of treatment. It is assumed 31% of suppression-fire acres would be in spruce-fir vegetation. This amounts to 35% of this vegetation type. Amount is based on historical averages over the past 25 years. Fire spread predictions (Appendix F) indicate that under high (90^{th} percentile) or very high (97^{th} percentile) pre-monsoon weather conditions, fire would spread readily through most of the spruce-fir vegetation type.

There is a high level of uncertainty in predicting amount of wildland fire-use or suppressed fire that would occur in the spruce-fir type. Although fuels are generally sufficient to carry fire readily during high or very high weather conditions, recent historic lightning ignitions are less dense than in mixed-conifer and ponderosa pine (Figure 4-3). Fire season is shorter, especially on northerly slopes where moisture is retained longer. As noted earlier, during mild (50^{th} percentile) and moderate (80^{th} percentile) weather conditions, fire spread is often more limited across flatter areas and other sites with shallow, rocky soils, since fuels are patchy and discontinuous. Under most weather conditions during fire season, fire spread would be relatively slow. However, given the thin bark and low crowns of the dominant species (spruce), fire effects during any type of fire (surface or crown) are likely to be more severe than other vegetation types. Currently, an estimated 46% of the spruce-fir type would burn as crown fire during high (90^{th} percentile) weather conditions. More than 46% of the type would experience high severity, since surface fire could also result in tree mortality. The greatest difference in fire patterns under different weather scenarios is the spatial pattern. Under high or very high weather conditions, fire spread would be greater and severity more uniform. Under mild or moderate weather conditions, fire spread would be more variable and consequently patchier, or more heterogeneous fire severity and extent would result.

An indirect, beneficial effect of proposed treatments in adjacent mixed-conifer would reduce likelihood of high fire severity in spruce-fir. Reduced fuel levels and potential crown fire after mixed-conifer treatments would make fire behavior and intensity less (not as intense or rapidly spreading) if fire starts in mixed-conifer and moves toward spruce-fir. On the other hand, it is possible that some wildland fire-use fire that ignites in untreated mixed-conifer stands could increase in fire intensity and spread rate and could likely move toward spruce-fir at high fire severity and intensity levels.

Fire Behavior **Alternative 1** **Vegetation**
Spruce-Fir

Table 4-14 summarizes predicted fire behavior in spruce-fir vegetation type in proposed treatment areas, determined through FlamMap, based on several weather conditions. To meet MSO habitat mitigation low intensity fire requirement for prescribed fire, weather conditions would have to be no greater than 50th percentile. Assuming worst case, under 50th weather percentile conditions, 74% of the fire would burn as surface fire and 26% as passive crown fire (individual tree torching) and no active crown fire (fire spreading from crown to crown). These predictions are based on head fire, and application of prescribed fire would be with lower intensity backing or spot ignitions. Spruce has thin bark and crowns low to the ground. Even low intensity surface fire can easily transition into passive crown fire patches in low crowns and result in high tree mortality given thin bark that affords little to no heat resistance.

It is likely that very limited or no wildland fire-use fires would be implemented given MSO habitat and fire ecology mitigation measures described above for prescribed fires. Suppression fires would more likely burn in 97th percentile weather conditions. Predicted fire behavior for these weather conditions result in 51% crown fire with 25% active crown fire (Table F-6, Figure F-1).

There is a high degree of uncertainty about amount of crown fire that occurred in the spruce-fir type. Overall, the historic fire regime was thought to be mixed severity with infrequent high severity fires. Given the dominant species' (spruce) susceptibility to fire, an unknown mixture of surface and crown fire could have resulted in a historic mixed severity pattern.

Table 4-14 Predicted Fire Behavior from Prescribed Fire Treatments in Spruce-Fir Based on Various Weather Conditions

	Weather Percentile			
Fire Type	**50th**	**80th**	**90th**	**97th**
Active Crown	0%	0%	0%	25%
Passive Crown	26%	37%	39%	19%
Surface Fire	74%	63%	61%	56%

Fire Severity **Alternative 1** **Vegetation**
Spruce-Fir

Table 4-9 projects fire severity by fire type in spruce-fir for each alternative. In summary, fire severity levels would be higher than expected in ponderosa pine and mixed-conifer vegetation types. Prescribed and wildland fire-use fires would have the same expected severity levels (high to moderate/high levels at 40%, low to low/moderate levels 30%, unburned 30%). Suppression fires would have higher severity levels (69% high to moderate/high levels, 27% low to low/moderate levels; 4% unburned). It is assumed that even with careful prescribed fire application to meet MSO mitigation constraints, high fire severity effects may exceed 15% due to dominant species (spruce) fire ecology (thin bark and low crowns).

Predicted Fire Regime, and Fire Behavior after Planning Period **Alternative 1** **Vegetation Spruce-Fir**

Impacts would vary depending on amount of wildland fire-use fire in the spruce-fir vegetation type. In the one unit where prescribed fire and manual treatment is proposed, effects would be beneficial with a minor, local, long-term effect. Based on very limited fire-effects monitoring data, prescribed fire reduces surface fuel amount and conifer seedling density. Effect would be beneficial, minor and local, since only a small proportion of the type would be treated (19%). After planned prescribed fire and manual treatments in the spruce-fir type, the predicted area proportion that would burn as crown fire would be 49% during very high (97th percentile) weather conditions, a slight reduction from 51% before treatments. It is uncertain how much wildland fire use would occur in this vegetation type, but it is assumed it would reduce the proportion of future potential crown fire in areas treated. Outside treated and suppression fire areas, and assuming little wildland fire-use fire, 50% of this vegetation type's departure from historic fire would continue to trend away from the natural range of variability with an increasing area at moderate or moderate/high departure levels. Fuel amount and crown fire potential would continue to increase, as predicted by Fulé et al. (2004). In this untreated portion, impacts would be adverse with a short-term, moderate intensity effects at a regional scale.

Wildland fire-use impacts on departure of historic fire regime are uncertain. If fire-use fires occurred during any weather conditions except 97th percentile, resulting fire effects, spatial pattern, and severity are expected to have a beneficial trend toward the natural range of variability in fuel conditions and fire effects. There would be a trend toward a mixed severity pattern including low, moderate, and high severity effects in a patchy, complex, spatial pattern. If wildland fire-use and suppression fires occurred during 97th percentile weather conditions, there would be a high level of uncertainty about whether effects would be adverse or beneficial. Under very high weather conditions, fire spread would likely be extensive and severity more uniformly high. It is unknown what the historic role of more extensive high severity fires were in this type. It is possible they occurred particularly during drought years and following insect-related mortality peaks. Range of extents, or patch size, of higher severity fire is unknown. Exact likelihood of these fires types is not known, but they could occur several days on average each year (Table 4-13). The Outlet Fire occurred during very high weather conditions in mixed-conifer and spruce-fir and resulted in an extensive fire with 69% of spruce-fir burning at moderate/high to high severity levels. This severity level is right at the boundary between mixed severity and high severity fire regimes.

Overall, impacts to fire regime in spruce-fir are uncertain. It is believed there would be a minor, beneficial, long-term, local effect from the one planned prescribed fire and manual treatment unit in this vegetation type. The most likely impacts from wildland fire-use fires would be moderate, beneficial, long term and regional (depending on wildland fire use acreage that occurs during the planning period). There is an unknown level of likelihood wildland fire use would occur at the 97th percentile weather condition, and whether impacts would be adverse or beneficial.

Vegetation Composition and Structure after the Planning Period **Alternative 1** **Vegetation Spruce-Fir**

Effects on vegetation composition and structure would follow a similar trend toward that described under the fire regime section above. Limited monitoring data shows that prescribed fire results in reduced surface fuels and conifer seedling density. This is a trend toward the natural range of variability. In the one unit where a prescribed burn and manual treatment is proposed, effects would be beneficial with a minor, local effect. Effects in untreated areas (neither prescribed nor wildland fire use) and un-burned areas from suppression fires would be adverse with a short-term, moderate intensity impact at a regional scale. Historically, the spruce-fir type burned at moderate fire-return intervals with a mixed severity pattern (see Chapter 3.1.1.2). With fire suppression, there has been an increase in surface fuels, in fire intolerant spruce, in overall tree density, and most importantly in fuel continuity. These vegetation changes would continue in absence of vegetation treatment and wildland fires, resulting in a continued trend away from the natural range of variability. Fulé et al. (2004) reported increases in crown fire potential since the 1880s, and with increasing future potential (to 2040) without fire treatment. How much area would remain untreated in Alternative 1 depends on the amount of wildland fire-use and/or suppression fires and their potential fire behavior and effects.

Although dominant species in the spruce-fir type, namely spruce and subalpine fir, are easily killed by most fire intensities, fire was present historically and resulted in a complex spatial pattern of vegetation composition and structure. Fires, at weather conditions other than the 97th percentile, would likely restore this complex spatial pattern. Fires at all weather conditions would increase and restore the aspen component, since fire favors aspen. Aspen sprouts readily following fire and has greater survival and growth when conifers are reduced.

Most likely, wildland fire use impacts on spatial and fire severity patterns would primarily be beneficial with a moderate to major, potentially regional effect. If fire-use fires occurred during weather conditions less than 97th percentile, spatial pattern and severity would move the spruce-fir vegetation type toward the natural range of variability in vegetation composition and structure. Given MSO habitat mitigation constraints, it is unlikely that few if any wildland fire use acres would occur in the spruce-fir type; therefore, any beneficial impacts from wildland fire-use fire would be minor, short term, and local. The same high uncertainty level about effects to historic fire-regime departure, from wildland fire-use or suppression fires under 97th percentile weather conditions, would be true for effects on vegetation composition and structure.

Insects/Pathogens/Drought Spruce-Fir **Alternative 1** **Vegetation**

Effects would be beneficial and indirect on insect and pathogen levels and extent, as well as drought resilience, where treatment is proposed and where fire-use and suppression fires occur. This effect is due to both decreased tree density in treated and burned areas and, more importantly, to increased heterogeneity in tree density and composition. In addition, increased aspen proportion and decreased spruce and fir proportion would limit extent of spruce budworm outbreaks. Effect would be adverse, minor, local, and long term if wildland fire-use fire does not occur. If wildland fire-use fire would occur in the majority of this vegetation type, beneficial indirect impacts would be major, regional, and long term.

Piñon-Juniper **Alternative 1** **Vegetation**

At least one-third of piñon-juniper mapped occurs Below the Rim. Areas of piñon-juniper Below the Rim are covered in the Below the Rim section.

Treatment Types and Amounts Piñon-Juniper **Alternative 1** **Vegetation**

Very little (3%) of the piñon-juniper type is proposed for prescribed fire and/or manual treatment in Alternative 1. Primary piñon-juniper areas treated would be on South Rim around park headquarters. This area is planned for treatment with both prescribed burning and manual treatments (around structures and developed areas). Very limited wildland fire use would occur in piñon-juniper, primarily where it occurs in small patches intermixed with or at edges of ponderosa pine forests. The primary action proposed in the piñon-juniper type for wildland fire use is to improve understanding of ecological functions and processes through monitoring what limited or negligible amounts may burn. It is assumed 9% of suppression fire acres would be in the piñon-juniper vegetation type. This amounts to approximately 1,800 acres or less than 1% of this vegetation type. The amount is based on historical averages over the past 25 years.

Fire Behavior Piñon-Juniper **Alternative 1** **Vegetation**

Table 4-15 is a summary of predicted fire behavior in the piñon-juniper vegetation type, determined through FlamMap, based on several weather conditions. Amount of prescribed fire proposed in this Alternative is minor (3% of the vegetation type).

A small amount of wildland fire-use fire is expected in the piñon-juniper type primarily where it occurs in small patches adjacent to or near ponderosa pine. Fire behavior would be primarily low/moderate intensity surface fire.

Suppressed fires would most likely occur during 97th percentile weather conditions. Under 97th percentile weather conditions, crown fire proportion is predicted to be 10% with primarily surface fire across the entire extent of piñon-juniper. This is predicted because much of the piñon-juniper type has a relatively low tree density and, as a result, treeless areas in between are predicted to burn as surface fire.

Table 4-15 Predicted Fire Behavior from Prescribed Fire in Piñon-Juniper Based on Various Weather Conditions

	Weather Percentile			
Fire Type	**50th**	**80th**	**90th**	**97th**
Active Crown	0%	0%	0%	35%
Passive Crown	3%	5%	12%	31%
Surface Fire	97%	95%	88%	34%

Fire Severity **Alternative 1** **Vegetation**
Piñon-Juniper

Table 4-11 projects fire severity by fire type in piñon-juniper vegetation for each alternative. No fire severity was estimated for fire-use treatments because limited treatments are proposed with this alternative. Low to low/moderate fire severity is estimated for prescribed fire at 57%, and for suppression fires 49%; high to moderate/high fire severity for prescribed fire at 7% and 48% for suppression fires.

Predicted Fire Regime and Fire Behavior after Planning Period **Alternative 1** **Vegetation** **Piñon-Juniper**

A high level of uncertainty exists regarding historic fire regimes in the piñon-juniper type; therefore, there is a high level of uncertainty on effects of implementing proposed treatments on fire regimes for piñon-juniper during the planning period. Departure from historic fire regime is assigned moderate/high (29% of the vegetation type) in piñon-juniper sites with greater amounts of grass and shrub surface fuels, since the advent of fire suppression has reduced fire (Figure 4-2). Without treatment, these areas would continue to trend toward increased departure from historic fire regime. Due to the limited amount of prescribed fire and wildland fire use, and emphasis on fire suppression, the majority of piñon-juniper would not be treated. Effect after Alternative 1 implementation would be adverse, but it is unknown whether effect would be minor or major, given uncertainty about historic fire regimes. The remainder of vegetation type area is assigned as low/moderate departure (71% of the vegetation type). In these piñon-juniper sites, understory vegetation and fuels are more limited in amount and continuity. There would be a continued, slight trend away from the natural range of variability for this portion of the type, but trend magnitude is uncertain, given uncertainties about the historic fire regime. Since historic fire frequency in these more fuel-limited piñon-juniper sites may have exceeded 100 years between fires, only a portion of these sites would have burned in the last 100 years, and impacts would be adverse and minor.

As noted in Effects Common to All Alternatives, cheatgrass, an invasive exotic grass, has invaded these piñon-juniper sites. Cheatgrass invasion can cause a dramatic fire regime shift, since it cures and becomes flammable earlier in the year than native plants. Fires, where cheatgrass occurs, could become more frequent and occur earlier in the year than historically. If cheatgrass invades or increases in treated South Rim areas, this could cause a minor, local, adverse impact with mitigation measures. Cheatgrass could invade and increase in areas where fire occurred (prescribed and suppression fires). Because only 3% of this vegetation type is proposed for treatment, and crown fire likelihood is low, the risk of cheatgrass severely impacting this vegetation type from proposed treatment is low. It would be difficult to determine impacts from suppression fires because of inability to predict suppression fire severity. Mitigation measures to minimize exotic plant invasion would also limit this adverse impact. See 4.2.1.5 and 4.2.3.5 for specifics on invasive exotic plants.

Primary actions proposed in the piñon-juniper type is monitoring, research, and adaptive management to improve understanding of ecological processes and functions. These actions would have a beneficial and likely regional effect on piñon-juniper by reducing uncertainty regarding historic fire regimes and vegetation structure and composition.

Vegetation Composition and Structure after Planning Period **Alternative 1** **Vegetation Piñon-Juniper**

Little prescribed fire and fire-effects monitoring have occurred in the piñon-juniper vegetation type. Most piñon-juniper treatments to date have been in South Rim WUI surrounding Grand Canyon Village. Monitoring data indicates limited effects of prescribed fire, as implemented to date, on piñon-juniper vegetation composition and structure. This is also common with treatment effects in piñon-juniper in areas other than GRCA. With typically sparse understory vegetation and surface fuels, it is difficult for fire to carry across piñon-juniper sites unless high winds result in crowning. Shrub-stem densities and surface-fuel loads show initial, relatively small decreases, but can recover. Litter and duff show more sustained decreases. Treatments proposed in WUI are more likely to reduce vegetation density and fuel loads because manual treatments would also be applied. In some areas piñon-juniper tree densities increased and in others piñon-juniper vegetation expanded, especially into grasslands that may not have occurred under natural fire regimes (see Chapter 3.1.1.5). Because of this, effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, but local in effect (since only 3% of the piñon-juniper type is proposed for treatment). Should cheatgrass increase in the vegetation type from proposed treatments, it would have an adverse affect on vegetation composition and structure.

Insects/Pathogens/Drought Piñon-Juniper **Alternative 1** **Vegetation**

Throughout the Southwestern U.S. there is currently an evident pattern of drought-related mortality in piñon, and to a lesser extent juniper. Some of this is thought concentrated on sites where piñon and juniper have expanded or increased in density in the last century due to fire suppression and/or climate shifts. In proposed Alternative 1treatment areas, there would likely be a decrease in level or likelihood of tree mortality due to drought in piñon-juniper because of planned reductions in stem density. Decreases in stem density would increase water availability to remaining trees, increasing resilience to drought. These indirect effects are expected to be beneficial, long term and moderate in treated areas, but local because treatment area is only 3% of vegetation type. Where no treatment is proposed, risk of drought-related mortality would be higher. Overall, if drought conditions continue, mortality could have an adverse, major, regional, long-term impact to piñon-juniper vegetation. At GRCA, drought-related mortality has not been observed at levels in adjacent land units. Therefore, if drought conditions continue, impacts would be adverse, minor to moderate, local, and long term.

Montane-Subalpine Grassland Treatment Types and Amounts **Alternative 1** **Vegetation**

There are no planned prescribed fire treatments in montane-subalpine grasslands (meadows). It is unlikely that this type would burn during wildland fire-use fires based on past fire observations. As stated in Chapter 3.1.1.6, there likely was a fire effect historically at the grassland-forest boundary. Prescribed fire and possibly wildland fire-use and suppression fires could occur around grasslands in this alternative.

Fire Regime and Vegetation Composition and Structure | **Alternative 1 Montane-Subalpine Grassland** | **Vegetation**

Little is known about historic fire regime in the grassland type; therefore, there is high uncertainty on Alternative 1's effect on departure from historic fire regime. Grassland-forest boundary observations, in areas burned during prescribed or wildland fire-use fire, indicate tree mortality can occur at the boundary. There have been areas where, after fires, aspens sprouts surfaced twenty to several hundred feet further into grasslands than before fire. Since fire occurred historically in adjacent forests, it is presumed the effect of prescribed, wildland fire-use, or suppression fires in adjacent forests would have a beneficial, moderate, local impact on fire regimes and vegetation composition and structure in grasslands, concentrated in the grassland-forest boundary. Impacts would be local, since effects would be concentrated around grassland margins, encompassing less than 35% of total vegetation area.

Below the Rim Treatment Types and Amounts | **Alternative 1** | **Vegetation**

No treatments are proposed Below the Rim in any alternative, including Alternative 1. However, lightning and rolling material from fires above the rim occasionally ignite fires Below the Rim. These could be managed as wildland fire-use fires or suppressed. Overall, lightning ignition densities are low Below the Rim (Figure 4-3). As noted in 4.2.1.10 most of these ignitions historically resulted in limited fire spread due to very sparse or patchy and discontinuous fuels in the shrub or piñon-juniper vegetation types dominant Below the Rim. Below North Rim, some extensive Gambel oak patches intersperse with individual or small conifer patches, such as ponderosa pine. These areas can sustain fire spread over larger areas, especially on drier south or west aspects; however, observed fire extent is limited due to limited fuel barriers. There are also smaller patches of denser mixed-conifer forest below South Rim that could burn, but with limited fire spread as they are surrounded by cliffs or rocky sites with limited vegetation.

Fire Regime and Vegetation Composition and Structure | **Alternative 1** | **Vegetation Below the Rim**

Potential wildland fire-use fires occasionally affect locations below the rim and would have a beneficial moderate local effect on departure from historic fire regime. Since fire, although limited, occurred here historically, occurrence of some fire would cause a trend from low/moderate to low historic fire regime departure. A moderate/high level of uncertainty exists regarding historic fire regime Below the Rim.

Fire severity is likely mixed in areas that burn Below the Rim, as is thought to have occurred historically. Fires tend to burn more intensely and result in greater severity on steep slopes. Most Below the Rim areas are steep. However, given fuel discontinuities, a patchy pattern of widely varying severities, including unburned areas, is most likely. Most Below the Rim areas where vegetation does occur have lower productivity and, as a result, fuel accumulations are more limited, which, in addition to steep slopes, means even though fires may be higher intensity due to steep slopes, fire spread is likely rapid with little heat concentration for long periods. Potential fire behavior Below the Rim during all four fire weather conditions (50^{th}, 80^{th}, 90^{th} and 97^{th} percentiles), reasonably shows these patterns (see Appendix F). Crown fire areas are generally small and patchy, except during high (90^{th} percentile) and very high (97^{th} percentile) weather conditions in areas below North Rim where larger areas of Gambel oak occur.

These fire behavior characteristics would cause relatively low severity effects to soils and surface and overstory vegetation, but moderate/high severity effects to understory and midstory vegetation. Gambel oak and New Mexico locust are two prevalent area species, and both resprout vigorously after fires. Midstory vegetation recovery is likely rapid and vigorous. Overall, expected Alternative 1 effects to vegetation composition and structure Below the Rim would be beneficial, moderate, and local. Effects to insects/pathogens/drought resilience to would be similar to that for vegetation composition and structure.

It is assumed that decreased densities and increased vegetation heterogeneity would result in decreased insect/pathogen incidence and increased drought resilience.

South Rim WUI **Alternative 1** **Vegetation**
Fire Regime

Limited treatment would occur directly in the WUI in Alternative 1. Currently, fuels are not treated around all structures to the degree necessary to reduce potential for ignition and fire behavior. Treated areas would have beneficial, minor, local, short-term effects. There would be an adverse, moderate, local effect in the immediate vicinity of structures since treatment level is low, and current fuel conditions around many structures make ignition relatively high. Planned prescribed fire in the surrounding larger area would result in reduced fire behavior and crown fire potential in surrounding areas (see Appendix F). This is particularly true southwest of Grand Canyon Village. Prevailing winds are from the southwest; therefore, treatments to the southwest are likely to decrease likelihood of fire progressing uncontained from this area toward Grand Canyon Village. Reduced ember production potential from treatment would reduce likelihood of spotting from treated areas into Grand Canyon Village. Effect to WUI fire potential would be beneficial, minor, short term, and local.

Mitigation of Effects **Alternative 1** **Vegetation**

Mitigation measures acknowledged in 4.2.1.5 would reduce adverse impacts to vegetation from exotic plant species invasion and expansion. Recommended mitigation measures for exotic plant are in 4.2.3.5.

Cumulative Effects **Alternative 1** **Vegetation**
Past or Planned Actions in and Surrounding GRCA

Cumulative effects to fire regimes from other past or planned actions in GRCA would be very limited. One that would have an additional beneficial effect is the Corridor Fire Protection Project (2003a). This project is focused on increased fire protection for structures below the rim resulting in reduced likelihood of unplanned ignition or fire spread from structures to wildland areas.

Table 4-15a Past Fire Severity by Fire Category (2000-2008)

Severity Level	Fire Type						
	Prescribed Fire		Wildland Fire Use		Suppression Fire		All Fires
	Acres	Percent of Forest Type	Acres	Percent of Forest Type	Acres	Percent of Forest Type	Percent of Forest Type
Pinon Juniper							
unburned	1831	1	521	0	11	0	1
low	2132	1	905	0	45	0	1
low/mod	597	0	503	0	87	0	0
mod/high	255	0	225	0	114	0	0
high	41	0	17	0	9	0	0
Ponderosa Pine							
unburned	3389	6	1825	3	88	0	9
low	12655	21	18707	31	122	0	53
low/mod	3765	6	5003	8	72	0	15
mod/high	685	1	1126	2	28	0	3
high	193	0	195	0	1	0	1
Mixed Conifer							
unburned	651	2	471	1	238	1	4
low	2284	7	6544	19	427	1	27

Severity Level	Fire Type: Prescribed Fire Acres	Prescribed Fire Percent of Forest Type	Wildland Fire Use Acres	Wildland Fire Use Percent of Forest Type	Suppression Fire Acres	Suppression Fire Percent of Forest Type	All Fires Percent of Forest Type
low/mod	1198	4	3711	11	441	1	16
mod/high	276	1	2428	7	530	2	10
high	75	0	1447	4	198	1	5
Spruce-Fir							
unburned	6	0	64	1	226	1	2
low	19	0	46	1	527	3	3
low/mod	13	0	19	0	816	5	5
mod/high	1	0	39	1	1904	11	11
high	0	0	0	0	1559	9	9

Cumulative Effects Alternative 1 Vegetation
Past or Planned Actions in and Surrounding GRCA Pinon-Juniper

It is unclear how many acres of each forest type will burn with suppression or resource benefit objectives. It is assumed the history of past fires suppressed or managed for resource benefit will be similar to future fires. Past fire history in piñon-juniper shows approximately 2% of total acres have burned, so it will be assumed an additional approximate 2% of piñon-juniper will burn during the life of this plan. According to Table 4-15a, the majority of past fire severity has been low and moderate-low with a large amount of unburned areas, and that same type of fire severity is expected to continue. Table 4-11 projects the amount of high and moderate/high severity in the piñon-juniper forest type to be 7-48%. The lower percentages are projected for prescribed fires, and the 48% percent is projected for fires with suppression objectives. Current models can't predict sizes of high and moderate/high severity patches, but if the past is an indicator, very little (less than 1% of the forest type) will experience that fire severity. Due to the small overall fire percentage that has occurred and is expected in the piñon-juniper forest type, cumulative impacts of past and proposed fire severities would be negligible, local, short to long term.

Tusayan District of the KNF has identified approximately 189,000 acres of piñon-juniper woodland vegetation (USDA, 2008c). When these acres are added to acres in the park (309,800 acres), the total comes to approximately 498,000 acres. The cumulative impacts to piñon-juniper forests in and adjacent to the park would be less than impacts in the park since the combined piñon-juniper acres are so large. Those impacts would be negligible, local to regional, short to long term.

Cumulative Effects Alternative 1 Vegetation
Past or Planned Actions in and Surrounding GRCA Ponderosa Pine

The amount of suppression fires in the ponderosa pine could be similar or slightly more than past fire seasons, and there could be an increase in fires managed for resource benefit. The prescribed fire program in this forest type will be less than in the past. According to projected fire severity calculations there will be an increase in high severity fires (suppression fires) and an increase in lower severity fires (wildland fire use). Past fire severity data (2000 – 2007), by fire and forest types, is located in Table 4-15a. Fire history shows approximately 80% of total acres have burned, so it will be assumed that many fires that occur in the pine forest, regardless of ignition source, will be second-entry or multiple-entry burns. Past fires were primarily first-entry burns. Past burns that were second- or third-entry burns showed a higher percent of low and moderate/low severity fire effects (two examples include Topeka at 98%, and Walhalla Cape Final at 99%). The amount of high and moderate/high severity in the ponderosa pine forest type from past projects (2000-2007) is approximately 4%. Projected fire severity levels for future fires (8-13%) can be found in Table 4-5. Current models can't predict sizes of high and moderate/high severity patches. The size of these high and moderate/high severity patches will determine if impacts are beneficial or adverse. If patch size are large, then impacts would be adverse, minor to moderate, local, long term. If patch size is small and scattered, then impacts would be beneficial, minor, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse minor to moderate; and beneficial, minor, local, short to long term.

The North Kaibab Ranger District identified approximately 155,000 acres of Ponderosa Pine forests (USDA, 2008c), and the Tusayan District of the KNF approximately 105,000 acres (USDA, 2008c). When these acres are added to acres in the park (59,600 acres), the total comes to approximately 319,600 acres. Cumulative impacts to the ponderosa pine forests in and adjacent to the park would be less than impacts in the park since the increase in total acres of ponderosa pine is so large. Those impacts would be adverse and beneficial, minor, regional, short to long term.

Cumulative Effects **Alternative 1** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Mixed Conifer**

The amount of suppression fires in the mixed-conifer forest could be similar or slightly more than past fire seasons, and there could be an increase in fires managed for resource benefit. The prescribed fire program is focused on reestablishing fire in mixed-conifer forests which have the highest level of departure from historic fire regime (Figure 4-2), so there will be an increase in the amount of prescribed fire. According to projected fire severity calculations there could be a similar level of high severity fires (suppression fires up to 42%) and in lower severity fires (wildland fire use, prescribed fire up to 30%). Table 4-7 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type, except Alternative 1 where Mexican spotted owl constraints require low intensity fire for fire treatments. Past fires burned approximately 15% of the mixed-conifer forest type. Past fire severity data (2000 – 2007) by fire and forest types is located in Table 4-15a. Successful mitigation measure implementation involving mixed-conifer forest protection would leave fire managers no additional moderate/high and high severity fire effects on future fires regardless of ignition. The cumulative amount of moderate/high and high severity fire would remain at 15% of the forest type. Approximately half the moderate/high and high severity fire is concentrated on three past fires and in large patches. The remaining 85% of mixed-conifer vegetation type would have unburned, low and moderate/low fire effects. Since current patches are large, but limited to just 15% of the forest type, impacts would be adverse, minor, local, long term. Since the other 85% of the forest type has and will burn under lower severities, impacts would be beneficial, moderate, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse, minor; beneficial, moderate, local to regional, long term.

The North Kaibab Ranger District identified approximately 114,000 acres of mixed-conifer fuels (USDA, 2008c). When these acres are added to park acres, and above the rim acres (33,800), the total comes to 147,800 acres. Cumulative impacts to mixed-conifer forests in and adjacent to the park would be less than the impacts within the park, since the increase in acres of mixed-conifer is large. Those impacts would be adverse, minor; beneficial, moderate, local to regional, long term.

Cumulative Effects **Alternative 1** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Spruce-Fir**

The amount of suppression fires in spruce-fir could be similar or slightly more than past fire seasons, and there could be an increase in fires managed for resource benefit. There is only one prescribed fire planned in the spruce-fir forest type so effects of that project could be small. According to projected fire severity calculations there could be a similar or slightly higher amount of higher severity fires (suppression fires up to 69%) and an increase in lower severity fires (wildland fire use up to 40%). Table 4-9 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. There is only a small amount of data from past suppression and wildland fire use fires, but the information available has been used to determine severity levels that have occurred since 2000 (See Table 4-8, Table 4-15a). Section 2.4.2.2 states,"Various authors have suggested that current structure and composition of Southwest spruce-fir forests are in the natural range of variation present before Euro-American influence. They reasoned that, 1) the fire exclusion period has been shorter than fire intervals for a presumed crown-fire regime (White and Vankat 1993, Dahms and Geils 1997, Laughlin et al. 2005), and 2) stands may have been little affected by historic livestock grazing (Dahms and Geils 1997)." Future fire effects could be close to the natural range of variation, since forest conditions are close or within the natural range of variation. Successful implementation of mitigation measures that involve protection of Mexican spotted owl habitat would require the park to keep high and moderate/high fire severity below 15% of the forest. Approximately 19% of the spruce-fir has burned under high and moderate/high severity effects. The remaining 81% of the mixed-conifer vegetation type would experience unburned, low and moderate/low fire effects. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if the impacts are beneficial or adverse. Large patches of high and moderate/high severity fire will move the forest away from some desired conditions listed in section 2.4.1.3, and small patches scattered through the forest will move the forest toward those desired conditions. Since past patch sizes are large and located in one area, but limited to just 19% of the forest type, impacts would be adverse, minor, local, long term. Since the other 81% of the forest type has and could burn under lower severities, and would not bring the forest type toward desired conditions, impacts would be adverse, minor, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse, minor, local, long term.

The North Kaibab Ranger District identified approximately 29,000 acres of spruce-fir forests (USDA, 2008c). When these acres are added to acres in the park (17,700 acres), the total comes to 46,700 acres. Cumulative impacts to spruce-fir forests in and adjacent to the park would be the same as impacts in the park since the acres of spruce-fir on the Kaibab Plateau double, but the total amount of spruce-fir forests in the Southwest is very small. Those impacts would be adverse, minor, local to regional, long term.

Other actions in areas surrounding GRCA that influence effects to fire regimes and vegetation composition and structure are prescribed fire, mechanical treatments, wildland fire-use fires, and wildfires. Kaibab National Forest has completed and planned numerous treatments that reduce hazardous fuel loads and restore fire regimes.

Projects south of GRCA have a significant cumulative effect on park fire regimes and vegetation structure and composition in two ways. First, since prevailing winds are from the southwest, fires on the south Kaibab National Forest have potential to travel into GRCA. There have been prescribed and wildland fire-use fires and mechanical thinning treatments just south of the park boundary that reduce likelihood of a large, severe wildfire burning into GRCA. These treatments, with those planned in GRCA, add cumulatively to a beneficial moderate to major impact, and contribute to restoring historic fire regimes and vegetation structure and composition in ponderosa pine. It is not known if this cumulative impact is local or regional. There is a similar beneficial moderate to major effect in the piñon-juniper type.

North of GRCA, Kaibab National Forest has also planned and implemented similar projects. Although prevailing winds from the southwest make it unlikely that most fires would spread from the Kaibab National Forest into the North Rim portion of GRCA, they do add to Alternative 1's beneficial, moderate to major impact of treatments toward restoration of historic fire regime and vegetation structure and composition. This is particularly the case in the ponderosa pine type. In areas outside GRCA not planned for treatment, there is a trend toward an adverse, major effect on increased departure from historic fire regime and vegetation composition and structure.

Effects of not treating mixed-conifer on the Kaibab National Forest, and subsequent sustained high and increasing likelihood of high severity effects from a wildfire, are adverse. There is uncertainty about future amounts of wildfire or wildland fire-use fires in mixed-conifer forests or spruce-fir forests on the Kaibab Plateau. If fires occur during weather conditions other than the 97th percentile, it is likely cumulative effects would be beneficial and major, regionally. If they occur during 97th percentile weather conditions, cumulative effects would be adverse, moderate, and regional, given current levels of fuel accumulation and continuity across the landscape.

Cumulative Effects **Alternative 1** **Vegetation**
Longer-term Effects and Climate Change

Areas left untreated for a period of 40 years would trend toward adverse effects to fire regime and vegetation composition and structure. Simulations of changes in North Rim ponderosa pine, mixed-conifer, and spruce-fir forests by Fulé et al. (2004), 2000 to 2040, suggest continued increased crown fuel and crown fire potential. This effect is likely exacerbated by predicted climate change.

Recent analysis of fire extent and climate during the last 35 years revealed a trend in increasing incidence of large, high severity Southwest fires since the mid-1980s (Westerling et al. 2006). A positive correlation was found between increased fire incidence and warmer years, and fire season length increased. It is likely that forest or vegetation types with fuel accumulations and increased vegetation density from fire suppression are more sensitive to climatic variability—less resilient to fires during droughts and warmer years, when fire behavior is most intense. Cumulative effects of reduced fuels and fire behavior potential in treated areas in Alternative 1, along with those areas treated outside GRCA, would be a beneficial, major, regional impact through a trend in increased resilience to future climate warming or droughts.

Conclusion **Alternative 1** **Vegetation**

- Ponderosa Pine
  Impacts to vegetation composition and structure will be major, beneficial, long term, and regional. Protection from Insects/Pathogens/Drought impacts would range from moderate to major beneficial short to long term direct and indirect regional. Minor adverse impacts would occur from untreated areas and the low intensity fire stipulation.
- Mixed-Conifer
  Impacts from suppression fires with large crown fires and at 97th weather percentile would be moderate to major adverse, long term but local. There would also be moderate beneficial impacts due to this fire treatment. Predicted fire behavior and fire regime after the planning period would only have minor beneficial impacts due to MSO mitigation limitations. After the planning period, impacts from suppression fires would be minor adverse. There would be a moderate, beneficial, short term, regional impact on vegetation composition and structure after the planning period. Protection from Insects/Pathogens/Drought impacts would be moderate beneficial long term regional.
- Spruce-Fir
  After the planning period, predicted fire regime and fire behavior would have minor, beneficial, long-term, local impacts in areas where prescribed fire treatment will occur. There will also be moderate, adverse, short-term, regional impacts in untreated areas and beneficial, moderate, long-term, regional impacts in areas treated with wildland fire use. After the planning period, vegetation composition and structure would have minor, beneficial, local impacts for areas treated with prescribed fire. There will also be adverse, moderate, short-term, regional impacts in untreated areas. Areas treated with wildland fire use would have a moderate to major, beneficial, regional impact for spatial pattern and severity. Minor, beneficial, short-term, local impacts in areas treated with wildland fire use due to MSO mitigation limitations. Protection from Insects/Pathogens/Drought impacts would be major beneficial long term regional from wildland fire use, and minor adverse local long-term impacts where wildland fire use does not occur.
- Piñon-Juniper
  After the planning period there would be minor, adverse impacts to predicted fire regime and fire behavior. There would be moderate, beneficial, local impacts to vegetation composition and structure in treated areas. Protection from Insects/Pathogens/Drought impacts would be moderate, beneficial,

long term, and local in treated areas due to tree density reduction. If the drought continues on a regional scale, there would be major, adverse, long-term, regional impacts. If drought continues in GRCA only, there would be minor to moderate, adverse, local, long-term impacts.

- Montane-Subalpine Grasslands
  After the planning period there would be moderate, beneficial, local impacts to predicted fire regime and fire behavior. After the planning period moderate, beneficial, local impacts to vegetation composition and structure.
- Below the Rim
  After the planning period there would be moderate beneficial local impacts to predicted fire regime and fire behavior from unplanned events. Vegetation composition and structure would have moderate beneficial local impacts after the planning period from unplanned events.
- South Rim WUI
  After the planning period there would be minor, beneficial, local, short-term impacts to predicted fire regime and fire behavior in treated areas. Since treatment level is low in the immediate vicinity of structures there would be moderate, adverse, and local impacts. There would also be minor, beneficial, short-term, local impacts for fire potential. After the planning period there would be moderate, beneficial, local impacts to vegetation composition and structure.
- Cumulative Effects
  - Past or Planned Actions in Areas Surrounding GRCA
    - Beneficial, moderate to major, local or regional on South Rim
    - Beneficial, moderate to major in treated areas on North Rim
    - Adverse, major in unplanned and untreated areas
    - Beneficial, major, regional if fires occur in Mixed-Conifer in weather conditions other than 97th percentile
    - Adverse, moderate, regional if fires occur in Mixed-Conifer in weather conditions at the 97th percentile
  - Long-term Effects and Climate Change
    - Beneficial, major, regional in treated areas due to reduced fuels and fire behavior potential

Impairment — Alternative 1 — Vegetation

Although there are short- to long-term, local and regional, major adverse impacts to these resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair Vegetation during Alternative 1 implementation.

Unacceptable Impacts — Alternative 1 — Vegetation

Because impacts previously described are not inconsistent with park purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on vegetation as a result of implementation of this Alterative.

4.2.1.12 Alternative 2 — Preferred Alternative Mixed Fire Treatment Program — Vegetation

Alternative 2 differs from Alternative 1 in development of new fire management units (See Chapter 2), implementation of fire management strategies based on adaptive management, and addition of WUI mechanical/manual treatments. In Alternative 2, prescribed and wildland fire-use fires are not restricted to low intensity fires in any vegetation type. Another principal difference is the increased amount of non-fire hazardous fuel reduction treatments in WUI, and the option to use mechanical equipment. The non-fire hazardous fuel treatments would encompass approximately 2,490 acres in Alternative 2 (compared to 400 in Alternative 1), applied to ponderosa pine and piñon-juniper types in the primary WUI.

Direct and Indirect Effects **Alternative 2** **Vegetation**
Treatment Types and Amounts/Fire **Ponderosa Pine**

Treatment types and amounts would be the same as Alternative 1 with additional acres of non-fire treatment (manual and mechanical) in the ponderosa pine vegetation type. This alternative also assumes similar suppression acreage as Alternative 1, at 4% (approximately 2400 acres) in this vegetation type.

Ponderosa Pine **Alternative 2** **Vegetation**
Fire Behavior, Fire Severity, Predicted Fire Regime and Fire Behavior After the Planning Period, Predicted Fire Regime and Fire Behavior after Planning Period, and Insects/Pathogens/ Drought

Effects are not expected to differ significantly from Alternative 1 related to fire behavior, fire severity, predicted fire regimes, and fire behavior after the planning period; vegetation composition and structure after the planning period; and effects from insects, pathogens, and drought. Because over 75% of this vegetation type is already at low or low/moderate departure from historic fire regimes (Figure 4-2), fire behavior and severity are not anticipated to change with the ability to allow prescribed and wildland fire-use fires on North Rim to burn at higher fire intensities than Alternative 1. Table 4-12 shows that under all but the 97th weather percentile, nearly all (greater than 96%) of the ponderosa pine type is predicted to burn as surface fire. Fire behavior under 97th weather percentile for wildland fire-use and suppression fires is predicted to be 20% crown fire.

Effects on understory plant species composition include crushing from mechanical treatment compared to manual fuel hazard reductions in the WUI area. Impacts are adverse, minor, local, and short term. Manual and mechanical treatments are expected to be more effective in reducing tree density than with prescribed fire. Because of this, effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, but local in effect.

Mixed-Conifer **Alternative 2** **Vegetation**
Treatment Types and Amounts/Fire

Treatment types and amounts would be similar to Alternative 1 in the mixed-conifer vegetation type for prescribed fire, but it is likely that more wildland fire use would occur due to change of existing severity constraints. More than 57% of this vegetation type is proposed for prescribed fire. Prescribed fire areas include areas currently classified as high level of departure from historical fire regimes. In addition, 20% of the wildland fire-use acres are estimated to be in this vegetation type (or 30% of the mixed-conifer vegetation type). This alternative also assumes similar suppression acreage as Alternative 1 of 18% (approximately 6800 acres) in this vegetation type.

Fire Behavior **Alternative 2** **Vegetation**
Mixed-Conifer

The main difference in fire behavior between Alternatives 2 and 1 is the change of existing severity constraints, and implementation of adaptive management on prescribed and wildland fire-use fire intensities with Alternative 2. Prescribed fires would commonly burn between 50th to 80th weather percentiles (Table 4-2). Under these conditions, fire predictions (based on FlamMap) show that crown fire would be higher than Alternative 1. Passive crown fire could be between 28 and 42% (Table 4-13). Beneficial impacts are major, long term. Ability for prescribed and wildland fire-use fires to burn at greater intensities in mixed-conifer would result in greater reductions in vegetation densities and fuel loads, and thus a greater trend toward desired conditions.

Wildland fire-use fire would also burn under more variable weather conditions, primarily at the 90th weather percentile or less. Based on current potential fire behavior, 60% of the mixed-conifer type would burn as surface fire during 90th percentile weather conditions, 62% at 80th weather percentile, and 76% during half or more of the fire season (50th percentile). Crown fire would vary from 24% at 50th percentile weather to 40% at 90th percentile weather.

Predicted fire behavior from prescribed and wildland fire-use fires would be in the historic range of variability. An unknown amount of wildland fire-use fire would burn as higher intensity at 97th weather percentile, with up to 47% of mixed-conifer potentially burning as crown fire. Depending on extent of area burned under 97th weather percentile conditions, impacts could be beneficial or adverse.

Suppression fires would have the same fire behavior effect as Alternative 1.

Fire Severity **Alternative 2** **Vegetation**
Mixed-Conifer

Fire severity would be expected greater in the mixed-conifer vegetation type compared with ponderosa pine. Since fire intensity could be higher, fire severity would be greater in this vegetation type than in Alternative 1. Based on Table 4-7, fire severity would vary depending on fire category (unburned, low and low/moderate would be 70% in prescribed fire, 71% in wildland fire-use fire, and moderate/high to high 30% in prescribed fire, 29% in wildland use fire).

These severity projections for prescribed and wildland fire-use fires are in the natural range of variability for mixed severity historic regime for this type. These fires would result in a beneficial, major, regional, long-term impact. Impacts could also be adverse, moderate to major, and regional from wildland fire-use or suppression fires, assuming 97th weather percentile. With alternative implementation, even at the 97% weather percentile, impacts are expected to be adverse, moderate, and regional from wildland fire-use or suppression fires. Amount of high severity fire could be greater during these conditions and may exceed natural range of variability in extent and patch uniformity (larger, more uniform patches) given the uniformly higher density vegetation in mixed-conifer compared to historic conditions.

Suppression fires would have the same fire severity effect as Alternative 1.

Predicted Fire Regime And Fire Behavior After Planning Period **Alternative 2 Mixed-Conifer** **Vegetation**

Predicted fire regime and fire behavior after the planning period would be beneficial with a major, long-term, regional impact. Greatest levels of low or low/moderate departure from historic fire regime are projected in Alternative 2 (93%) (Figure 4-6). Alternative 2 would allow for more spatial complexity due to less restrictive mitigation measures on low intensity treatment fires. Fire severity would be more mixed for both prescribed and wildland fire-use fires which would mirror historic fire regime for this vegetation type. After prescribed fire treatments and WFU fires, level of area with crown fire potential at very high weather conditions (97th percentile weather) is second lowest in Alternative 2 (22%), only exceeded by Alternative 5 (18%) (Figure 4-7).

Vegetation Composition and Structure After Planning Period **Alternative 2 Mixed-Conifer** **Vegetation**

Vegetation composition and structure after the planning period would be more similar to what occurred historically in this vegetation type. As noted in Chapter 2, the mixed-conifer vegetation type typically occurred historically in a mosaic pattern due to the mixed severity fire regime allowing for patchy crown fires. This alternative brings the mixed-conifer vegetation type closer to natural range of variability and desired conditions. Higher intensity fire permitted would also result in greater reductions in understory and midstory tree densities bringing mixed-conifer forests closer to desired conditions. There would be a beneficial, major, long-term, regional impact on vegetation composition and structure.

Insects/Pathogens/Drought — Alternative 2 — Vegetation
Mixed-Conifer

Lowering stem densities and increasing spatial complexity would result in greater resilience of mixed-conifer forests. These effects would be greater in Alternative 2 than Alternative 1, due to higher fire intensities allowed and greater areas burned with wildland fire use. There would be a beneficial, moderate to major, regional, long-term impact.

Spruce-Fir — Alternative 2 — Vegetation
Treatment Types and Amounts/Fire

Treatment types and amounts would be the same as Alternative 1 in the spruce-fir vegetation type. 19% of this vegetation type is proposed for prescribed fire and non-fire treatment. An unknown amount of wildland fire use would occur, and it is assumed the same suppression acreage would occur as Alternative 1, at 35% (approximately 6200 acres).

Fire Behavior — Alternative 2 — Vegetation
Spruce-Fir

Table 4-14 summarizes predicted fire behavior in prescribed fire treatment units in the spruce-fir vegetation type, determined through FlamMap, based on several weather conditions. Assuming worst case, under 50th percentile weather conditions, 74% of fire would burn as surface fire, and 26% as passive crown fire (individual tree torching) and no active crown fire (spreading crown to crown).
Wildland fire-use fires would burn under more variable weather conditions, primarily at 90th percentile or less. Based on current conditions, 54-69% of these fires would burn as surface fire; 31-46% as crown fire.

As noted in Alternative 1, a high degree of uncertainty exists about amount of crown fire that occurred in the spruce-fir type; the historic fire regime was thought to be mixed severity with infrequent high severity.

Fire Severity — Alternative 2 — Vegetation
Spruce-Fir

As summarized in Table 4-9, fire severity levels would be higher in spruce-fir than expected in the ponderosa pine and mixed-conifer vegetation types, and prescribed and wildland fire-use fires would have the same expected severity levels (high to moderate/high levels 40%; low to low/moderate levels 30%; unburned 30%).

Predicted Fire Regime And Fire Behavior And Vegetation Composition And Structure After Planning Period — Alternative 2 — Vegetation
Spruce-Fir

Similar to the mixed-conifer vegetation type, this alternative would allow more spatial complexity in fire treatments; therefore, would more likely trend towards the natural fire regime and range of variability. There would be a minor, beneficial, local, long-term impact in the one treatment area, similar to Alternative 1. In contrast to Alternative 1, there may be an additional moderate, beneficial, local to regional impact from fire-use fires. Regional effects from fire-use fire in adjacent mixed-conifer will give additional protection to spruce-fir from high intensity fires moving from mixed-conifer to spruce-fir.

Although dominant species in the spruce-fir type, namely spruce and subalpine fir, are easily killed by most fire intensities, fire was present historically and resulted in a complex spatial pattern of vegetation composition and structure. Fires, at weather conditions other than the 97th percentile, would likely restore this complex spatial pattern. Fires at all weather conditions would increase and restore the aspen component, since fire favors aspen. Aspen sprouts readily following fire and has greater survival and growth when conifers are reduced.

Most likely, impacts from wildland fire use on spatial pattern and fire severity patterns would be primarily beneficial with a moderate to major, potentially regional effect.

There is an unknown level of likelihood wildland fire use would occur at the 97th percentile weather condition, and whether impacts would be adverse or beneficial.

Insects/Pathogens/Drought Spruce-Fir **Alternative 2** **Vegetation**

Impacts to vegetation from insects, pathogens, and drought would be the same as Alternative 1.

Piñon-Juniper **Alternative 2** **Vegetation**

Effects to the piñon-juniper vegetation type would be similar to Alternative 1, except there would be an increase in non-fire treatment (manual and mechanical treatment) in Alternative 2. In addition, approximately 410 acres treated with prescribed fire only in Alternative 1 would be treated with both mechanical/manual treatment and prescribed fire in Alternative 2. This increase is minor when compared to the total size of this vegetation type (approximately 306,600 acres). See Alternative 1 for a full description of effects to the piñon-juniper vegetation type.

Effects on understory plant species composition include crushing from mechanical treatment (Alternative 2) compared to manual fuel-hazard reductions in the WUI (Alternative 1). Impacts are adverse, minor, local, and short term. Manual and mechanical treatments are expected to be more effective in reducing tree density than prescribed fire. Because of this, effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, and local.

Montane-Subalpine Grassland **Alternative 2** **Vegetation**

As in Alternative 1, there is no proposed direct treatment in this vegetation type, and little is known about historic fire regime. There is high uncertainty on effects of Alternative 1 on departure from historic fire regime, but it is thought that fires were infrequent in montane-subalpine grasslands historically.

There have also been areas where, after both fire treatments and suppression fires, aspens sprouts surfaced farther into grasslands than prior to fire. Since fire occurred historically in adjacent forests, it is presumed effects of prescribed, suppression, or wildland fire-use fires in adjacent forests would have a beneficial, moderate, local impact on grassland fire regimes and vegetation composition and structure, concentrated in the grassland-forest boundary. Impact would be local, since effects would be concentrated around grassland margins, encompassing less than 35% of total area in this vegetation type.

Below the Rim **Alternative 2** **Vegetation**

Impacts to vegetation types Below the Rim would be similar to those described for Alternative 1.

South Rim WUI **Alternative 2** **Vegetation**

Difference in impacts with Alternative 1 in South Rim WUI would be decreased likelihood of fire spread to WUI, particularly around Grand Canyon Village, due to amount of mechanical and manual treatment proposed in and adjacent to this area. There would be decreased likelihood of high intensity or crown fire spreading into or burning this area. The impact, by decreasing potential for high intensity or crown fire (more difficult to contain), would be beneficial, moderate to major, local and short term.

Mitigation Of Effects **Alternative 2** **Vegetation**

Mitigation measures acknowledged in 4.2.1.5, would reduce adverse impacts to vegetation from exotic plant species invasion and expansion. Recommended mitigation measures for exotic plants are in 4.2.3.5; recommended mitigations to minimize soil compaction due to mechanical treatments are in 4.2.3.11.

Cumulative Effects **Alternative 2** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Piñon-Juniper**

It is unclear how many acres of each forest type will burn with suppression or resource benefit objectives. It is assumed the history of past fires suppressed or managed for resource benefit will be similar to future fires. Past fire history in the piñon-juniper shows approximately 2% of the total acres have burned, so it will be assumed an additional approximate 2% of the piñon-juniper will burn during the life of this plan. According to Table 4-15a the majority of past fire severity has been low and moderate/low with a large amount of unburned areas, and the same type of fire severity is expected to continue. Table 4-11 projects the amount of high and moderate/high severity in the piñon-juniper forest type to be 7-48%. The lower percentages are projected for prescribed fires, and the 48% percent is projected for fires with suppression objectives. Current models can't predict sizes of high and moderate/high severity patches, but if the past is an indication of the future, very little (less than 1% of the forest type) will experience that type of fire severity. Due to the small overall percentage of fire that occurred and is expected to occur in the piñon-juniper forest type, cumulative impacts of past and proposed fire severities would be negligible, local, short to long term.

The Tusayan District of the KNF identified approximately 189,000 acres of piñon-juniper woodland vegetation (USDA, 2008c). When these acres are added to park acres (309,800 acres), the total comes to approximately 498,000 acres. Cumulative impacts to the piñon-juniper forests in and adjacent to the park would be less than impacts in the park since combined acres of piñon-juniper are so large. Those impacts would be negligible, local to regional, short to long term.

Cumulative Effects **Alternative 2** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Ponderosa Pine**

The amount of suppression fires in ponderosa pine could be similar or slightly more than past fire seasons, and there could be an increase fires managed for resource benefit. The prescribed fire program, in this forest type, will be less than in the past. According to projected fire severity calculations there will be an increase in high severity fires (suppression fires) and in lower severity fires (wildland fire use). Past fire severity data (2000 – 2007) by fire and forest types is located in Table 4-15a. Fire history shows approximately 80% of the total acres burned, so it will be assumed that many of the fires that occur in the pine forest regardless of ignition source will be second- or multiple-entry burns. Past fires were primarily first-entry burns. Past burns that were second- or third-entry burns showed a higher percent of low and moderate/low severity fire effects (two examples include Topeka at 98%, and Walhalla Cape Final at 99%). The amount of high and moderate/high severity in the ponderosa pine forest type from past projects (2000-2007) is approximately 4%. Projected fire severity levels for future fires (8-13%) can be found in Table 4-5. Current models can't predict sizes of high and moderate/high severity patches. Size of these high and moderate/high severity patches will determine if impacts are beneficial or adverse. If patch size is large then impacts would be adverse, minor to moderate, local, long term. If patch size is small and scattered, impacts would be beneficial, minor, local, long term. Thus, cumulative impacts of GRCA's past and proposed fire severity in the ponderosa pine forest type in relation to ponderosa pine forests in and adjacent to the park would be adverse minor to moderate, to minor beneficial, local, short to long term.

The North Kaibab Ranger District identified approximately 155,000 acres of ponderosa pine forests (USDA, 2008c) and the Tusayan District of the KNF identified approximately 105,000 acres (USDA, 2008c). When these acres are added to park acres (59,600 acres), the total comes to approximately 319,600 acres. Cumulative impacts to the ponderosa pine forests in and adjacent to the park would be less than impacts in the park since the increase in total acres of ponderosa pine is so large. Those impacts would be adverse and beneficial, minor, regional, short to long term.

Cumulative Effects **Alternative 2** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Mixed-Conifer**

The amount of suppression fires in the mixed-conifer forest could be similar or slightly more than past fire seasons, and there could be an increase in fires managed for resource benefit. The prescribed fire program is focused on reestablishing fire in mixed-conifer forests, which have the highest level of departure from historic fire regime (Figure 4-2). Thus, there will be an increased amount of prescribed fire. According to projected fire severity calculations there could be a similar amount of high severity fires (suppression fires up to 42%) and in lower severity fires (wildland fire use, prescribed fire up to 30%). Table 4-7 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. Mitigation measures developed to protect the mixed-conifer forests limits the park to no more than 30% high and moderate/high fire severity effects in mixed-conifer from past (2000-2007) and proposed fires. Since 15% of the forest type has already burned with high and moderate/high severity effects, all future high and moderate/high fire effects will not exceed 15% of the forest type. Past fire severity data (2000 – 2007) by fire and forest types is located in Table 4-15a. There is no current model that describes sizes of high and moderate/high severity patches. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Approximately half of moderate/high and high severity fire is concentrated on three past fires and in large patches. If future fire patch size is large, then impacts would be adverse, moderate, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse to beneficial, moderate, local to regional, long term.

The North Kaibab Ranger District identified approximately 114,000 acres of mixed-conifer fuels (USDA, 2008c). When these acres are added to acres in the park and above the rim (33,800), the total comes to approximately 147,800 acres. Cumulative impacts to mixed-conifer forests in and adjacent to the park would be less than impacts within the park since the increase in acres of mixed-conifer is large. Those impacts would be averse minor to moderate, to beneficial, moderate, local to regional, or long term.

Cumulative Effects **Alternative 2** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Spruce-Fir**

The amount of suppression fires in spruce-fir could be similar or slightly higher than past fire seasons, and fires managed for resource benefit could increase. There is only one prescribed fire planned in the spruce-fir forest type, so effects of that project could be small. According to projected fire severity calculations, there could be a smaller amount of higher severity fires (suppression fires up to 69%) and an increase in lower severity fires (wildland fire use up to 40%). Table 4-9 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. There is only a small amount of data from past suppression and wildland fire-use fires, but available information determined levels of severity that occurred since 2000 (See Table 4-8, Table 4-15a). Section 2.4.2.2 states,"Various authors have suggested that current structure and composition of Southwest spruce-fir forests are in the natural range of variation present before Euro-American influence. They reasoned that, 1) the fire exclusion period has been shorter than fire intervals for a presumed crown-fire regime (White and Vankat 1993, Dahms and Geils 1997, Laughlin et al. 2005), and 2) stands may have been little affected by historic livestock grazing (Dahms and Geils 1997)." Future fire effects could be close to the natural range of variation, since forest conditions are close or within the natural range of variation. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Large patches of high and moderate/high severity fire will move the forest away from some of the desired conditions listed in section 2.4.1.3, and small patches scattered through the forest will move the forest toward those desired conditions. If future fire patch size is large, impacts would be adverse, minor, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Therefore, cumulative impacts of past and proposed fire severities would be adverse, minor, to beneficial, moderate, local, long term.

The North Kaibab Ranger District identified approximately 29,000 acres of spruce-fir forests (USDA, 2008c). When these acres are added to acres in the park (17,700 acres), the total comes to approximately 46,700 acres. Cumulative impacts to spruce-fir forests in and adjacent to the park would be the same as impacts in the park since acres of spruce-fir on the Kaibab Plateau double, but the total amount of spruce-fir forests in the Southwest is very small. Those impacts would be adverse, minor, to beneficial, moderate, local to regional, long term.

Cumulative Effects Alternative 2 Vegetation

Cumulative effects are similar to Alternative 1 from past and planned treatments adjacent to the park.

Conclusion Alternative 2 Vegetation

- Ponderosa Pine
  Impacts to vegetation composition and structure will be major, beneficial, long term, and regional. However, there will be adverse, minor, short-term, local impacts as plants are crushed during mechanical treatments. As surface fuels and tree densities decrease there will be beneficial, moderate, local impacts. Protection from Insects/Pathogens/Drought impacts would range moderate to major beneficial short to long term direct and indirect regional. Minor adverse impacts would occur from untreated areas and low intensity fires.
- Mixed-Conifer
  There would be beneficial, major, long-term impacts due to greater fire intensities in the absence of Alternative 1's MSO mitigation restrictions. Impacts from suppression fires with large crown fires and at 97th weather percentile would be moderate to major, adverse, long term, regional. There would be beneficial, major, long-term, regional impacts due to fire severities allowed within the natural range of variability for mixed severity. There would also be moderate, beneficial impacts due to this fire treatment. After the planning period, impacts from suppression fires would be minor adverse. There would be an overall beneficial, major, long-term, regional impacts due to more spatial complexity from less restrictive mitigation measures after the planning period. Protection from Insects/Pathogens/Drought impacts would be moderate beneficial long term regional.
- Spruce-Fir
  After the planning period, predicted fire regime and fire behavior would have minor, beneficial, long-term, local impacts in areas where prescribed fire treatment will occur. There will be moderate, adverse, short-term, regional impacts in untreated areas; and beneficial, moderate, long-term, regional impacts in WFU-treated areas. After the planning period, vegetation composition and structure would have minor, beneficial, local impacts for areas treated with prescribed fire. There will also be adverse, moderate, short-term, regional impacts in untreated areas. WFU-treated areas would have moderate to major, beneficial, regional impact for spatial pattern and severity. Protection from

Insects/Pathogens/Drought impacts would be major, beneficial, long term and regional from WFU and minor, adverse, local, long-term impacts where WFU does not occur.

- Piñon-Juniper
  After the planning period there would be minor, adverse impacts to predicted fire regime and fire behavior, and moderate, beneficial, local impacts to vegetation composition and structure in treated areas. Protection from Insects/Pathogens/Drought impacts would be moderate, beneficial, long term, local in treated areas due to reduction in tree density. If the drought continues regionally, there would be major, adverse, long-term regional impacts; and minor to moderate, adverse, local, long-term impacts in piñon-juniper if drought continues only at Grand Canyon.
- Montane Subalpine Grasslands
  After the planning period, there would be moderate, beneficial, local, impacts to predicted fire regime and fire behavior, and moderate, beneficial, local impacts to vegetation composition and structure.
- Below the Rim
  After the planning period, there would be moderate beneficial local impacts to predicted fire regime and fire behavior; vegetation composition and structure impacts would be moderate beneficial local.
- South Rim WUI
  After the planning period there would be minor, beneficial, local, short-term impacts to predicted fire regime and fire behavior in treated areas. Since treatment level is low in the immediate vicinity of structures there would be moderate, adverse, local impacts. There would be minor, beneficial, short-term, local impacts for fire potential. After the planning period there would be moderate, beneficial, local impacts to vegetation composition and structure.
- Cumulative Effects
  - Past or Planned Actions in areas surrounding GRCA
    - Beneficial, moderate to major, local or regional on South Rim
    - Beneficial, moderate to major in treated areas on North Rim
    - Adverse, major in unplanned and untreated areas not treated with fire in the past 25 years
    - Beneficial, major, regional if fires occur in Mixed-Conifer in weather conditions other than 97th percentile
    - Adverse, moderate, regional if fires occur in Mixed-Conifer in weather conditions at the 97th percentile
  - Long term effects and climate change
    - Beneficial, major, regional in treated areas due to reduced fuels and fire behavior potential

Impairment **Alternative 2** **Vegetation**

Although there are short- to long-term, local and regional, major adverse impacts to these resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair Vegetation during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Vegetation**

Because impacts previously described are not inconsistent with park purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on vegetation as a result of implementation of this Alterative.

4.2.1.13 Alternative 3 Non-Fire Treatment Emphasis Vegetation

Alternative 3 emphasis would be non-fire mechanical and manual treatments in the WUI. Alternative 3 proposes the highest amount of manual and mechanical treatment in the WUI, and the least amount of prescribed and wildland fire-use fire compared with other alternatives. There would be approximately 4,000 acres treated in the WUI through mechanical and manual treatment. This alternative treats the lowest number of total acres, with estimates of 25,400 acres for prescribed fire; 8,800 for wildland fire-use fire; and a projected 26,070 acres annually in fire suppression. The majority of additional suppression acres are assumed to be primarily in North Rim forests. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 3 Vegetation
Treatment Types and Amounts/Fire Ponderosa Pine

The amount of prescribed fire-treated ponderosa pine would be reduced to 21% of this vegetation type in Alternative 3. It is possible that with the limited WFU that would occur, total area treated with prescribed or wildland fire-use fire might increase slightly. Most of the ponderosa pine type treated is South Rim WUI. In addition, it is assumed 6% of ponderosa pine vegetation type (approximately 3,600 acres) would be burned in suppression fires.

Fire Behavior Alternative 3 Vegetation
Ponderosa Pine

Table 4-16 summarizes predicted fire behavior in the ponderosa pine vegetation type in proposed prescribed fire-treatment areas, determined through FlamMap, based on several weather conditions. Similar to Alternative 2, fire severity with fire treatment on North Rim could be greater than low severity. Most prescribed fire would occur between 50th and 80th percentile weather but, depending on conditions, could go higher. Under 90th percentile weather conditions, 94% of fire would burn as surface fire and 6% as passive crown fire (individual tree torching) and no active crown fire (fire spreading crown to crown).

Table 4-16 Predicted Fire Behavior in Prescribed Fire Treatment Areas in Ponderosa Pine During Various Weather Conditions

	Weather Percentile			
Fire Type	50th	80th	90th	97th
Active Crown	0%	0%	0%	17%
Passive Crown	1%	2%	6%	16%
Surface Fire	99%	98%	94%	67%

Specific fire behavior during wildland fire-use fire is not predictable because it is unknown where or during which weather it will burn. Wildland fire-use fires will burn during a variety of weather conditions, potentially including all weather percentiles. Based on current conditions, under all but 97th percentile weather, nearly all (greater than 95%) of the ponderosa pine type is predicted to burn as surface fire. Suppression fires, and a small but unknown percentage of wildland fire-use fires, would more likely burn at 97th percentile weather. As with Alternatives 1 and 2, fire behavior under these weather conditions is predicted at 20% crown fire.

Fire Severity Alternative 3 Vegetation
Ponderosa Pine

Table 4-5 summarizes predicted direct effects to fire severity by fire category in the ponderosa pine vegetation type. Projected severities by fire category are similar to those for Alternatives 1 and 2. Because of past treatments in this vegetation type, the majority of fire severity levels would be low to low/moderate

(73% for suppressed fires, 74% for prescribed fires, 84% for wildland fire-use fires), and a much smaller percentage would be high to moderate/high fire severity levels (13% for suppressed fires, 10% for prescribed fires, 8% for wildland fire-use fires).

Predicted Fire Regime And Fire Behavior After Planning Period **Alternative 3** **Vegetation Ponderosa Pine**

Departure from historic fire regime in Alternative 3 would trend the most away from natural range of variability compared to all alternatives, with a predicted 42% at low departure and 29% at low/moderate departure (Figure 4-4). There would be a trend toward increasing departure from historic fire regime overall, with increases in amount of low/moderate, moderate, and high departure. Monitoring data shows surface fuels accumulate at or near pre-fire levels after ten years. There would be a small increase in area burned as crown fire at high or very high weather conditions (Appendix F). This trend would increase to an unknown extent, but possibly extensively after 20 years of similar management. Over longer periods, in addition to surface fuel accumulation in untreated areas, there would be increased density and decadence of understory vegetation providing ladder fuels and increasing likelihood of crown fire initiation.

Direct effects to predicted fire behavior from implementing this alternative would primarily be low to low/moderate (85%) fire intensity surface fire, with less than 15% crown fire (Figure 4-5) after proposed prescribed fire and manual treatments and projected wildland fire-use fires (after the planning period). This is more than double the predicted crown fire amount in Alternatives 1 and 2 (6%), but fire behavior potential is still relatively low overall after ten years. Based on monitoring data discussed earlier, and predicted fire behavior changes, treated areas would result in continued trends toward natural range of variability in fire behavior in the ponderosa pine vegetation type in treated areas. However, limited treatment area in Alternative 3 would result in a large ponderosa pine portion, particularly on North Rim, that would receive no prescribed or wildland fire-use fire treatments. Since monitoring data shows fuels beginning to accumulate in the fifth to tenth year after fire, there would be a trend away from natural range of variability in fuel loading and fire intensity in untreated areas.

There would be a trend of increasing moderate/high and high severity effects from suppression fires, wildland fire use, and possibly prescribed fires in untreated areas. This adverse effect would be moderate and local initially (during the planning period). Treated areas would remain consistent with the pattern observed since 1993 with low/moderate severity dominating ponderosa pine forests. There would be a beneficial, moderate, local, short-term impact in treated sites in the ponderosa pine type. Since the area treated is very limited in Alternative 3, overall impacts to fire regimes would be adverse, major, regional, and short term in the near future (ten years) and long term after that.

Vegetation Composition And Structure After Planning Period **Alternative 3** **Vegetation Ponderosa Pine**

In treated areas, and most likely some suppression fires areas, there would be a continued trend toward desired conditions with reduced tree densities and surface fuels based on monitoring data, similar to Alternative 1. This effect would be limited since untreated areas would encompass the majority of the ponderosa pine vegetation. In these areas a trend away from desired conditions exists due to a lack of fire that reduces surface fuels, tree density, and tree recruitment. An adverse impact on understory species composition is assumed since many plants in this type are adapted to frequent fire and lower overstory canopy cover. Overall, impact would be adverse, moderate, regional, short term within the planning cycle.

Insects/Pathogens/Drought **Alternative 3** **Vegetation Ponderosa Pine**

In treated areas, there would be a trend toward decreased insect and pathogen levels and increased drought resilience. However, the beneficial trend would be less than described in Alternatives 1 and 2 because less landscape would be treated. Over much of the landscape not planned for treatment, resilience to drought and insect/pathogen incidence would trend away from natural range of variability. Insect levels tend to increase when larger landscape areas contain higher tree densities, providing more opportunities to expand. Untreated area would expand to a large proportion of the ponderosa pine type in Alternative 3, leading to greater likelihood of a large portion of the landscape with increased tree densities and susceptibility to high incidence of insects/pathogens, especially under drought conditions. There would be an adverse, moderate or possibly major, regional, short-term impact on resilience to drought and insect/pathogen incidence.

Mixed-Conifer Alternative 3 Vegetation
Treatment Types and Amounts

An estimated 12% of the mixed-conifer forest type would be treated with prescribed fire in Alternative 3. It is unlikely that many if any additional areas would burn under wildland fire use, since few acres are planned, and historically most of these have focused in the ponderosa pine type. Approximately 24% of mixed-conifer vegetation type (approximately 8,900 acres) is anticipated to burn from suppression fires.

Mixed-Conifer Alternative 3 Vegetation
Fire Behavior

Table 4-17 summarizes predicted fire behavior for prescribed fire units, determined through FlamMap, based on several weather conditions. GRCA normally intends to implement prescribed fire between 50th and 80th percentile weather, or with ignition patterns that would result in mostly moderate/low intensities. Assuming 50th to 80th percentile weather conditions, fire predictions are that 82 to 56% of fire would burn as surface fire, and 18 to 43% as passive crown fire (individual tree torching), and no active crown fire (fire spreading crown to crown). However, these predictions assume higher intensity head fire while prescribed fires are applied as lower intensity backing or patchy fires.

Wildland fire-use fires would burn under more variable weather conditions, primarily at 90th percentile weather or less. Similar to Alternative 2, based on current potential fire behavior, 60% of mixed-conifer type would burn as surface fire during 90th percentile weather conditions, 62% at 80th percentile weather, and 76% during half or more of the fire season (50th percentile). Crown fire would vary from 24% at 50th percentile weather to 40% at 90th percentile weather.

Table 4-17 Predicted Fire Behavior from Prescribed Fire Treatments in Mixed-Conifer Based on Various Weather Conditions

Fire Type	Weather Percentile 50th	80th	90th	97th
Active Crown	0%	0%	0%	45%
Passive Crown	18%	43%	47%	27%
Surface Fire	82%	56%	53%	29%

Predicted fire behavior from prescribed and wildland fire-use fires would be within historic range of variability under most weather conditions (90th percentile weather or less). There would be an unknown amount of wildland fire-use fire, and likely suppression fires, which would burn as higher intensity at 97th percentile weather, with up to 47% of the mixed-conifer vegetation type potentially burning as crown fire. Depending on area burned under 97th percentile weather conditions, impacts could be beneficial or adverse. Larger areas would result in a moderate to major adverse impact with a trend away from natural range of variability. Impacts would be long term but, most likely local since it is unlikely that all mixed-conifer area susceptible to crown fire would burn as crown fire during 97th percentile weather conditions. As noted earlier (Table 4-13), these weather conditions are relatively rare (three days on average per year).

Planned wildland fire-use fire in Alternative 3 is very low; therefore, it is likely that few areas would burn in the mixed-conifer type during these fires types. Likelihood of suppression fires burning in 97th percentile weather conditions would be greater in Alternative 3 than projected in Alternatives 1 or 2, since fewer treatments are planned. This leaves more area with untreated fuel accumulations and a continued trend of greater accumulation.

Mixed-Conifer **Alternative 3** **Vegetation**
Fire Severity

Table 4-7 projects fire severity by fire category in the mixed-conifer vegetation type for each alternative. Projections for Alternative 3 are similar to those for Alternative 2. In summary, fire severity levels would be higher than expected in the ponderosa pine vegetation type. Fire severity varied depending on fire category (unburned, low and low/moderate would be 70% in prescribed fire, 71% in wildland fire-use fire, and 58% in suppression fire; high/moderate to high would be 30% in prescribed fire, 29% in wildland use fire, and 42% in suppression fire). These severity projections for prescribed, wildland fire-use, and some portion of suppression fires are within the natural range of variability for mixed severity historic regime for this type. These fires would result in beneficial, major, local, short-term impacts. There is an increased possibility, compared to Alternative 2, there could also be an adverse, moderate to major, local impact from wildland fire-use or suppression fires that burn at 97th percentile weather conditions. More area burned as suppression fires are projected for Alternative 3 (24% of this vegetation type). This would increase total area expected to burn as high severity fire. Since very little prescribed fire is planned in mixed-conifer in Alternative 3, there would be a trend toward fuel accumulation, higher fire intensity, and hence severity through the planning period. Amount of high severity fire could be greater during 97th percentile weather conditions and may exceed the natural range of variability in extent given uniformly higher density vegetation in the mixed-conifer type compared to historic conditions. There is some evidence that extensive high severity fire may have occurred in some mixed-conifer historically, but frequency and extent of these types of fire events are unknown (Fulé et al. 2003a).

Mixed-Conifer **Alternative 3** **Vegetation**
Predicted Fire Regime And Fire Behavior After Planning Period

After implementation of this alternative, an estimated 29% or more of the mixed-conifer type would be at a high-departure level, with 53% at a low-departure level (Figure 4-6). This is an increase in the low level and a decrease in the high level over current conditions. Even though a limited portion (12%) is treated through prescribed fire, areas where treatments are planned are currently at high level departure. There would be a trend toward increased fire severity levels from suppression and limited wildland fire-use fires due to limited area treated with prescribed fire. Fulé et al. (2004) reported the greatest rates of fuel accumulation and susceptibility to crown fire occur in the mixed-conifer type. There is limited monitoring data for mixed-conifer sites for ten years after treatment, but two sites at ten years show substantial increases in white fir regeneration, thus ladder fuels could increase likelihood of crown fire initiation. Monitoring data also show increases in stem density from understory shrubs five years after fire. If this density is sustained at ten years and decadence increases, then shrubs could also contribute to increased likelihood of crown fire initiation.

As with Alternatives 1 and 2, before fire treatment activities proposed with this alternative can be implemented, 47% of mixed-conifer treated would burn as crown fire under very high (97th percentile) weather conditions. After prescribed fire, manual treatments, and projected wildland fire-use fires (planning period), crown fire proportion under these weather conditions is predicted to decrease slightly to 41% (Figure 4-7). Wildland fire-use fire would result in decreased surface fuels and increased canopy base height, reducing future crown fire potential. In areas burned under wildland fire-use fires there would be a beneficial trend toward the natural range of variability in the spatial complexity aspect of fire regimes. But these areas are likely to be very limited in Alternative 3; beneficial impacts would be minor.

There would be a trend away from fire pattern spatial complexity due to the low amount of wildland fire-use fire. Areas treated with prescribed fire could have a trend toward restoration of fire regime spatial complexity, depending on ignition pattern. This beneficial impact would be minor to moderate due to limited acres planned for prescribed fire.

Overall, there would be a beneficial, minor or possibly moderate, local, short-term impact on fire regimes in the mixed-conifer type. Projected increase in fires suppressed would add to the long-term, moderate to major, adverse impact.

Mixed-Conifer　　Alternative 3　　Vegetation
Vegetation Composition And Structure After Planning Period

There would be a trend away from desired condition in most of the mixed-conifer landscape since a relatively small proportion would be treated. Effects to vegetation composition and structure in treated areas would be beneficial, major, long-term, regional. This alternative is different than any of the other action alternatives due to lack of prescribed fire treatments and increased suppression treatments. Because of this difference, impacts would be adverse, moderate to major, local, short to long term.

Mixed-Conifer　　Alternative 3　　Vegetation
Insects/Pathogens/Drought

There would be increased potential for greater insect/pathogen incidence and drought effects across most of the mixed-conifer landscape since a relatively small proportion is treated. Although treated areas would have a beneficial impact on levels of insects/pathogens and resilience to drought, overall landscape proportion treated would be small. Similar to effects described above for ponderosa pine, proportionate effect across the landscape increases non-linearly with treatment amount. That is, the more treated area in the landscape, the greater benefit across all areas, treated or not. Impacts would be adverse, moderate, regional, and short term.

Spruce-Fir　　Alternative 3　　Vegetation
Treatment Types and Amounts

Very low probability of wildland fire-use fire exists here. Further, given greatly reduced levels of prescribed burn treatments and wildland fire use in adjacent mixed-conifer forests, it is more likely that wildfires in mixed-conifer forests would be difficult to contain, and spread into spruce-fir areas. Suppression fires are estimated at 46% (or 8,100 acres) in this vegetation type in the planning period.

Spruce-Fir　　Alternative 3　　Vegetation
Fire Behavior

Table 4-18 summarizes predicted fire behavior from prescribed fire units in spruce-fir, determined through FlamMap, based on several weather conditions. Similar to Alternative 2, conditions would likely be between 50^{th} and 80^{th} percentile weather for prescribed fire, or ignition patterns that would limit uniformly high intensity fire. Assuming worst case, under 50^{th} and 80^{th} percentile weather conditions, 71 to 57% of fire would burn as surface fire, 29 to 43% as passive crown fire (individual tree torching), and no active crown fire (fire spreading crown to crown). As noted earlier, this is assumes higher intensity head fire; prescribed fire conditions would likely have less crown fire.

Wildland fire-use fires would burn under more variable weather conditions, primarily 90^{th} percentile or less. Based on current conditions, 54 to 69% would burn as surface fire; 46 to 31% as crown fire. Suppressed fires would more likely burn under 97^{th} percentile weather conditions. Predicted fire behavior for these weather conditions result in 51% crown fire with 25% active crown fire (Table F-6, Figure F-3).

Table 4-18 Predicted Fire Behavior from Prescribed Fire Treatments in Spruce-Fir Based on Various Weather Conditions

Fire Type	Weather Percentile 50th	80th	90th	97th
Active Crown	0%	0%	0%	27%
Passive Crown	29%	43%	46%	23%
Surface Fire	71%	57%	54%	50%

There is high degree of uncertainty about amount of crown fire that occurred in spruce-fir. Overall, historic fire regime was thought to be mixed severity with some infrequent high severity fires. Given the susceptibility of the dominant species (thin bark spruce) to fire, an unknown mixture of surface and crown fire could have resulted in the historic mixed severity pattern.

Spruce-Fir Alternative 3 Vegetation
Fire Severity

Table 4-9 projects fire severity by fire type in spruce-fir vegetation for each alternative. Similar to Alternatives 1 and 2, fire severity levels would be higher than expected in ponderosa pine or mixed-conifer vegetation types, and prescribed and wildland fire-use fires would have the same expected severity levels (high to moderate/high levels 40%; low to low/moderate levels 30%; unburned 30%). Suppression fires would have higher severity levels (69% high to moderate/high levels; 27% low to low/moderate levels; 4% unburned).

Spruce-Fir Alternative 3 Vegetation
Predicted Fire Regime, and Fire Behavior After Planning Period

Effects to fire regime would be similar to Alternative 2, but with greater likelihood of suppression fires, especially at 97th percentile weather conditions when fires are least likely to be effectively suppressed. 46% of this vegetation type is predicted to burn as suppression fire (compared to 36% for Alternatives 1 and 2). There would be an increased trend away from historic fire regimes, and increased area with moderate/high departure. There would be a trend of increasing fire severity, particularly from suppression fires more difficult to contain in mixed-conifer forests and that move into the spruce-fir type. This would also result in a decreased spatial complexity of fires.

After planned prescribed fire and manual treatments in spruce-fir, predicted area burned as crown fire during very high (97th percentile) weather conditions would be similar to Alternatives 1 and 2, at 49%.

Outside the area planned for prescribed fire treatment, without any wildland fire use, historic fire departure would continue to trend away from the natural range of variability with an increasing area at moderate or moderate/high departure levels. In the untreated portion, impacts would be adverse, short term, moderate at the regional scale.

There is uncertainty on impact of wildland fire-use or suppression fires on historic fire-regime departure. If these fires occur at conditions other than the 97th percentile weather, beneficial, minor to moderate, long term impacts are expected. Impacts would most likely be local. For suppression fires or portions of wildland fire-use fires at 97th percentile weather, fire intensity and severity would be greater, and potential for adverse, minor to moderate, long-term effects. Potential adverse impact would be greater in Alternative 3 than Alternative 1 and 2 due to reduced treatment in adjacent mixed-conifer type and a predicted increase in acres burned by suppression fires. As stated earlier, there is increased likelihood of suppression fires initiated in mixed-conifer building increased behavior, decreasing suppression effectiveness and, as a result, increasing probability of high intensity fire spreading to spruce-fir.

Spruce-Fir **Alternative 3** **Vegetation**
Vegetation Composition and Structure After Planning Period

Effects to vegetation composition and structure in untreated areas trend away from desired conditions. These impacts would be adverse, short term, moderate, regional. Because there is a higher likelihood of wildfire occurring at 97th percentile weather conditions, there is higher likelihood of uniformly high severity fire. For suppression fires at 97th percentile weather, vegetation composition would be less complex, and potential for adverse, minor to moderate, long-term effects. Decreased spatial complexity from wildfire and/or no wildland fire-use fire would result in a continued trend toward uniform vegetation. Uniform vegetation is a trend away from a historic pattern of spatially heterogeneous vegetation composition and structure.

Spruce-Fir **Alternative 3** **Vegetation**
Insects/Pathogens/Drought

Insect/pathogen incidence would increase; drought resilience decrease. Effects occur due to vegetation uniformity and lack of agents to reduce density; an adverse moderate short-term regional impact.

Effects would be beneficial and indirect on insect/pathogen levels and extent, as well as resilience to drought, where suppression fires occur due to decreased tree density in burned areas. In addition, an increased aspen proportion and decreased spruce-fir proportion would limit extent of spruce budworm outbreaks. In the absence of wildland fire use, effects would be adverse, minor, local and long term.

Piñon-Juniper **Alternative 3** **Vegetation**

Effects to the piñon-juniper vegetation type would be similar to those described for Alternative 1, except there would be an increase in non-fire treatment (manual and mechanical treatment). In addition, areas treated with prescribed fire only in Alternative 1 would be treated with both mechanical/manual treatment and prescribed fire in Alternative 3. This increase is small when compared to the vegetation type's total size (approximately 306,600 acres). See Alternative 1 for a full description of effects to the piñon-juniper vegetation type.

There would be effects on understory plant species composition including crushing from mechanical treatment compared to manual fuel-hazard reductions in the WUI. Impacts are adverse, minor, local, short term. Manual and mechanical treatments are expected to be more effective in reducing tree density than prescribed fire. Because of this, effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, and local.

Montane-Subalpine Grassland **Alternative 3** **Vegetation**

Effects to montane and subalpine grasslands are similar to Alternative 2, except for a decrease in beneficial impact of fire treatments on forest encroachment into adjacent grasslands. However, an increase in suppression fire and fire severity in mixed-conifer and spruce-fir would decrease encroachment, and may offset decreased effects of prescribed and wildland fire-use fires. Therefore impacts would be beneficial, minor to moderate, and local.

Below the Rim **Alternative 3** **Vegetation**

Effects to vegetation Below the Rim would be similar to Alternative 1, except more high intensity fire is more likely to spill fire over the rim. This impact would be adverse, minor, local, and short term.

These fire-behavior characteristics would cause relatively low severity effects to soils and surface and overstory vegetation, but moderate/high severity effects to understory and midstory vegetation. Gambel oak and New Mexico locust are two prevalent species, and both resprout vigorously after fire. Midstory vegetation recovery is likely rapid and vigorous. Overall, expected effects from Alternative 3 to vegetation composition and structure Below the Rim would be beneficial, moderate, and local.

South Rim WUI **Alternative 3** **Vegetation**

The greatest treatment amount in WUI of all alternatives is planned in Alternative 3. Prescribed fire in the secondary WUI would result in reduced fire behavior and crown fire potential in surrounding areas. This is particularly true southwest of Grand Canyon Village. Prevailing winds are from the southwest; therefore, treatments to the southwest are likely to decrease likelihood of fire progressing uncontained from this area toward Grand Canyon Village. Treatments in this area would also reduce ember production potential, reducing likelihood of spotting from this area into Grand Canyon Village. Considerable treatment is planned in developed areas and adjacent undeveloped areas. It is assumed these treatments would be effective in reducing dead fuel load (including dead shrub branches), resulting in decreased likelihood of ignition or fire spread in developed areas in the South Rim WUI. Effect would be beneficial, major, short-term, regional impact to WUI fire potential.

Mitigation of Effects **Alternative 3** **Vegetation**

Mitigations acknowledged in 4.2.1.5 would reduce adverse impacts to vegetation from invasion and expansion of exotic plant species. Recommended mitigation measures for exotic plants are in 4.3.5.1.3; recommended mitigation measures for soil compaction due to mechanical treatments are in 4.2.3.11.

Cumulative Effects **Alternative 3** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Pinon-Juniper**

It is unclear how many acres of each forest type will burn with suppression or resource benefit objectives. Suppression fires will increase slightly while future fires managed for resource benefit will decrease in Alternative 3 as compared to the past. Past fire history in piñon-juniper shows approximately 2% of total acres have burned, and it will be assumed an additional approximation of 2% of piñon-juniper will burn during the life of this plan. According to Table 4-15a the majority of past fire severity has been low and moderate/low with a large amount of unburned areas, and that same type of fire severity is expected to continue. Table 4-11 projects the amount of high and moderate/high severity in the piñon-juniper forest type to be 7-48%. The lower percentages are projected for prescribed fires, and the 48% percent is projected for fires with suppression objectives. If more fires burn under a suppression response than in the past there may be a slight increase in the amount of high and moderat/ high severity effects compared to past fires. Current models can't predict sizes of high and moderate/high severity patches, but if the past is any indicator, very little (less than 1% of the forest type) will experience that type of fire severity. Due to the small overall percentage of fire that has and is expected to occur in the pi-on juniper forest type, cumulative impacts of past and proposed fire severities would be negligible, local, short to long term.

The Tusayan District of the KNF identified approximately 189,000 acres of piñon-juniper woodland vegetation (USDA, 2008c). When these acres are added to park acres (309,800 acres), the total comes to 498,000 acres. Cumulative impacts to piñon-juniper forests in and adjacent to the park would be less than impacts in the park since combined acres of piñon-juniper are so large. Those impacts would be negligible, local to regional, short to long term.

Cumulative Effects **Alternative 3** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Ponderosa Pine**

The amount of suppression fires in ponderosa pine could be more than past fire seasons, and there could be a large decrease of fires managed for resource benefit. Reduction in the prescribed fire and fire use program will mean an increase in dead-and-down fuel loading creating additional higher severity fire effects on future suppression fires. Past fire severity data (2000 – 2007) by fire and forest types are located in Table 4-15a. Fire history shows approximately 80% of the total acres burned, so it will be assumed many fires in the pine forest, regardless of ignition source, will be a second- or multiple-entry fire. Past fires were primarily first-entry burns. Past burns that were second- or third-entry showed a higher percent of low and moderate/low severity fire effects (two examples include Topeka 98%, and Walhalla Cape Final 99%). The amount of high and moderate/high severity in the ponderosa pine forest type from past projects (2000-2007) is approximately 4%. Most fires in this forest type have been from prescribed fire projects and wildland fire-use fires. Projected fire severity levels for future fires (8-13%) can be found in Table 4-5. Higher severity fires are predicted on fires with suppression objectives. Prescribed fires and fires managed for resource benefit are predicted to be lower severity fires. Current models can't predict sizes of high and moderate/high severity patches. Size of high and moderate/high severity patches will determine if impacts are beneficial or adverse. Increase in suppression fires will increase the chance of large patches of high and moderate/high severity fire effects. Impacts from predicted patches of high and moderate/high severity patches along with past patches would be adverse, moderate, local, long term. If patches are not large but stay small and scattered, impacts would be beneficial, minor, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse, moderate, to beneficial, minor, local, short to long term.

The North Kaibab RD has identified approximately 155,000 acres of ponderosa pine forests (USDA, 2008c) and the Tusayan District of the KNF identified approximately 105,000 acres (USDA, 2008c). When these acres are added to park acres (59,600 acres), the total comes to approximately 319,600 acres. Cumulative impacts to ponderosa pine forests in and adjacent to the park would be less than impacts in the park since the increase in total acres of ponderosa pine is so large. Those impacts would be adverse, minor, regional, short to long term.

Cumulative Effects **Alternative 3** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Mixed-Conifer**

The amount of suppression fires in mixed-conifer forest could be more than past fire seasons, and there could be a significant decrease in fires managed for resource benefit. The prescribed fire program does not focus on reestablishing fire in mixed-conifer forests, which has the highest level of departure from historic fire regime (Figure 4-2). Thus, there will be a large decrease in amount of prescribed fire. According to projected fire severity calculations, there could be a higher amount of high severity fires (suppression fires up to 42%) and a decrease in lower severity fires (wildland fire use, prescribed fire up to 30%). Table 4-7 provides a summary of projected fire severity by fire category percentage and fire severity level used in determining effects for all alternatives in this vegetation type. Mitigation measures developed to protect mixed-conifer forests limits the park to no more then 30% high and moderate/high fire severity effects in mixed-conifer from past (2000-2007) and proposed fires. Since 15% of the forest type has already burned with high and moderate/high severity effects, all future high and moderate/high fire effects will not exceed 15% of the forest type. Past fire severity data (2000 – 2007) by fire and forest types are located in Table 4-15a. There is no current model that describes sizes of high and moderate/high severity patches. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Approximately half of moderate/high and high severity fire is concentrated on three past fires and in large patches. It is assumed that more large patches of high and moderate/high severity fire will occur during future suppression fires, and more suppression fire could occur in this alternative than any other alternative. If patch size from future fires is large, impacts would be adverse, moderate to major, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse, moderate to major; beneficial, moderate, local to regional, long term.

The North Kaibab Ranger District identified approximately 114,000 acres of mixed-conifer fuels (USDA, 2008c). When these acres are added to park acres and above the rim (33,800), the total comes to approximately 147,800 acres. Cumulative impacts to mixed-conifer forests in and adjacent to the park would be less than impacts within the park since the increase in acres of mixed-conifer is large. Those impacts would be adverse to beneficial, moderate, local to regional, long term.

Cumulative Effects — Alternative 3 — Vegetation
Past or Planned Actions in and Surrounding GRCA — Spruce-Fir

Amount of suppression fire in spruce-fir could be more than past fire seasons, and there could be a large decrease in fires managed for resource benefit. There is only one prescribed fire planned in the spruce-fir forest type, so effects of that project could be small. According to projected fire severity calculations, there could be an increase in higher severity fires (suppression fires up to 69%) and a decrease in lower severity fires (wildland fire use up to 40%). Table 4-9 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. There is only a small amount of data from past suppression and wildland fire use fires, but available information was used to determine levels of severity since 2000 (See Table 4-8, Table 4-15a). Section 2.4.2.2 states, "Various authors have suggested that current structure and composition of Southwest spruce-fir forests are in the natural range of variation present before Euro-American influence. They reasoned that, 1) the fire exclusion period has been shorter than fire intervals for a presumed crown-fire regime (White and Vankat 1993, Dahms and Geils 1997, Laughlin et al. 2005), and 2) stands may have been little affected by historic livestock grazing (Dahms and Geils 1997)." Future fire effects could be close to the natural range of variation, since forest conditions are close or within the natural range of variation. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Large patches of high and moderate/high severity fire will move the forest away from some desired conditions listed in section 2.4.1.3, and small patches scattered through the forest will move the forest toward those desired conditions. The increase in amount of suppression fires may lead to an increase in high and moderate/high severity fire effects. If patch sizes from future fires are large, impacts would be adverse, minor-moderate, local, long term. If patch sizes are small and scattered, impacts would be beneficial, moderate, local, long term. Therefore, cumulative impacts of past and proposed fire severities would be adverse, minor, to beneficial, moderate, local, long term.

The North Kaibab Ranger District identified approximately 29,000 acres of spruce-fir forests (USDA, 2008c). When these acres are added to park acres (17,700 acres), the total is 46,700 acres. Cumulative impacts to spruce-fir forests in and adjacent to the park would be the same as impacts in the park since acres of spruce-fir on the Kaibab Plateau double, but the total amount of spruce-fir forests in the Southwest is very small. Those impacts would be adverse, minor, to beneficial, moderate, local to regional, long term.

Cumulative Effects — Alternative 3 — Vegetation

The South Kaibab National Forest District would continue fire treatments, but due to the limited amount of fire treatments in this alternative, impacts would be beneficial, minor to moderate, regional, long term.

There would be an increased cumulative, adverse, major, regional, and long-term impact on departure from historic fire regime across all vegetation types in this alternative. There would be an increase in amount of wildfire and high severity fire, particularly in mixed-conifer. This may lead to a higher probability of uncontained wildfire crossing from the park on North Rim into adjacent Kaibab National Forest. There is uncertainty regarding magnitude of increased wildfire and severity probability, but there is certainty that this trend would occur.

Conclusion **Alternative 3** **Vegetation**

- Ponderosa Pine
  Most ponderosa pine type treated is in South Rim WUI. The total area treated with prescribed or wildland fire-use fire might increase slightly. The majority of fire severity levels would be low to low/moderate (73% for suppression fires, 74% for prescribed fires, 84% for wildland fire-use fires). A much smaller percentage would be high to moderate/high fire severity levels (13% for suppressed fires, 10% prescribed fires, 8% wildland fire-use fires). Overall fire regime impact would be adverse, major, regional and short term in the near future (ten years) and long-term after that. Impact to vegetation composition and structure after the planning period would be adverse, moderate, regional and short term. In treated areas, there would be a trend toward decreased insect and pathogen levels and increased drought resilience. In areas untreated with fire activities, there would be moderate adverse or possibly major, regional impacts to insect/pathogens and resilience to drought.
- Mixed-Conifer
  Overall, there would be a beneficial, minor or possibly moderate, local, short-term impact on fire regimes in the mixed-conifer type. Projected increase in fires suppressed would add to the long-term, moderate to major, adverse impact. Impacts to vegetation composition and structure after the planning period would be adverse, moderate to major, local, short to long term. Impacts to insects, pathogens and drought would be adverse, moderate, regional, and short term.
- Spruce-Fir
  There is a very low probability of wildland fire-use fire occurring here. Impacts would be adverse, short term, moderate, and regional. At 97th percentile weather there is potential for adverse, minor to moderate, long-term effects. Incidence of insects/pathogens would increase and resilience to drought decrease. Therefore, impacts would be adverse, moderate, short term and regional.
- Piñon-Juniper
  Similar to effects of Alternative 1, but with an increase in non-fire treatment. Predicted fire regime and fire behavior after the planning period would be adverse and minor due to the small fire treatment and if cheatgrass invades or increases. Vegetation would be subject to increased crushing from mechanical treatments. Impacts would be adverse, minor, local, and short term, yet, beneficial, moderate, and local in treated areas. In relationship to Insects/Pathogens/Drought, effects of decreasing surface fuels and tree densities would be beneficial and moderate in treated areas, but local. If drought continues regionally, impacts will be adverse, major, long term, and regional. If drought continues only at Grand Canyon, impacts for piñon-juniper will be adverse, minor to moderate, local, and long term.
- Montane Subalpine Grasslands
  Predicted fire regime and fire behavior after the planning period would be similar to Alternative 2 except for a decrease in beneficial impact of fire treatments on forest encroachment into adjacent grasslands. Impacts would be beneficial, minor to moderate, and local in relationship to vegetation composition and structure after the planning period.
- Below the Rim
  Predicted fire regime and behavior after the planning period would have effects similar to Alternate 1, except more high intensity fire is likely to spill over the rim. Impact would be adverse, minor, local, and short term. Under this alternative there would be low severity impacts to soils and surface, and moderate/high severity effects to understory and midstory vegetation. Overall, effects would be beneficial, moderate, local.
- South Rim WUI
  Alternative 3 has the greatest treatment amount of all alternatives. There would be reduced fire behavior and reduced crown fire potential in surrounding areas. Predicted fire regime and behavior after the planning period would be a reduced fuel load; effect would be beneficial, major, short term and regional.

- Cumulative Effects

  There would be an increased cumulative, adverse, major, regional, long-term impact on departure from historic fire regime across all vegetation types in this alternative. There would be an increase in high severity fire, particularly in mixed-conifer.

Impairment **Alternative 3** **Vegetation**

Although there are short- to long-term local to regional major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair Vegetation during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Vegetation**

Because impacts previously described are not inconsistent with park purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on vegetation as a result of implementation of this Alterative.

4.2.1.14 Alternative 4 Prescribed Fire Emphasis Vegetation

In Alternative 4, emphasis would be on prescribed fire, burning approximately 90,000 acres. An approximate 24,070 acres would burn from suppression fires; wildland fire-use fire would be used least of the alternatives at 5,500 acres; and mechanical and manual treatments would occur on approximately 800 acres in GRCA's top priority areas. A detailed description of this alternative is found in Chapter 2.

Direct, Indirect And Cumulative Effects **Alternative 4** **Vegetation**
Treatment Types And Amounts/Fire **Ponderosa Pine**

The greatest proportion of the ponderosa pine type (54%) is treated with prescribed fire and manual/mechanical treatment in Alternative 4. However, total area treated is less than other alternatives except Alternative 3 due to the limited wildland fire use expected. Areas planned for treatment manually or mechanically exist around park facilities. Amount of wildland fire use is most restricted in Alternative 4, with an expected 5,500 total acres over the planning period. As a result, total area expected to burn as prescribed or wildland fire-use fire is slightly lower than projected for Alternatives 1 and 2. Suppression acres predicted for ponderosa pine is estimated at 3,000 acres or 5% of this vegetation type.

Ponderosa Pine **Alternative 4** **Vegetation**
Fire Behavior

Table 4-19 summarizes predicted fire behavior in the ponderosa pine vegetation type in proposed prescribed fire treatment areas, determined through FlamMap, based on several weather conditions. Similar to Alternatives 2 and 3, during prescribed fire, normal conditions would be between 50th and 80th percentile weather but could go higher. At greater weather conditions, test fires and ignition patterns would be used to ensure burn objectives were met. Between 50th and 80th percentile weather conditions, 98 to 96% of fire would burn as surface fire, 2 to 4% as passive crown fire (individual tree torching), and no active crown fire (fire spreading crown to crown). At 90th percentile weather conditions, slightly more passive crown fire is predicted (6%); however, these projections assume head fires which are higher intensity than typical backing fires or spot ignitions used in prescribed fires.

Specific fire behavior during wildland fire-use fires is not predictable because it is unknown where or during which weather they would burn. Wildland fire-use fires would burn during a variety of weather conditions, potentially including all weather percentiles. Under all but 97th percentile weather, nearly all (greater than 95%) of the ponderosa pine type is predicted to burn as surface fire. Suppression fires and a small but unknown percentage of wildland fire-use fires would more likely burn at 97th percentile weather. Fire behavior under these weather conditions is predicted to be 20% crown fire.

Table 4-19 Predicted Fire Behavior within Prescribed Fire Treatment Areas in Ponderosa Pine During Various Weather Conditions

	Weather Percentile			
Fire Type	50th	80th	90th	97th
Active Crown	0%	0%	0%	14%
Passive Crown	2%	4%	6%	10%
Surface Fire	98%	96%	94%	76%

Ponderosa Pine **Alternative 4** **Vegetation**
Fire Severity

Table 4-5 summarizes predicted direct effects to fire severity by fire category in the ponderosa pine vegetation type. Projected severities by fire category are similar to those for previously discussed alternatives (Alternatives 2, 3). Due to past treatments in this vegetation type, the majority of fire severity levels would be low to low/moderate (73% for suppressed fires, 74% prescribed fires, 84% wildland fire-use fires) and a much smaller percentage would be high to moderate/high fire severity levels (13% for suppressed fires, 10% prescribed fires, 8% wildland fire-use fires).

Ponderosa Pine **Alternative 4** **Vegetation**
Predicted Fire Regime and Fire Behavior After Planning Period

Area at low departure from historic fire regime is projected at 32% after implementation of Alternative 4, the lowest of all alternatives (Figure 4-4). An additional 42% would be at low/moderate departure. There would be a trend toward desired conditions in treated areas, but in untreated areas the trend would be away from desired conditions. This is particularly so in North Rim ponderosa pine forests, since more planned prescribed burns are in the mixed-conifer type (See Alternative 4, Chapter 2). On South Rim, all ponderosa pine is treated and would trend toward low departure from historic fire regime.

The direct effect from implementation of this alternative to predicted fire behavior during very high weather conditions (97th percentile weather) would be nearly the same as Alternative 3, with 86% surface fire and 14% crown fire (Figure 4-5) after proposed prescribed fire and manual treatments, and projected wildland fire-use fires (after the planning period). This is more than double the amount of predicted crown fire in Alternative 1 (6%). This is based on monitoring data discussed earlier and predicted changes in fire behavior. Direct and indirect effects from all fire categories (prescribed, suppression, and wildland fire-use fires) would result in continued trends toward natural range of variability in fire behavior in the ponderosa pine vegetation type in treated areas. However, limited treatment area in ponderosa pine in Alternative 4 would result in a large portion of the ponderosa pine type, particularly on North Rim, that would not receive any type of prescribed fire or wildland fire-use fire. Since monitoring data shows increased fuel loading from the fifth to the tenth year after fire, there would be a trend away from the natural range of variability in fuel loading and fire intensity in untreated areas. Fuel accumulations are especially pronounced after ten years.

Fire severity in areas treated with prescribed fire and burned under suppression fires would continue to experience primarily low severity effects. Outside treated areas, there would be a trend toward increased fire severity due to fuel accumulations, although the exact amount of change is uncertain. There would be a trend toward an increased likelihood of moderate or moderate/high severity with wildland fire use or especially suppression fires.

Spatial complexity of prescribed fires is assumed to be less than that of wildland fire-use fires. Therefore, given emphasis on prescribed fires, there would be a trend away from restoring the spatial complexity component of fire regime in the ponderosa pine type.

Overall, there would be some areas with beneficial and some with adverse impacts to fire regimes. North Rim ponderosa forests would have an adverse impact across the majority of the area, but South Rim impact would be beneficial. Impacts of Alternative 4 to fire regime in the ponderosa pine type would be adverse, moderate, short term and regional in the planning period. As fuels continue to accumulate in the future, impact would become adverse, major, long term, and regional.

Ponderosa Pine Alternative 4 Vegetation
Vegetation Composition And Structure After Planning Period

Effects to vegetation composition and structure in the ponderosa type would be similar to Alternative 3. Areas receiving treatment, and areas where suppression fires occur, would continue to trend toward desired conditions, and those not receiving treatment would trend away from desired conditions. The majority of the North Rim ponderosa pine type would trend away from desired conditions. Most or all South Rim ponderosa would trend toward desired conditions.

Similar to impacts to fire regime, overall, there would be some areas with beneficial impacts and some with adverse impacts to vegetation composition and structure. North Rim ponderosa forests would have an adverse impact across the majority of the area, but South Rim impacts would be beneficial. Alternative 4 impacts to vegetation composition and structure in ponderosa pine would be adverse, minor to moderate, short term, and regional. If fuels continue to accumulate and vegetation density increases beyond the planning period, impact would become adverse, major, long term, and regional.

Ponderosa Pine Alternative 4 Vegetation
Insects/Pathogens/Drought

Impacts would be similar to for Alternative 3. The area untreated would expand to a large proportion of the ponderosa pine type in Alternative 4, leading to greater likelihood of a large portion of the landscape with increased tree densities and susceptibility to high incidence of insects/pathogens; drought conditions would increase susceptibility. There would be an adverse, minor to moderate, regional, short-term impact in untreated areas on resilience to drought and insect/pathogen incidence. In treated areas impacts would be minor, beneficial, regional, and short term.

Mixed-Conifer Alternative 4 Vegetation
Treatment Types and Amounts

The greatest area (62%) in mixed-conifer is proposed for prescribed fire in Alternative 4. However, very limited to no wildland fire use is planned (5,500 total acres in all vegetation types over the planning cycle). Only areas currently within the natural range of variability would be allowed to burn as wildland fire use. Because very little mixed-conifer would be classified in this category, total combined amount of prescribed and wildland fire-use fire would likely be 62% total for this vegetation type. Based on historical data, analysis assumes 22% of the vegetation type (8,200 acres) would burn as suppression fires.

Mixed-Conifer **Alternative 4** **Vegetation**
Fire Behavior

Table 4-20 summarizes predicted fire behavior for prescribed fire units, determined through FlamMap, based on several weather conditions. Similar to Alternatives 2 and 3, prescribed fires would normally occur between 50th and 80th percentile weather conditions, or at greater weather conditions with ignition patterns resulting in similar fire behavior. Assuming 50th to 80th percentile weather conditions, fire predictions are: 74 to 60% of fire would burn as surface fire, 26 to 40% would be passive crown fire (individual tree torching), and no active crown fire (fire spreading crown to crown). However, these predictions assume higher intensity head fire, while prescribed fires are applied as lower intensity backing or patchy fires with likely lower crown fire amounts.

Wildland fire-use fires would burn under more variable weather conditions, primarily at 90th percentile weather or less. Similar to Alternatives 2 and 3, based on the current potential fire behavior, 60% of mixed-conifer type would burn as surface fire during 90th percentile weather conditions, 62% at 80th percentile weather, and 76% during half or more of the fire season (50th percentile). Crown fire would vary from 24% at 50th percentile weather to 40% at 90th percentile weather.

Table 4-20 Predicted Fire Behavior from Prescribed Fire Treatments in Mixed-Conifer Based on Various Weather Conditions

Fire Type	Weather Percentile 50th	80th	90th	97th
Active Crown	0%	0%	0%	25%
Passive Crown	26%	40%	42%	27%
Surface Fire	74%	60%	58%	48%

Predicted fire behavior from prescribed fire and wildland fire-use fires would be within the historic range of variability. An unknown amount of suppression and wildland fire-use fire would burn as higher intensity at 97th percentile weather, with up to 47% of mixed-conifer type potentially burning as crown fire. Depending on extent of area burned under 97th percentile weather conditions, impacts could be beneficial or adverse. Larger areas would result in a moderate to major, long-term, adverse impacts with a trend away from the natural range of variability. Impacts would be long term, but most likely local since it is unlikely that all mixed-conifer area susceptible to crown fire would burn as crown fire during 97th percentile weather conditions. As noted earlier, this weather condition is relatively rare (three days on average per year). The planned amount of wildland fire-use fire in Alternative 4 is very low; therefore, it is likely that few areas would burn in mixed-conifer during these fires types.

Mixed-Conifer **Alternative 4** **Vegetation**
Fire Severity

Table 4-7 projects fire severity by fire category in the mixed-conifer vegetation type for each alternative. Projections for Alternative 4 are similar to those for Alternatives 2 and 3. In summary, fire severity levels would be higher than expected in the ponderosa pine vegetation type. Fire severity varied depending on fire category (unburned, low and low/moderate would be 70% in prescribed fire, 71% in wildland fire-use fire, 58% in suppression fire; high to moderate/high would be 30% in prescribed fire, 29% in wildland use fire, 42% in suppression fire). These severity projections for prescribed, wildland fire-use, and some suppression fires are within the natural range of variability for the mixed severity historic regime for this type. These fires would result in a beneficial, major, local, short-term impact. Similar to Alternatives 2 and 3, there could be an adverse impact of wildland fire-use fires or suppression fires that might occur during 97th percentile weather conditions The amount of high severity fire could be greater during 97th percentile weather conditions and may exceed the natural range of variability in extent given the more uniformly higher density vegetation in the mixed-conifer type compared to historic conditions. There is some evidence that extensive high severity fire may have occurred in some of the mixed-conifer type historically, but frequency and extent of these fire events are unknown (Fulé et al. 2003a). With implementation of this alternative even at 97th percentile weather, impacts are expected to be adverse, moderate, and local from suppression fires.

Mixed-Conifer Alternative 4 Vegetation
Predicted Fire Regime and Fire Behavior After Planning Period

Effects of Alternative 4 on fire regime would be similar to treated areas in Alternative 2. In treated areas there would be a trend toward the natural range of variability and desired conditions for fire regime. Fire severity in treated areas is expected to be within the natural range of variability, with primarily low and moderate severity. This beneficial impact would occur across at least 62% of the type. As summarized in Figure 4-6, departure of historic fire regime overall would trend mostly toward lower amounts of high departure (decreasing from 42% currently to 8%). Amount of mixed-conifer type in a low departure level would increase from 40% currently to 72%. Treated areas would result in reduced fuel load, potential fire intensity and crown fire, and would make containment less difficult.

As with other alternatives, before fire treatment activities proposed with this alternative are implemented, 47% of mixed-conifer treated would burn as crown fire under very high (97th percentile) weather conditions. After prescribed and projected wildland fire-use fires (planning period), the proportion of crown fire under these weather conditions is predicted to decrease to 35% (Figure 4-7). Prescribed fire would result in decreased surface fuels and increased canopy base height, reducing potential for future crown fire. In areas burned with prescribed fire there would be a beneficial trend toward the natural range of variability in spatial complexity aspect of fire regimes, but this would be less than what would occur with wildland fire-use fires. Alternative 4 impacts would be beneficial minor to moderate and regional.

Overall, there would be a beneficial, moderate, short-term, regional impact on fire regimes in the mixed-conifer type since a large portion is treated with prescribed fire (62%) and there is a substantial reduction in area with a high level of departure from historic fire regimes.

Mixed-Conifer Alternative 4 Vegetation
Vegetation Composition And Structure After Planning Period

Effects to vegetation composition and structure would be similar to that described above for fire regimes. In treated areas, there would be a trend toward desired conditions. In untreated areas there would be a continued trend away from desired conditions. Since a large portion (approximately 62%) of the mixed-conifer type would be treated, overall there would be a beneficial, moderate, short-term, regional impact on vegetation structure and composition with lack of wildland fire-use fire.

Mixed-Conifer Alternative 4 Vegetation
Insects/Pathogens/Drought

The relatively high treatment level in mixed-conifer would result in beneficial impacts to resilience to drought and insect/pathogen incidence in treated areas. Vegetation in untreated areas or areas not burned from suppression fires would remain dense, with a lower level of resilience to drought and susceptibility to increased insect/pathogen incidence. Adverse impacts to adjacent ponderosa pine might result in increased potential for insect incidence in mixed-conifer, particularly to ponderosa pine because insect incidence can increase when larger landscape areas are susceptible or have higher tree densities. Uncertainty exists about potential adverse impact magnitude on mixed-conifer. Overall, expected impact of decreasing potential for insect/pathogens would be beneficial, moderate to major, regional, short term.

Spruce-Fir **Alternative 4** **Vegetation**
Treatment Types and Amounts

Alternative 4 has the greatest amount of prescribed fire treatment planned in the spruce-fir type (27%). There are two prescribed burns planned in the northern portion of the spruce-fir vegetation type. Fire Staff predicts 43% of this vegetation type would burn from suppression fires in this alternative. Wildland fire use in Alternative 4 is limited to where desired conditions have been met.

Spruce-Fir **Alternative 4** **Vegetation**
Fire Behavior

Table 4-21 summarizes predicted fire behavior for prescribed fire units in the spruce-fir vegetation type, determined through FlamMap, based on several weather conditions. Similar to Alternatives 2 and 3, prescribed fires would normally occur when conditions are between 50th and 80th percentile weather, or under greater weather conditions with ignition patterns that would result in similar fire behavior. Assuming worst case, under 50th to 80th percentile weather conditions, 77 to 67% of the fire would burn as surface fire, 23 to 33% as passive crown fire (individual tree torching), and no active crown fire (fire spreading crown to crown). Because these estimates are based on higher intensity head fire, crown fire percentages would most likely be lower.

Table 4-21 Predicted Fire Behavior from Prescribed Fire Treatments in Spruce-Fir Based on Various Weather Conditions

Fire Type	Weather Percentile 50th	80th	90th	97th
Active Crown	0%	0%	0%	24%
Passive Crown	23%	33%	35%	19%
Surface Fire	77%	67%	65%	57%

Wildland fire-use fires would burn under more variable weather conditions, primarily at 90th percentile or less. Based on estimated conditions, 54 to 69% of these fires would burn as surface fire, and 31 to 46% as crown fire during 50th to 90th percentile weather conditions. The exact amount of surface versus crown fire is unknown since it is also unknown during which weather conditions areas might burn.

Suppression fires would more likely burn under 97th percentile weather conditions. Predicted fire behavior for these weather conditions result in 51% crown fire, 25% active crown fire (Table F-6, Figure F-4). There is some unknown possibility that wildland fire-use fires may burn through periods of 97th percentile weather.

There is a high degree of uncertainty about amount of crown fire that would occur in the spruce-fir type. Overall, historic fire regime was thought to be mixed severity with infrequent high severity. Given susceptibility of the dominant species (spruce) to fire, an unknown mixture of surface and crown fire could have resulted in the historic mixed severity pattern.

Spruce-Fir **Alternative 4** Vegetation
Fire Severity

Table 4-9 projects fire severity by fire type in the spruce-fir vegetation type for each alternative. Similar to the other alternatives, fire severity levels would be higher than expected in ponderosa pine or mixed-conifer vegetation types, and prescribed and wildland fire-use fires would have the same expected severity levels (high to moderate/high levels 40%, low to low/moderate levels 30%, unburned 30%).

Suppression fires would have higher severity levels (69% high to moderate/high levels, 27% low to low/moderate levels; 4% unburned).

Spruce-Fir **Alternative 4** **Vegetation**
Predicted Fire Regime, and Fire Behavior After Planning Period

There would be an increase in proportion of spruce-fir with a low or low/moderate departure of historic fire regime in Alternative 4. Proportion of low departure would increase from 16% currently to 29% after proposed treatments. Proportion of low/moderate departure would increase from 38% currently to 42%. Proportion of moderate departure would decline from 45% currently to 28%. It is assumed that treatments would have a beneficial impact on vegetation structure and composition; a trend toward desired conditions in treated areas. In treated areas impact would be beneficial, moderate, and short term. There would be an increased trend away from historic fire regimes and increased area with moderate/high departure. Although treated areas in spruce-fir are greatest in Alternative 4, they only encompass 27% of the type. Therefore, overall impacts would be adverse, moderate, regional, and short-term. Suppression fires in 97th percentile weather may have an adverse, moderate, regional, and long-term impact. If suppression fires occur at conditions below 97th percentile weather then impacts are expected to be beneficial, minor to moderate, regional, and long term.

Spruce-Fir **Alternative 4** **Vegetation**
Insects/Pathogens/Drought

Treated areas would trend toward natural range of variability for drought resilience and insects/pathogen incidence. There would also be a beneficial impact of reduced insect/pathogen incidence in adjacent mixed-conifer. This would reduce area in overall landscape with a higher insect/pathogen incidence potential. Larger landscape areas in susceptible conditions can increase likelihood of insect incidence, since insect populations are more likely to increase overall and migrate to different landscape areas. Overall, there would be a beneficial, moderate, local, short-term impact to resilience to drought, and effects from insects/pathogens.

Piñon-Juniper **Alternative 4** **Vegetation**

Alternative 4 shows increase in proportion of treated acres in prescribed fire of all the other alternatives. Impacts to treated areas would be similar to all alternatives, beneficial but moderate, local, and short term.

There would be effects on understory plant species composition including crushing from mechanical treatment compared to manual fuel-hazard reductions in the WUI. Impacts are adverse, minor, local, short term. Manual and mechanical treatments are expected to be more effective in reducing tree density than prescribed fire. Because of this, effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, and local.

Montane and Subalpine Grasslands **Alternative 4** **Vegetation**

Effects to montane and subalpine grasslands are similar to Alternative 2, except for an overall decrease in beneficial impacts of fire use or treatments on grassland encroachment into adjacent forests. There would be a local beneficial impact in grasslands near mixed-conifer forests, since more of this vegetation is proposed for prescribed fire treatment. Impacts would beneficial minor to moderate local short term.

Below the Rim **Alternative 4** **Vegetation**

Impacts of Alternative 4 Below the Rim are similar to Alternative 1.

South Rim WUI **Alternative 4** **Vegetation**

There is a reduced treatment level in the WUI in Alternative 4 compared to Alternatives 2 and 3. Since there will be less acres treated in Alternative 4 than Alternative 2, impacts will be minor to moderate, beneficial, local and short term.

Mitigation Of Effects **Alternative 4** **Vegetation**

Mitigation measures in 4.2.1.5 would reduce adverse impacts to vegetation from invasion and expansion of exotic plant species. Recommended mitigation measures for exotic plants are in 4.3.5.1.3; recommended mitigation measures for soil compaction due to mechanical treatments are in 4.2.3.11.

Cumulative Effects **Alternative 4** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Piñon-Juniper**

It is unclear how many acres of each forest type will burn with suppression or resource benefit objectives. Suppression fires will increase slightly, and future fires managed for resource benefit will decrease in Alternative 4 as compared to the past. Past fire history in piñon-juniper shows approximately 2% of total acres have burned, and it will be assumed an additional approximation of 5% of pinon-juniper will burn during the life of this plan. According to Table 4-15a the majority of past fire severity has been low and moderate/low with a large amount of unburned areas, and that same type of fire severity is expected to continue. Table 4-11 projects the amount of high and moderate/high severity in the piñon-juniper forest type to be 7-48%. The lower percentages are projected for prescribed fires, and the 48% percent is projected for fires with suppression objectives. If more prescribed fires occur in the future than in the past, there may be a decrease in amount of high and moderate/high severity effects compared to past fires. Current models can't predict sizes of high and moderate/high severity patches, but if the past is any indication, very little (less than1% of the forest type) will experience that type of fire severity. Due to the small overall percentage of fire that occurred and is expected to occur in the piñon-juniper forest type, cumulative impacts of past and proposed fire severities would be negligible, local, short to long term.

The Tusayan District of the KNF identified approximately 189,000 acres of piñon-juniper woodland vegetation (USDA, 2008c). When these acres are added to park acres (309,800 acres), the total is 498,000 acres. Cumulative impacts to piñon-juniper forests in and adjacent to the park would be less than impacts in the park since combined piñon-juniper acres are so large. Those impacts would be negligible, local to regional, short to long term.

Cumulative Effects **Alternative 4** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Ponderosa Pine**

The amount of suppression and prescribed fires in ponderosa pine could increase, and there could be a decrease of fires managed for resource benefit. The slight increase in the suppression program could lead to more high and moderate/high fire severity effects. The large increase in the prescribed fire program will lead to more acres of lower severity fire effects. Past fire severity data (2000 – 2007) by fire and forest types is located in Table 4-15a. Fire history shows approximately 80% of total acres have burned, so it will be assumed that many fires that occur in the pine forest, regardless of ignition source, will be second- or multiple-entry fires. Past fires were primarily first-entry burns. Past second- or third-entry burns showed a higher percent of low and moderate/low severity fire effects (two examples include Topeka 98%, and Walhalla Cape Final 99%). Amount of high and moderate/high severity in the ponderosa pine forest type from past projects (2000-2007) is approximately 4%. Most fires that occurred in this forest type were from prescribed fire projects and wildland fire-use fires. Projected fire severity levels for future fires (8-13%) can be found in Table 4-5. Higher severity fires are predicted to occur on fires with suppression objectives. Prescribed fires and fires managed for resource benefit are predicted to be lower severity fires. Current models can't predict sizes of high and moderate/high severity patches. The size of these high and moderate/high severity patches will determine if impacts are beneficial or adverse. The increase in suppression fires will increase the chance of large patches of high and moderate-high severity fire effects. Impacts from predicted patches of high and moderate/high severity patches along with past patches would be adverse, minor, local, long term. If patches are not large, but small and scattered, impacts would be beneficial, minor, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse to beneficial, minor, local, short to long term.

The North Kaibab Ranger District identified approximately 155,000 acres of ponderosa pine forests (USDA, 2008c), and the Tusayan District of the KNF identified approximately 105,000 acres (USDA, 2008c). When these acres are added to park acres (59,600 acres), the total is 319,600 acres. Cumulative impacts to ponderosa pine forests in and adjacent to the park would be less than impacts in the park since the increase in total acres of ponderosa pine is so large. Those impacts would be negligible to minor beneficial, regional, short to long term.

Cumulative Effects Alternative 4 Vegetation
Past or Planned Actions in and Surrounding GRCA Mixed-Conifer

Amount of suppression fires in mixed-conifer forest could be slightly more than past fire seasons, and there could be a large decrease in fires managed for resource benefit. The prescribed fire program is focused on reestablishing and maintaining fire in mixed-conifer forests, which has the highest level of departure from historic fire regime (Figure 4-2), so there will be a large increase in amount of prescribed fire. According to projected fire severity calculations there could be a similar or slightly higher amount of high severity fires (suppression fires up to 42%), and a large increase in lower severity fires (prescribed fire up to 30%). Table 4-7 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. Mitigation measures developed to protect Mexican spotted owl habitat limits the park to no more then 30% high and moderate/high fire severity effects in mixed-conifer from past (2000-2007) and proposed fires. Since 15% of the forest type has already burned with high and moderate/high severity effects, all future high and moderate/high fire effects will not exceed 15% of the forest type. Past fire severity data (2000 – 2007) by fire and forest types are located in Table 4-15a. There is no current model that will describe sizes of high and moderate/high severity patches. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Approximately half of moderate/high and high severity fire are concentrated on three past fires and in large patches. If patch size from future fires are large, impacts would be adverse, moderate, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse to beneficial, moderate, local to regional, long term.

The North Kaibab Ranger District identified approximately 114,000 acres of mixed-conifer fuels (USDA, 2008c). When these acres are added to park acres and above the rim (33,800), the total is 147,800 acres. Cumulative impacts to mixed-conifer forests in and adjacent to the park would be less than impacts within the park since the increase in acres of mixed-conifer is large. Those impacts would be minor to moderate to beneficial, moderate, local to regional, long term

Cumulative Effects Alternative 4 Vegetation
Past or Planned Actions in and Surrounding GRCA Spruce-Fir

Amount of suppression fires in spruce-fir could be similar or slightly more than past fire seasons, and there could be a large decrease in fires managed for resource benefit. There are three prescribed fires planned in the spruce-fir forest type, which is more than all other alternatives. According to projected fire severity calculations, there could be a similar or slightly higher amount of higher severity fires (suppression fires up to 69%), and an increase in lower severity fires (prescribed fire up to 40%). Table 4-9 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. There is only a small amount of data from past suppression and wildland fire-use fires, but available information determined levels of severity 2000 (See Table 4-8, Table 4-15a). Section 2.4.2.2 states, "Various authors have suggested that current structure and composition of Southwest spruce-fir forests are in the natural range of variation present before Euro-American influence. They reasoned that, 1) the fire exclusion period has been shorter than fire intervals for a presumed crown-fire regime (White and Vankat 1993, Dahms and Geils 1997, Laughlin et al. 2005), and 2) stands may have been little affected by historic livestock grazing (Dahms and Geils 1997)." Future fire effects could be close to the natural range of variation since the forest conditions are close or within the natural range of variation. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Large patches of high and moderate/high severity fire will move the forest away from some desired conditions listed in section 2.4.1.3, and small patches scattered through the forest will move the forest toward those desired conditions. Increase in amount of suppression fires may lead to an increase in high and moderate/high severity fire effects, but the increase in prescribed fire could decrease future adverse fire effects. If patch size from future fires are large, impacts would be adverse, minor, local, long term. If patch sizes are small and scattered, impacts would be beneficial, moderate, local, long term. Therefore, cumulative impacts of past and proposed fire severities would be adverse, minor, to beneficial, moderate, local, long term.

The North Kaibab RD has identified approximately 29,000 acres of Spruce-fir forests (USDA, 2008c). When these acres are added to the acres in the ark (17,700 acres), the total comes to approximately 46,700 acres. The cumulative impacts to the spruce-fir forests that are in and adjacent to the Park would be the same as the impacts within the park since the acres of spruce-fir on the Kaibab Plateau double, but the total amount of spruce-fir forests within the Southwest is very small. Those impacts would be adverse, minor, to beneficial, moderate, local to regional, and long term.

Cumulative Effects Alternative 4 Vegetation

Alternative 4 is similar to Alternative 1, but due to increased fire treatments in this alternative impacts would be beneficial, moderate, regional, long term.

Conclusion Alternative 4 Vegetation

- Ponderosa Pine
  Impacts of Alternative 4 to fire regime in the ponderosa pine type would be adverse, moderate, short term and regional in the planning period. As fuels continue to accumulate, impact would become adverse, major, long term, and regional. The majority of North Rim ponderosa pine type would trend away from desired conditions. Most or all South Rim ponderosa pine type would trend toward desired conditions. North Rim ponderosa pine forests would have an adverse impact across the majority of the area, but South Rim impacts would be beneficial. Impacts of Alternative 4 to vegetation composition and structure in the ponderosa pine type would be adverse, minor to moderate, short term, and regional in the planning period. If fuels continue to accumulate and vegetation density increases beyond the planning period, impacts would become adverse, major, long term, and regional. There would be an adverse, minor to moderate, regional short-term impact in untreated areas on resilience to drought and insect/pathogen incidence. In treated areas impacts would be minor, beneficial, regional, and short term.
- Mixed-Conifer
  Depending on area extent burned under 97th percentile weather conditions, impacts could be beneficial or adverse. Larger areas would result in a moderate to major, long-term, adverse impact with a trend away from the natural range of variability. Impacts would be long term but likely local since it is unlikely that all mixed-conifer area susceptible to crown fire would burn as crown fire during 97th percentile weather conditions.
  - *Fire Severity* At 97th percentile weather, adverse, moderate, local impacts are expected from suppression fires.

- *Predicted Fire Regime And Fire Behavior After Planning Period* Overall, there would be a beneficial, moderate, short-term, regional impact on fire regimes in the mixed-conifer type since a large portion is treated with prescribed fire (62%), and there is a substantial reduction in area with a high level of departure from historic fire regimes. Overall, there would be a beneficial, moderate, short-term, regional impact on vegetation structure and composition with lack of wildland fire-use fire. Overall, expected impact of decreasing potential for insects and pathogens would be beneficial, moderate to major, regional, and short term.

- Spruce Fir

  Predicted Fire Regime And Fire Behavior After Planning Period Overall impacts would be adverse, moderate, regional, and short term.

  Vegetation Composition and Structure after the Planning Period In treated areas impact would be beneficial, moderate, and short term.

  Overall, there would be a beneficial, moderate, local, and short-term impact to resilience to drought, and effects from insects/pathogens.

- Piñon-Juniper

  Impacts to treated areas would be similar to all alternatives, beneficial but moderate, local, and short term. Effects on understory plant species composition would include crushing from mechanical treatment. Impacts would be adverse, minor, local, and short term. Effects of decreasing surface fuels and tree densities would be beneficial and moderate in the treated area, and local in effect.

- Montane Subalpine Grasslands

  After the planning period there would be moderate, beneficial, local impacts to predicted fire regime and fire behavior. After the planning period moderate, beneficial local impacts to vegetation composition and structure.

- Below the Rim

  Very similar to Alternative 1 with predicted fire regime and fire behavior after the planning period being beneficial, moderate, local since WFU may occur. Overall, vegetation composition and structure after the planning period would be beneficial, moderate, and local.

- South Rim WUI

  Minor to moderate, beneficial, local, and short term.

- Cumulative Effects

  Impacts would be beneficial, moderate, regional, and long term.

Impairment Alternative 4 Vegetation

Although there are short- to long-term, local and regional, major adverse impacts to these resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair Vegetation during implementation of Alternative 4.

Unacceptable Impacts Alternative 4 Vegetation

Because impacts previously described are not inconsistent with park purpose and values; do not prevent the attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on vegetation as a result of implementation of this Alterative.

4.2.1.15 Alternative 5 Fire Use Emphasis Vegetation

Alternative 5 emphasis is to restore and maintain forest types with wildland fire use (88,000 acres). With wildland fire use focus, fewer fires would be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative deemphasizes prescribed fire treatments with treatment of 29,900 acres. Mechanical and manual treatments would total approximately 2,675 acres and would occur in the WUI. A description is found in Chapter 2 .

Direct, Indirect and Cumulative Effects **Alternative 5** **Vegetation**
Treatment Types and Amounts/Fire **Ponderosa Pine**

Amount of prescribed fire and manual/mechanical treatments (23%) planned in Alternative 5 is similar to Alternative 3. The greatest amount of wildland fire-use fire is proposed in Alternative 5, with 88,000 total acres for all vegetation types over the planning cycle. It is likely that a large proportion would occur in ponderosa pine. In the past 25 years, an average 57% of wildland fire use has occurred in ponderosa pine, in some years up to 90%. Total area in the ponderosa pine type is just under 60,000 acres; thus, it is likely a high proportion or all of the ponderosa pine type on North Rim could have wildland fire-use fire. It is impossible to predict exactly how much or where wildland fire-use fire would occur. Based on historical data, it is assumed approximately 2,400 acres (4%) of this vegetation type would burn as suppression fire.

Ponderosa Pine **Alternative 5** **Vegetation**
Fire Behavior

Table 4-22 summarizes predicted fire behavior in the ponderosa pine vegetation type in proposed prescribed fire treatment areas, determined through FlamMap, based on several weather conditions. As with the other alternatives, most prescribed fires would occur between 50th and 80th percentile weather but depending on conditions, could go higher. Under 50th to 80th percentile weather conditions, 99 to 98% of the fire would burn as surface fire and 1 to 2% as passive crown fire (individual tree torching) and no active crown fire (fire spreading crown to crown).

Table 4-22 Predicted Fire Behavior in Prescribed Fire Treatment Areas in Ponderosa Pine During Various Weather Conditions

	Weather Percentile			
Fire Type	50th	80th	90th	97th
Active Crown	0%	0%	0%	17%
Passive Crown	1%	2%	6%	15%
Surface Fire	99%	98%	94%	68%

As with the other alternatives, specific fire behavior during wildland fire-use fires is not predictable because it is unknown where or during which weather they will burn. Wildland fire-use fires would burn during a variety of weather conditions, potentially including all weather percentiles. Under all but 97th percentile weather, nearly all (greater than or equal to 95% according to Table F-4) of the ponderosa pine type is predicted to burn as surface fire. Suppression fires and a small but unknown percentage of wildland fire-use fires would more likely burn at 97th percentile weather. Under these conditions 20% crown fire behavior is predicted (Table F-4).

Ponderosa Pine **Alternative 5** **Vegetation**
Fire Severity

Table 4-5 summarizes predicted direct effects to fire severity by fire category in the ponderosa pine vegetation type. Projected severities by fire category are similar to Alternatives 1 through 4. Due to past treatments in this vegetation type, the majority of fire severity levels would be low to low/moderate (73% for suppressed fires, 74% for prescribed fires, 84% for wildland fire-use fires) and a much smaller percentage would be high to moderate/high fire severity levels (13% suppressed fires, 10% prescribed fires, 8% wildland fire-use fires).

Ponderosa Pine **Alternative 5** **Vegetation**
Predicted Fire Regime And Fire Behavior After the Planning Period

Impacts of wildland fire-use fire in Alternative 5 would be similar to ponderosa pine in the other alternatives. However, impact would be more extensive. As summarized in Figure 4-4, after Alternative 5 implementation an estimated 81% of the ponderosa pine type is predicted to be at a low level of departure from historic fire (after the planning period). This is assuming an average of 57% of wildland fire-use fires would occur in ponderosa pine type. If the amount is greater, then the level of ponderosa pine at a low departure level could be even greater than 81%.

The direct effect from this alternative to predicted fire behavior would be primarily low to low/moderate intensity surface fires (98%), with less than 2% crown fire (Figure 4-5) after proposed prescribed fire and manual treatments, and projected wildland fire-use fires (after the planning period). This is slightly less crown fire than predicted for Alternative 1 (at 6%). Based on monitoring data discussed earlier and predicted fire behavior changes, direct and direct effects from all fire categories (prescribed, suppression, and wildland fire-use fires) would result in continued trends toward natural range of variability in fire behavior in ponderosa pine vegetation.

In addition, similar to Alternative 1 areas burned under wildland fire use would display beneficial direct impacts to fire regime element of spatial complexity—with spatial complexity at or trending toward natural range of variability.

Overall, Alternative 5 impact on fire regimes in the ponderosa pine type would be beneficial, major, regional, and short term.

Ponderosa Pine **Alternative 5** **Vegetation**
Vegetation Composition and Structure After the Planning Period

Impact to vegetation composition and structure would be similar to that described above to fire regime. There would be a continued trend toward desired conditions. Since wildland fire-use fire would provide a second or, in some areas, third fire entry, fuel levels and tree densities would trend nearer to desired conditions, similar to Alternatives 1 and 2. Overall, impact would be beneficial, major, regional, and long term. Impacts would be long term as there would be a widespread trend toward continued decreases in small tree and seedling density. This would have a long-lasting, beneficial impact on future medium- and large-tree densities.

Ponderosa Pine **Alternative 5** **Vegetation**
Insects/Pathogens/Drought

Impact to drought resilience and insect/pathogen incidence are similar to Alternative 1.

Mixed-Conifer **Alternative 5** **Vegetation**
Treatment Types and Amounts

Amount of prescribed fire proposed in Alternative 5 (24%) is less than all other alternatives except Alternative 3. Since 1980, an average 20% of wildland fire-use fires have occurred in the mixed-conifer type. In many years, no wildland fire-use fire occurred in mixed-conifer, but in several years the level ranged from 33 to 47%, and in 2003 reached 65% of total wildland fire-use acres that burned in GRCA. Impacts to fire regime described below were determined assuming the average level of 20% of wildland fire-use acres would occur in the mixed-conifer type (47% of the mixed-conifer vegetation type). Based on historical data, it is assumed 17% (approximately 6,400 acres) of the mixed-conifer vegetation type would burn as suppression fires during this planning period.

Mixed-Conifer **Alternative 5** **Vegetation**
Fire Behavior

Table 4-23 summarizes predicted fire behavior for prescribed fire-treatment units, determined through FlamMap, based on several weather conditions. Similar to Alternatives 2 through 4, most prescribed fire would occur between 50th and 80th weather percentiles, but could occur at higher weather conditions with ignition patterns that would result in similar fire behavior. Assuming 50th to 80th weather percentile conditions, fire predictions are that 64 to 46% of fire would burn as surface fire and 36 to 54% would be passive crown fire (individual tree torching) and no active crown fire (fire spreading crown to crown). However, these predictions assume higher intensity head fire while prescribed fires are applied as lower intensity backing or patchy fires. Projected crown fire percentage would likely be less.

Wildland fire-use fires would burn under more variable weather conditions, primarily at 90th percentile weather or less. Based on current potential fire behavior (Table F-5), 60% of mixed-conifer type would burn as surface fire during 90th percentile weather conditions, 62% at 80th percentile weather, and 76% during half or more of the fire season (50th percentile). Crown fire would vary from 24% at 50th percentile weather to 40% at 90th percentile.

Table 4-23 Predicted Fire Behavior from Prescribed Fire Treatments in Mixed-Conifer Based on Various Weather Conditions

Fire Type	Weather Percentile 50th	80th	90th	97th
Active Crown	0%	0%	0%	38%
Passive Crown	36%	54%	57%	35%
Surface Fire	64%	46%	43%	27%

Similar to Alternatives 2 through 4, predicted fire behavior from prescribed fire and wildland fire-use fires would be within historic range of variability under most weather conditions (90th percentile weather or less). An unknown amount of wildland fire-use and suppression fires would burn as higher intensity at 97th percentile weather, with up to 47% of mixed-conifer potentially burning as crown fire. Depending on extent of area burned under 97th percentile weather conditions, impacts could be beneficial or adverse. Larger areas would result in a moderate to major adverse impact with a trend away from natural range of variability. Impacts would be long term but most likely local since it is unlikely that all mixed-conifer susceptible to crown fire would burn as crown fire during 97th percentile weather conditions. As noted in the other alternatives, this weather condition is relatively rare (three days on average per year).

Mixed-Conifer **Alternative 5** **Vegetation**
Fire Severity

Table 4-7 projects fire severity by fire category in the mixed-conifer vegetation type for each alternative. Similar to Alternatives 2 through 4, fire severity levels would be higher than expected in the ponderosa pine vegetation type. Fire severity varied depending on fire category (unburned, low and low/moderate would be 70% in prescribed fire, 71% in wildland fire-use fire, 58% in suppression fire; high to moderate /high 30% in prescribed fire, 29% in wildland use fire, 42% in suppression fire). Severity projections for prescribed, wildland fire-use, and some suppression fires are within natural range of variability for the mixed severity historic regime for this type. These fires would result in a beneficial, major, local, short-term impact. There is possibility there could also be an adverse, moderate to major, local impact from wildland fire-use or suppression fires at 97th percentile weather. Amount of high severity fire could be greater during these conditions and may exceed natural range of variability in extent given the more uniformly higher density vegetation in the mixed-conifer type compared to historic conditions. With implementation of this alternative even at 97th percentile weather, impacts are expected to be adverse, moderate, and local from wildland fire-use or suppression fires. There is some evidence that extensive high severity fire may have occurred in some of the mixed-conifer type historically, but frequency and extent of these fire events are unknown (Fulé et al. 2003a).

Mixed-Conifer Alternative 5 Vegetation
Predicted Fire Regime and Fire Behavior after the Planning Period

Effects of Alternative 5 on fire regime in mixed-conifer would be similar to Alternative 2. Estimated proportion of mixed-conifer at a low level of departure of historic fire regime is 75% at the end of the planning cycle (Figure 4-6). As with Alternative 2, overall a beneficial, major, long-term, regional impact is expected to fire regimes from wildland fire-use fire. Likelihood of high severity fire in the short term is greater than anticipated for Alternatives 1 and 2 because fewer mixed-conifer areas are planned for prescribed fire with this alternative. This means there would be more areas without a prior prescribed fire treatment that may have wildland fire-use fire. In addition, suppression fires would cover approximately 17% of this vegetation type. Likelihood of high severity effects would be limited primarily to several days each year when very high weather conditions occur. Therefore, there is some unknown likelihood of adverse, likely moderate, local impacts to fire regimes in the mixed-conifer type.

Before fire-treatment activities proposed with this alternative are implemented, 47% of mixed-conifer treated would burn as crown fire under very high (97th percentile) weather conditions. Similar to Alternative 1 and 2, after prescribed and projected wildland fire-use fires occur (after the planning period), crown fire proportion under these weather conditions is predicted to decrease to less than 18% (Figure 4-7). Wildland fire-use fire would result in decreased surface fuels and increased canopy base height, reducing future crown-fire potential. In areas burned under wildland fire-use fires there would be a beneficial trend toward the natural range of variability in spatial complexity aspect of fire regimes.

Overall, impacts would be primarily beneficial, major, regional and long term. However, there is increased likelihood beyond what is expected for Alternatives 1 and 2, that there may also be adverse, major, regional, long-term impacts if a substantial portion of mixed-conifer burns at or over 97th percentile weather conditions as either wildland fire-use or suppression fires. Likelihood of adverse impacts from wildland fire-use fires is greater in Alternative 5 because less than one-fourth of the type would be treated with prescribed fire. These prescribed fires would reduce fuels and potential fire behavior and severity for any future wildland fire-use fires.

Mixed-Conifer Alternative 5 Vegetation
Vegetation Composition and Structure after Planning Period

Effects to vegetation composition and structure would be similar to Alternative 2. Overall, a beneficial, major, long-term, regional impact is expected to vegetation structure and composition in the mixed-conifer type. However, there is a similar uncertainty of the likelihood of an uncharacteristically high severity fire as described above for impacts to fire regimes. Therefore, there is some unknown likelihood of some adverse, likely moderate and local, or possibly major and long-term, impact to vegetation composition and structure in the mixed-conifer type. This could occur from either wildland fire-use fires that burn during 97th percentile weather conditions or suppression fires.

Mixed-Conifer Alternative 5 Vegetation
Insects/Pathogens/Drought

Effects to drought resilience and insect/pathogen incidence would be similar to Alternative 2.

Spruce-Fir **Alternative 5** **Vegetation**
Treatment Types and Amounts

Similar treatment types and amounts would occur in Alternative 5 as in Alternative 2 in the spruce-fir vegetation type. Less than 20% of this vegetation type has planned prescribed fire treatment. Wildland fire use amount is uncertain, but likely similar to that described for Alternative 1 or 2, or it could be greater. Suppression fires are estimated to cover 32% (or 5,600 acres) of this vegetation type. This alternative proposes the least amount of suppression fires in this vegetation type.

Spruce-Fir **Alternative 5** **Vegetation**
Fire Behavior and Severity

Impacts would be similar to that described for Alternative 2.

Spruce-Fir **Alternative 5** **Vegetation**
Fire Regime

Alternative 5 effects would be similar to Alternative 2. There would be similar beneficial impacts in the one treatment area, but this effect would be local. Effects of wildland fire-use fire would be similar to Alternative 2. Overall, impacts would be expected to be beneficial, moderate to major, local to regional, and long term. There would be uncertainty associated with likelihood of more intense fire behavior and associated, uniformly high severity effects resulting in potentially adverse impact to fire regime in the spruce-fir type. There may be a higher likelihood of high intensity fire (during 97th percentile weather) moving from mixed-conifer into the spruce-fir type, since less mixed-conifer area would be treated with prescribed fire with this alternative. Also, wildland fire-use fire increase may increase likelihood of fire burning during very high weather conditions.

Spruce-Fir **Alternative 5** **Vegetation**
Vegetation Composition and Structure

Effects to vegetation composition and structure would be similar to Alternative 2, with increased uncertainty of potential adverse impacts as described above for fire regime.

Spruce-Fir **Alternative 5** **Vegetation**
Insects/Pathogens/Drought

Effects would be similar to those described for Alternatives 1.

Piñon-Juniper **Alternative 5** **Vegetation**

Impacts to the piñon-juniper type would be the same as those described in Alternative 2.

Montane and Subalpine Grasslands **Alternative 5** **Vegetation**

Impacts to montane and subalpine grasslands would be similar to Alternatives 1 and 2, except with an increase in wildland fire use in mixed-conifer and spruce-fir, more fire would occur in the grassland-forest boundary similar to what occurred historically, a trend toward natural range of variability for this portion of meadows bordering forests, and would be beneficial moderate long term local.

Below the Rim **Alternative 5** **Vegetation**

Impacts Below the Rim would be similar to those described for Alternatives 1.

South Rim WUI **Alternative 5** **Vegetation**

Impacts to South Rim WUI would be similar to Alternative 2. Slightly more area would be treated than Alterative 2. Impact of additional treatments would have moderate to major beneficial impacts to WUI.

Mitigation of Effects **Alternative 5** **Vegetation**

Mitigation measures in 4.2.1.5 would reduce adverse impacts to vegetation from invasion and expansion of exotic plant species. Recommended mitigation measures for exotic plants are in 4.3.5.1.3; recommended mitigation measures for soil compaction due to mechanical treatments are in 4.2.3.11.

Cumulative Effects **Alternative 5** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Piñon-Juniper**

It is unclear how many acres of each forest type will burn with suppression or resource benefit objectives. Suppression fires will decrease slightly, and future fires managed for resource benefit will increase in Alternative 5 as compared to the past. Past fire history in piñon-juniper shows approximately 2% of total acres have burned, and it will be assumed an additional approximation of 2-3% of piñon-juniper will burn during the life of this plan. According to Table 4-15a, the majority of past fire severity has been low and moderate/low with a large amount of unburned areas; that same type of fire severity is expected to continue. Table 4-11 projects the amount of high and moderate/high severity in the piñon-juniper forest type to be 7-48%. The lower percentages are projected for prescribed fires, and the 48% percent is projected for fires with suppression objectives. If more fires managed for resource benefit occur in the future than what occurred in the past, there may be a decrease or increase in amount of high and moderate/high severity effects compared to past fires. Current models can't predict sizes of high and moderate/high severity patches, but if the past is any indication, very little (less than 1% of the forest type) will experience that type of fire severity. Due to the small overall percentage of fire that has and is expected to occur in the piñon-juniper forest type, cumulative impacts of past and proposed fire severities would be negligible, local, short to long term.

The Tusayan District of the KNF identified approximately 189,000 acres of piñon-juniper woodland vegetation (USDA, 2008c). When these acres are added to park acres (309,800 acres), the total is 498,000 acres. Cumulative impacts to piñon-juniper forests in and adjacent to the park would be less than impacts in the park since combined acres of piñon-juniper are so large. Those impacts would be negligible, local to regional, short to long term.

Cumulative Effects **Alternative 5** **Vegetation**
Past or Planned Actions in and Surrounding GRCA **Ponderosa Pine**

The amount of suppression fires in ponderosa pine could be less than past fire seasons, and there could be a large increase in fires managed for resource benefit. The prescribed fire program, in this forest type, will be less than the past. According to projected fire severity calculations there could be a decrease in high severity fires (suppression fires) and an increase in lower severity fires (wildland fire use). Fire history shows approximately 80% of total acres have burned, so it will be assumed that many fires that occur in the pine forest regardless of ignition source will be second-entry or multiple-entry burns. Past fires were primarily first-entry burns. Those past second- or third-entry burns burns showed a higher percent of low and moderate/low severity fire effects (two examples include Topeka 98%, and Walhalla Cape Final 9%). The amount of high and moderate/high severity in the ponderosa pine forest type from past projects (2000-2007) is approximately 4%. Past fire severity data (2000 – 2007) by fire type and forest type is located in Table 4-15a. Projected fire severity levels for future fires (8 -13%) can be found in Table 4-5. Current models can't predict sizes of high and moderate/high severity patches. Size of these high and moderate/high severity patches will determine if impacts are beneficial or adverse. The decrease in suppression fires will decrease the chance of large patches high of moderate/high severity fire effects. If patch size is large, impacts would be adverse, minor, local, long term. If patch size is small and scattered, impacts would be beneficial, minor, local, long term. Thus, cumulative impacts of GRCA's past and proposed fire severity in the ponderosa pine forest type in relation to ponderosa pine forests in and adjacent to the park would be adverse to beneficial, minor, local, short to long term.

The North Kaibab Ranger District has identified approximately 155,000 acres of ponderosa pine forests (USDA, 2008c), and the Tusayan District of the KNF has identified approximately 105,000 acres (USDA, 2008c). When these acres are added to park acres (59,600 acres), the total is 319,600 acres. Cumulative impacts to ponderosa pine forests in and adjacent to the park would be less than impacts in the park since the increase in total acres of ponderosa pine is so large. Those impacts would be adverse and beneficial, negligible to minor, regional, short to long term.

Cumulative Effects — Alternative 5 — Vegetation
Past or Planned Actions in and Surrounding GRCA — Mixed-Conifer

The amount of suppression fires in mixed-conifer forest could be less than past fire seasons, and there could be a large increase fires managed for resource benefit. The prescribed fire program is focused on fuel reduction in the WUI and not in the mixed-conifer forest which has the highest level of departure from historic fire regime (Figure 4-2), so there will be a large decrease in amount of prescribed fire. According to projected fire severity calculations there could be a slightly lower amount of high severity fires (suppression fires up to 42%) and an large increase in lower severity fires (wildland fire use up to 29%). Table 4-7 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. Mitigation measures developed to protect mixed-conifer forests limits the park to no more than 30% high and moderate/high fire severity effects in mixed-conifer from past (2000-2007) and proposed fires. Since 15% of the forest type has already burned with high and moderate/high severity effects, all future high and moderate/high fire effects will not exceed 15% of the forest type. Past fire severity data (2000 – 2007) by fire and forest types is located in Table 4-15a. There is no current model that will describe sizes of high and moderate/high severity patches. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Approximately half of moderate/high and high severity fire is concentrated on three past fires and in large patches. If patch sizes from future fires are large, impacts would be adverse, moderate, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Thus, cumulative impacts of past and proposed fire severities would be adverse to beneficial, moderate, local to regional, long term.

The North Kaibab Ranger District has identified approximately 114,000 acres of mixed-conifer fuels (USDA, 2008c). When these acres are added to park acres and above the rim (33,800), the total is 147,800 acres. Cumulative impacts to mixed-conifer forests in and adjacent to the park would be less than the impacts within the park since the increase in acres of mixed-conifer is large. Those impacts would be minor to moderate to beneficial, moderate, local to regional, long term.

Cumulative Effects — Alternative 5 — Vegetation
Past or Planned Actions in and Surrounding GRCA — Spruce-Fir

The amount of suppression fires in spruce-fir could be less than past fire seasons, and there could be a large increase in fires managed for resource benefit. There is only one prescribed fire planned in the spruce-fir forest type, so effects of that project could be small. According to projected fire severity calculations, there could be a smaller amount of higher severity fires (suppression fires up to 69%) and an increase in lower severity fires (wildland fire use up to 40%). Table 4-9 provides a summary of the average percentage, by fire severity level, used in determining effects for all alternatives in this vegetation type. There is only a small amount of data from past suppression and wildland fire-use fires, but available information determined levels of severity since 2000 (See Table 4-8, Table 4-15a). Section 2.4.2.2 states, "Various authors have suggested that current structure and composition of Southwest spruce-fir forests are in the natural range of variation present before Euro-American influence. They reasoned that, 1) the fire exclusion period has been shorter than fire intervals for a presumed crown-fire regime (White and Vankat 1993, Dahms and Geils 1997, Laughlin et al. 2005), and 2) stands may have been little affected by historic livestock grazing (Dahms and Geils 1997)." Future fire effects could be close to the natural range of variation, since forest conditions are close or within the natural range of variation. The combination of patch size of high and moderate/high severity fire from past and proposed fires will determine if impacts are beneficial or adverse. Large patches of high and moderate/high severity fire will move the forest away from some desired conditions listed in section 2.4.1.3, and small patches scattered through the forest will move the forest toward those desired conditions. Wildland fire-use fires could reduce impacts from future higher severity suppression fires. If patch sizes from future fires are large, impacts would be adverse, minor, local, long term. If patch size is small and scattered, impacts would be beneficial, moderate, local, long term. Therefore, cumulative impacts of past and proposed fire severities would be adverse, minor, to beneficial, moderate, local, long term.

The North Kaibab Ranger District identified approximately 29,000 acres of spruce-fir forests (USDA, 2008c). When these acres are added to park acres (17,700 acres), the total is 46,700 acres. Cumulative impacts to spruce-fir forests in and adjacent to the park would be the same as impacts in the park since acres of spruce-fir on the Kaibab Plateau double, but the total amount of spruce-fir forests in the Southwest is very small. Those impacts would be adverse, minor, to beneficial, moderate, local to regional, long term.

Cumulative Effects — Alternative 5 — Vegetation

Overall, cumulative effects would be similar to those described for Alternatives 1.

Conclusion — Alternative 5 — Vegetation

- **Ponderosa Pine**
  Predicted fire regime and fire behavior after the planning period would demonstrate an overall impact on fire regimes in ponderosa pine that would be beneficial, major, regional, and short term. Vegetation composition and structure after the planning period would demonstrate a continued trend toward desired conditions with an overall beneficial, major, regional, and long-term impact. Impacts would be long term because there would be a widespread trend toward continued decreases in small tree and seedling density. This would have a beneficial impact on future medium- and large-tree densities. Protection from Insects/Pathogens/Drought impacts would be similar to Alternative 1. *Prescribed Fire Treatment* There would be a moderate to major beneficial, short- to long-term impact to insects/pathogens/drought tolerance. Wildland fire use would demonstrate indirect, moderate to major, beneficial impacts. Minor adverse impact from untreated areas and areas burned at low intensities. Overall, impacts would be beneficial, moderate, long term and regional.
- **Mixed-Conifer**
  Depending on extent burned under 97th percentile weather conditions, fire-behavior impacts could be beneficial or adverse. Larger areas would result in a moderate to major adverse impacts with a trend away from natural range of variability. Impacts would be long term, but likely local since it is unlikely all mixed-conifer susceptible to crown fire would burn as crown fire during 97th percentile weather. Overall fire severity would result in a beneficial major, local, short-term impact. Yet, severity could also be an adverse, moderate to major, local impact from wildland fire-use or suppression fires that burn at 97th percentile weather conditions. However, at 97th percentile weather, impacts are expected to be adverse, moderate, and local from wildland fire-use or suppression fires. Overall predicted fire regime and behavior after the planning period is expected to be a beneficial, major, long-term, regional impact from wildland fire-use fire. There is some unknown likelihood that there could be some adverse, likely moderate, local impact. Vegetation composition and structure after the planning period would be similar to Alternative 2 with overall impact being beneficial, major, long term, and regional. There is some unknown likelihood of some adverse, likely moderate, and local or

possibly major and long-term impact. Protection from Insects/Pathogens/Drought impacts are similar to Alternative 2 in being beneficial, moderate to major, long term, and regional.

- **Spruce-Fir**
  Treatment types and amounts would be similar to Alternative 2: beneficial and indirect in treated areas. Fire behavior would be similar to Alternative 2. The predicted overall fire regime and fire-behavior impacts after the planning period would be beneficial, moderate to major, local to regional, and long term. There would remain an uncertainty associated with the likelihood of more intense fire behavior. Vegetation composition and structure after the planning period would be similar to that of Alternative 2, and would be beneficial, minor, local for areas treated with prescribed fire. Impacts would be adverse, moderate, short-term, and regional in untreated areas, and beneficial, moderate to major, regional for spatial pattern and severity treated with WFU. Protection from Insects/Pathogens/Drought impacts would be beneficial indirect in areas treated with prescribed fire; adverse minor local long term if WFU does not occur; and beneficial major long term regional if WFU does occur.
- **Piñon-Juniper**
  Would be basically the same as Alternative 2. After the planning period there would be minor, adverse impacts to predicted fire regime and fire behavior. After the planning period there would be moderate, beneficial, local impacts to vegetation composition and structure in treated areas. Protection from Insects/Pathogens/Drought impacts would be moderate, beneficial, long term and local in treated areas due to reduction in tree density. If the drought continues regionally, there would be major, adverse, long-term regional impacts; and minor to moderate, adverse, local, long-term impacts in the piñon-juniper vegetation type if the drought continues in Grand Canyon only.
- **Montane Subalpine Grasslands**
  Predicted fire regime and behavior after the planning period would be beneficial, moderate and local. Vegetation composition and structure after planning period would be beneficial, moderate, and local.
- **Below the Rim**
  Predicted fire regime and fire behavior after planning period would be beneficial, moderate, and local since WFU may occur. Overall vegetation composition and structure after the planning period would be beneficial, moderate, and local.
- **South Rim WUI**
  Slightly more area would be treated than Alterative 2. Impact of additional treatments would have moderate to major beneficial impacts to WFU. Predicted fire regime and behavior after the planning period would be beneficial, minor, local, and short term in treated areas; adverse, moderate, local in the immediate vicinity of structures since treatment level is low. Effects would be beneficial, minor, short-term, local for fire potential. Overall vegetation composition and structure after the planning period would be beneficial, moderate, and local.
- **Cumulative Effects**
  Overall cumulative effects would be similar to Alternative 1.
  - Past or Planned Actions in areas surrounding GRCA
    - Beneficial, moderate to major, local or regional on South Rim
    - Beneficial, moderate to major in treated areas on North Rim
    - Adverse, major in unplanned and untreated areas
    - Beneficial, major, regional if fires occur in Mixed-Conifer in weather conditions other than 97th percentile
    - Adverse, moderate, regional if fires occur in Mixed-Conifer in weather conditions at 97th percentile
  - Long-term effects regarding climate change would be beneficial, major, and regional in treated areas due to reduced fuels and fire-behavior potential.

Impairment **Alternative 5** **Vegetation**

Although there are short- to long-term, local and regional, major adverse impacts to these resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair Vegetation during implementation of Alternative 5.

Unacceptable Impacts **Alternative 5** **Vegetation**

Because impacts previously described are not inconsistent with park purpose and values; do not prevent the attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on vegetation as a result of implementation of this Alterative.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Vegetation**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, either through implementing mitigation measures or by changing the nature of a proposed action. Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternative 1 would have adverse, moderate to major, long-term, local impacts in mixed-conifer forests from suppression fires that burn at 97th percentile weather conditions due to increased acres predicted to burn as high severity fire, such fire moves these forests away from desired conditions.

Alternative 2 would have adverse, moderate to major, long-term, local impacts from suppression fires that burn at 97th percentile weather conditions due to increased acres predicted to burn as high severity fire, which moves these forests away from desired conditions.

Alternative 3 would have adverse, moderate, regional, short-term impacts to vegetation composition and structure in ponderosa pine forests due to the trend away from desired conditions. Alternative 3 would have adverse, moderate to major, short- to long-term, regional, direct and indirect impacts in ponderosa pine forests due to reduced resilience of these forests to insects, pathogens, and drought. Alternative 3 would have adverse, moderate, short-term, regional, direct and indirect impacts in mixed-conifer forests due to reduced resilience of these forests to insects, pathogens, and drought. Alternative 3 would have adverse, moderate to major, long-term, local impacts from wildland fire-use or suppression fires that burn at 97th percentile weather conditions due to increased acres predicted to burn as high severity fire, which moves these forests away from desired conditions. Alternative 3 would have adverse, moderate, short-term, regional impacts to predicted fire regime and fire behavior in spruce-fir forests since there is a very low probability of WFU occurring. Alternative 3 would have adverse, moderate, short-term, regional impacts in spruce-fir forests due to reduced resilience of these forests to insects, pathogens, and drought.

Alternative 4 would have adverse, moderate, long-term, local impacts in mixed-conifer forests from suppression fires that burn at 97th percentile weather conditions due to increased acres predicted to burn as high severity fire, which moves these forests away from desired conditions. Alternative 4 would have adverse, moderate, short-term, regional impacts to predicted fire regime and fire behavior in spruce-fir forests since there is very low probability of wildland fire use occurring. Alternative 4 would have adverse minor to moderate, regional, short-term impacts to vegetation composition and structure in ponderosa pine forests due to reduced resilience of these forests to insects, pathogens, and drought.

Alternative 5 would have adverse, moderate, long-term, local impacts in mixed-conifer forests from suppression fires that burn at 97th percentile weather conditions due to increased acres predicted to burn as high severity fire, which moves these forests away from desired conditions.

Loss in Long-Term Availability Or Productivity Of the Resource To Achieve Short-Term Gain **Vegetation**

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Vegetation**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

Implementation of the Alternatives, except Alternative 3, would lead the ecosystem to move closer to the natural range of variability for historic fire regimes. Therefore, possibility of irretrievable or irreversible commitments of vegetative resources is decreased. Because Alternative 3 focuses more on manual and mechanical thinning, there is possibility of more high intensity fires which may cause irretrievable commitments of resources, but not irreversible. Vegetation would most likely return during the lifespan of the plan or beyond. There is possibility that Alternatives 1, 2, 4 and 5 may also have irretrievable commitments of resources, but not irreversible during the plan's life if larger, high intensity fires occur.

4.2.2 Special Status Plant Species

4.2.2.1 Guiding Regulations and Policies — Special Status Plant Species

Existing management direction for native plant resources (including threatened, endangered, proposed, and candidate species and their habitats) in GRCA include

- Executive Order 13112
- Director's Order #12, 18, 41, 46, 47, 60, and 77
- Endangered Species Act 1973 (as amended)
- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Wilderness Act of 1964
- Wild and Scenic Rivers Act 1968
- Arizona Revised Statutes Chapter 7, Title 3
- Health Forest Restoration Act of 2004
- Species management guides and conservation strategies
- NPS Management Policies 2006

4.2.2.2 Management Objectives — Special Status Plant Species

FMP goals and objectives related to special status plant species include

Goal 2 Restore and maintain park ecosystems in a natural, resilient condition

- Maintain ecosystems that are within the range of desired conditions (see Chapter 2) through natural processes within policy constraints
- Restore ecosystems that are not within the range of natural variability to desired conditions (see Chapter 2) and maintain them through natural processes within policy constraints
- Set priorities for treatment activities based on site-specific information including: departure from natural fire return intervals, desired conditions (see Chapter 2), and other relevant factors

Goal 3 Protect the park's natural, cultural, and social values

- Managing the ecosystem and natural processes are the primary objectives that will lead to healthy critical habitat for listed threatened, endangered and sensitive species
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species
- Minimize smoke impacts on air quality values including visibility

Goal 4 Promote a science-based program that relies on current and best-available information

- Conduct research that will help understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the Fire Management Program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, fuel reduction treatments) to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions (see Chapter 2), fire treatment priorities and prescriptions as relevant data become available

4.2.2.3 Methodology for Analyzing Impacts Special Status Plant Species

Tools Used to Analyze Effects

Impacts of each alternative on each special status plant species were evaluated qualitatively, using a compilation of the best available information for individual species in combination with the impact to habitat quality. All available location data was retrieved, mostly from the Arizona Game and Fish Department, which houses plant heritage information for the state. When location data was available, a species was determined to either be in or out of treatment boundaries (prescribed fire or mechanical /manual). This allowed determination of whether direct impacts would occur to a known population from these activities. When a special status plant inside treatment boundaries was limited to 1) a habitat that would not be treated or 2) an area where the treatment was prescribed fire in discontinuous fuels, the species was evaluated as if it was outside treatment boundaries. Literature searches then conducted to determine each species' fire response, fire adaptations, and responses to mechanical/manual treatments.

A range of values are given for impact intensity (e.g. minor to moderate) because large gaps exist on species locations, fire responses, and population trends.

The proposed Fire Management Plan encompasses a large area which makes grouping special status plant species by vegetation type necessary for presentation and comprehension. Because fire impacts various ecosystems (vegetation types) differently (based on fuel type, continuity, etc.), species are grouped and discussed by habitat preference. Because fire management is this document's focus, adaptations for living with fire have been included for each special status plant species in Chapter 3. Since no ground surveys were conducted for this FEIS/AEF, individual species habitat is assumed occupied. The following provides the special status plant species grouping by vegetation type (habitat) used in this analysis (some species occur in multiple vegetation types).

Ponderosa Pine Habitat Special Status Plant Species

Special status plant species known in ponderosa pine habitat are Flagstaff rockcress *(Arabis gracilipes*), Mt. Dellenbaugh sandwort (*Arenaria aberrants),* Arizona clematis (*Clematis hirsutissima* var. *arizonica*), rough whitlowgrass *(Draba asprella* var. *stelligera*), Arizona rubberweed *(Hymenoxys subintegra*), and Kaibab Plateau beardtongue *(Penstemon pseudoputus*). Arizona rabbitbrush *(Chrysothamnus molestus*) is an additional special status species not known to occur in GRCA boundaries, but has potential to occur based on potential habitat proximity and presence. No Federally listed plant species is known in this habitat type. Grand Canyon goldenbush *(Ericameria arizonica*) is a newly described endemic species in this habitat (see Chapter 3).

Mixed-Conifer Habitat **Special Status Plant Species**

No Federally listed plant species is known in the mixed-conifer habitat type, though special status plant species Kaibab whitlowgrass *(Draba asprella* var. *kaibabensis*) and Kaibab Indian paintbrush *(Castilleja kaibabensis*) occur.

Spruce-Fir Habitat **Special Status Plant Species**

No Federally listed plant species are known in GRCA spruce-fir habitat. Special status plant species spiked ipomopsis (*Ipomopsis spicata* ssp. *tridactyla*), Kaibab Plateau beardtongue *(Penstemon pseudoputus*), Kaibab whitlowgrass *(Draba asprella* var. *kaibabensis*), and Arizona rubberweed or bitterweed *(Hymenoxys subintegra*) occur in this habitat type. Spiked ipomopsis will not be addressed in this analysis due to its specific habitat type (4.2.2.10) and, since the other species are also located in the ponderosa pine vegetation type, impacts are addressed in ponderosa pine vegetation.

Piñon-Juniper Habitat **Special Status Plant Species**

Four special status plant species known to occur in this habitat type also occur in other habitat types and are discussed above; they include Macdougal Indian parsley *(Aletes macdouglaii* ssp. *macdouglaii*), Flagstaff rockcress *(Arabis gracilipes*), Mt. Dellenbaugh sandwort *(Arenaria aberrants*), and the newly described Grand Canyon goldenbush *(Ericameria arizonica*). Also known species specific to piñon-juniper are the Federally listed endangered sentry milk-vetch *(Astragalus cremnophylax* var. *cremnophylax*), and the special status plant species Kaibab agave *(Agave utahensis* ssp. *kaibabensis*), Tusayan flameflower *(Phemeranthus validulus* syn. *Talinum validulum*) and Grand Canyon rose *(Rosa stellata* ssp. s*tellata*). All species, except Mt. Dellenbaugh sandwort and Grand Canyon rose, are not analyzed in detail due to specific habitat type (4.2.2.10). In addition, impacts to Mt. Dellenbaugh sandwort, which occurs in both ponderosa pine and piñon-juniper habitats, are focused in the ponderosa pine vegetation type since minimal activities are proposed in the piñon-juniper vegetation type.

An additional species, *Astragalus septentriorema*, located in North Rim's piñon-juniper at Cape Final, is being considered for species designation. This species will be treated as a GRCA rare plant (Special Status/Species of Special Concern), and may be a candidate species for Federal listing.

4.2.2.4 Species Considered in Impact Analysis **Special Status Plant Species**

Based on habitat preferences, species with potential habitat or known occurrences in areas likely to be impacted, and which will be discussed in the impact analysis, are listed below.

Grand Canyon goldenbush *(Ericameria arizonica*) is not analyzed since it was not described until after analysis was complete. Since Grand Canyon goldenbush exists in very sparsely vegetated areas of nearly bare rock not prone to burning, it is unknown how this species responds to fire. If vegetation management specialists determine it to be affected by fire activities, the proposed FMP will incorporate, through the adaptive management process, implementable measures to protect and maintain or increase this species through appropriate ecosystem management.

- *Astragalus cremnophylax var. cremnophylax*
- *Arabis gracilipes*
- *Arenaria aberrans*
- *Castilleja kaibabensis*
- *Clematis hirsutissima var. arizonica*
- *Draba asprella var. kaibabensis*
- *Draba asprella var. stelligera*
- *Hymenoxys subintegra*

- *Penstemon psuedoputus*
- *Chrysothamnus molestus*
- *Rosa stellata ssp. abyssa*

4.2.2.5 Impact Thresholds Special Status Plant Species Methodology

Impacts Common to All Alternatives reviewed how various treatment types could affect special status plant species habitats generally. Alternative analysis provided impact differences between alternatives due to various treatment types, and focused on potential impacts to specific special status plant species based on vegetation (habitat) type.

Type of Impact

Adverse Impacts are classified as adverse if they negatively affect size, continuity, or integrity of special status plant population or habitat outside the normal range of variability or move areas away from desired conditions. Adverse impacts can be either short or long term (definitions below)

Beneficial Impacts are classified as beneficial if they positively affect size, continuity, or integrity of special status plant population or habitat in reaching the desired condition and provide for well-distributed populations in appropriate habitats. Beneficial impacts are normally considered long term

Intensity

Impact intensity and magnitude on habitat and special status plant species or groups are described as negligible, minor, moderate, or major

Negligible Impacts would not be of any measurable or perceptible consequence to special status species populations or the ecosystem supporting them. A negligible effect would equate to a no effect determination under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species

Minor Impacts to special status plant species would be perceptible or measurable, but severity and timing of changes to parameter measurements are not expected to be outside natural variability or to have effects on populations of special status plant species. A minor effect would equate to a determination of “not likely to adversely affect” or “likely to adversely affect” under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species

Moderate Impacts to special status plant species are perceptible and measurable, and severity and timing of changes to parameter measurements are expected to sometimes be outside the natural range of variability; changes with natural variability might be long term. Populations of special status plant species might have small to moderate declines, but are expected to rebound to pre-impact numbers. No species would be at risk of being extirpated from GRCA. A moderate effect would, in most cases, equate to a determination of “likely to adversely affect” under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species

Major Impacts to special status plant species measurable, and severity and timing of changes to parameter measurements expected to be outside natural range of variability for long periods or even permanently; changes in natural variability might be long term or permanent. Populations of special status plant species might have large declines with population numbers significantly depressed. In extreme cases, a species might be at risk of being extirpated from GRCA, key ecosystem processes like nutrient cycling might be disrupted, or habitat for any species might be rendered non-functional. Impacts would be long term or permanent. A major effect would equate to an "adverse affect with/without a jeopardy opinion" under Section 7 of ESA regulations

Context

Regional Impacts affect a widespread area of suitable habitat of the population's or species' GRCA range and possibly some areas immediately adjacent to treated areas

Local Impacts confined to a small part of the population or small percentage of a habitat or range in the park such as in a single project treatment area or plateau

Duration

Short term Short-term impacts to an individual, population, or habitat area would last from one growing season up to five years

Long term Long-term impacts would be five years or longer in duration

Timing Whether an impact is beneficial or detrimental to a special status plant species can depend on timing. For example, a prescribed fire could be beneficial or detrimental depending on the plant's life cycle stage during impact

4.2.2.6 Mitigation of Effects — Special Status Plant Species

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description and are addressed in other sections of this Chapter.

- Locate control lines, helispots, fire camps, and other soil-disturbing fire management activities to minimize damage to biological resources
- Protect aquatic habitat, riparian and wetland areas, meadows, and other sensitive resource areas by defining and avoiding these areas
- Establish trigger points (geographic locations that, when reached by fire, trigger an action to mitigate) if sensitive biological areas are located in Maximum Manageable Areas (MMA) that require some mitigation during wildland fire use fires. Implement mitigation plans when fire reaches the trigger point
- Rehabilitate affected sites (control lines, staging areas, and helispots) as soon as possible after disturbance. Develop Burned Area Emergency Response (BAER) plans as appropriate
- Assist with implementing the 2006 NPS Draft Invasive Species Action Plan (2006d). This plan provides a framework for implementing prevention, early detection and rapid response, control, education, research, and restoration activities for invasive species found on park lands
- Inspect helispots, staging areas, incident command posts/base camps, etc., periodically and minimize exotic species introduction
- Use Minimum Impact Suppression Techniques to reduce disturbances to soil and vegetation
- Clean fire vehicles, equipment, and clothing in compliance with parkwide policy
- Procure certified weed-seed-free mulching materials and native plant seed used in fire rehabilitation operations
- Prohibit prescribed fires and fire-related activities from encroaching on any known sentry milk-vetch (*Astragalus cremnophylax* var. *cremnophylax)* population
- Evaluate potential for fire to enter sentry milk-vetch habitat in unsurveyed areas of potential habitat, as defined in the USFWS Sentry Milk-vetch Recovery Plan (2006)

4.2.2.7 Cumulative Impacts — Special Status Plant Species

Cumulative impacts on special status plant species were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions (Appendix G). Spatial boundaries for cumulative impact analysis for special status plant species were: north, the Kaibab National Forest throughout the Kaibab Plateau; south, in the Kaibab National Forest throughout the ponderosa pine forest; east and west, the canyon rim in the northern portion of the project area, and reaches of contiguous ponderosa pine forest that extend into the KNF in the southern portion.

Events (actions) that contribute most to cumulative impacts include wildfires, prescribed fires, and visitor impacts. Events of significant proportion, like the Warm Fire and Jacob Planning Area Project described below, influence cumulative impacts through timing and projected impact length. Predicted wildfire acres and intensities are based on previous events, but as accurate predictions are impossible, the future is discussed in a general sense.

Many impacts are local (Appendix G). Several major fires (wildland fire-use, prescribed, and suppression) and fuels-reduction treatment projects contribute to analysis area cumulative impact.

Events noteworthy are the USFS Warm Fire (19,000 WFU acres when converted to wildlife; the fire then grew an additional 39,115 acres), and the USFS Jacob-Ryan Vegetation Management Project (approximately 26,000 total acres) The Warm Fire occurred in 2006 approximately 15 miles north of GRCA on the Kaibab Plateau in the Kaibab National Forest. Burn severity was assessed at 50% moderate/high (USFS 2007). Dominate pre-fire vegetation types were ponderosa pine (65%), mixed-conifer (14%), and piñon-juniper (10%). A Warm Fire Recovery Project (USFS 2008) proposes to salvage-log 9,900 acres, and reforest 14,690 acres by planting conifers. The only known sensitive plant species impacted by the fire is *Pedicactus paradise*. Other special status plant species found in the fire perimeters were *Castilleja kaibabensis*, *Lesquerella kaibabensis*, and *Penstemon psuedoputus*, but as they are meadow species, they were not considered impacted (USFS 2007).

The Jacob-Ryan Vegetation Management Project (USFS 2008b) lies north of GRCA in the North Kaibab Ranger District's northern portion (Kaibab National Forest). This planning area includes approximately 26,000 acres around Jacob Lake in northern Arizona. The Final DEIS/AEF for this project contains three alternatives including 1) no action, 2) vegetation management with no removal of trees over 18 inches dbh, and 3) vegetation management with no removal of trees over 12 inches dbh.

The Jacob Planning Area Project and similar projects are aimed at fuels reduction and habitat restoration. The overall cumulative impact would be beneficial and moderate.

4.2.2.8 Assumptions — Special Status Plant Species

Assumptions specifically related to the alternatives considered in this document and their effects on special status plant species are

- Human-caused fires will be deemed suppression fires using the same criteria across alternatives
- Wildland use fires converted to suppression fires have potential to change category between alternatives due to differing criteria per alternative. Suppression fire impacts vary due to suppression activities
- Based on the past 25 years of fire suppression, this analysis assumes that for all alternatives the percentage of suppression-impacted acres per vegetation type are
  - Mixed-Conifer 34%
  - Spruce-Fir 31%
  - Ponderosa Pine 13%
  - Piñon-Juniper 9% (Rasmussen 2007)

- Wildland fire-use and prescribed fire are fire management tools aimed at overall habitat restoration and returning the landscape to desired conditions
- High severity fires often kill above-ground plant portions but, depending on components such as fuel and fuel type, topography, soil moisture, and weather (Wohlgemuth et al. 2006), underground, sometimes regenerative, plant portions may survive
- A significant departure from fire regime over the past 100 years exists due to fire suppression (especially in mixed-conifer and spruce-fir vegetation types). Areas treated with fire in the past 25 years have a smaller departure from historic fire regime
- An increased probability of high intensity wildfire exists from years of fire suppression that resulted in unnatural fuel loads and tree densities
- Suppression activities, such as hand-line creation, have long-term adverse impacts (Crawford and Straka 2004)
- Per acre, the greatest adverse direct impacts, such as fireline construction, come from fire suppression compared to prescribed and wildland fire-use fire
- GRCA plants evolved with fire, and many have adaptations for coexisting with fire such as burl, caudex, etc. (Fites-Kaufman et al. 2006, USFS 2000)
- Based on vegetation analysis in 4.2.1, prescribed and wildland fire-use fire effects for ponderosa pine, mixed-conifer, and spruce-fir types trend them toward the natural range of variability

4.2.2.9 Incomplete and/or Unavailable Information — Special Status Plant Species

No single, comprehensive source for sensitive plant species locations exists. Locations presented in this document are a combination of voucher specimens found in databases through the Southwest Environmental Information Network (The National Science Foundation at http://www.seinet.asu.edu), locations mapped by AGFD, and GRCA data. Data used in this analysis may be incomplete.

Little information exists about fire effects on most special status plant species. The ability to analyze past, present, and reasonably foreseeable actions/projects impacts on special status plant species is limited to

- documentation made available on treatment type proposed and/or administered, and disclosed impacts on special status plant species
- available location data and known ranges for sensitive species being analyzed

4.2.2.10 Impact Analysis — Special Status Plant Species

Effects Common to All Alternatives — Special Status Plant Species Not Likely Affected

Table 4-24 provides a list of special status plant species not directly and/or indirectly affected by implementation of any of the alternatives considered in this analysis (and a summary of how this conclusion was made). These species are not discussed further for this analysis.

Table 4-24 Special Status Plant Species Not Likely Affected

Common Name	Reason Not Likely Affected
Agave utahensis ssp. *kaibabensis*	Found in rocky limestone outcrops which, due to discontinuous fuels, are unlikely to sustain fire and are thus not impacted by the proposed FMP
Aletes macdougalii ssp. *macdougalii*	Generally found on rocky ledges and in areas of discontinuous fuels unlikely to sustain fire (SEINet; The National Science Foundation, 2007); therefore, not impacted by FMP
Phemeranthus validulus	Found in willow microhabitat, gravelly soils in bedrock in relatively barren microsites (Phillips and Weage 1996); areas unlikely to sustain fire and not likely impacted by FMP implementation
Ericameria arizonica	Occupies rock-crevices and talus, often on granitic outcrops and soils (Barkeley et al. 1993) in rock canyons (Brian 2000). This habitat lacks contiguous fuels and is unlikely to sustain fire; therefore, would not be directly impacted by FMP implementation

Common Name	Reason Not Likely Affected
Ipomopsis spicata ssp. *tridactyla*	Prefers talus microhabitat, often in meadow communities not impacted by the proposed FMP
Lesquerella kaibabensis	Grows in meadow habitat on knolls with high percentage of rock exposure with discontinuous fuels unlikely to sustain fire. Unlikely impacted by FMP implementation

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Wildland Fire and Fire Suppression Activities

Suppression fire effects on special status plant species would be composed of not only wildland fire but associated fire management activities. It is sometimes difficult to differentiate between impacts of fire and suppression activities (Backer et al. 2004). Under a fire suppression strategy, risks of stand-replacing wildfire would increase due to fuels buildup. Associated impacts of wildland fire, fire suppression activities, and high severity wildfire affect soil, water, air, wildlife, plants, and habitat which could directly and indirectly affect special status plant species. Below are some direct and indirect effects common to all alternatives that could impact special status plant species.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Soils

Soils would be impacted directly by compaction from fire suppression equipment and indirectly by increased erosion caused by fires and handline. This could adversely affect special status plant species.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Vegetative Cover

Activities such as construction of fire lines, helispots, and fire base camps would impact plants and habitat by causing direct mortality through vegetation trampling, crushing, and breaking. Suppression could lead to increased canopy cover, as fire would not thin forest stands. Stand-replacing wildfire would drastically reduce overstory cover long term, and understory cover short term. Depending on special status plant species habitat requirements, these vegetative cover changes could have beneficial or adverse effects. Species that require open canopies and/or understories would be adversely impacted by fire suppression; species requiring denser forest or understory cover would be beneficially impacted. Stand-replacing wildfire would most likely adversely impact special status plant species as these fires may kill entire plant populations, and are more likely than low severity fires to carry into patchy fuels or rocky areas.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Succession

Disturbance creates an environment where primary succession species become established, an indirect adverse impact if the species becoming established are invasive exotic plant species, or a direct beneficial impact if the species becoming established are disturbance-adapted special status plant species.

Effects Common to All Alternatives **Special Status Plant Species**
Invasive Exotic Plant Species **Direct and Indirect Effects**

Disturbance created by fire suppression activities and wildfire suppression fires could adversely impact special status species indirectly by creating exotic plant habitat and providing vectors for invasion. Exotic plants could out-compete special status plant species for habitat. Post-fire rehabilitation activities could also impact special status plant species habitat through introduction of invasive exotic plants by seeding and straw-bales (Backer et al. 2004). Mitigation measures proposed to minimize this risk would benefit special status plant species. This indirect impact would be local to areas where fire management activities would impact habitat and, depending on whether invasive exotic plant species are successful in populating the habitat, it could have negligible to moderate long-term impacts. Invasive Exotic Plant Species, 4.2.3, provides a more detailed analysis invasive exotic-plant impacts.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Fuels and Litter

Fire suppression indirectly affects plant species and communities by allowing fuels buildup, which in turn increases likelihood of future high severity fire. Plant species that require bare ground or litter layers for germination would be adversely impacted by suppression. Species requiring thick duff layers would be beneficially impacted by suppression.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Fire Retardant

Direct adverse impacts from fire retardant would occur to plants by dissolving waxes on surfaces of leaves and other parts. Fire retardant is primarily composed of nitrogen and phosphorus, which could alter nutrient availability that may influence plant composition and facilitate exotic plant species invasion.

Impact Analysis **Special Status Plant Species**
Effects Common to All Alternatives **Direct and Indirect Effects**
Wildland Fire-Use Fires

Below are potential impacts to special status plant species related to fire effects from prescribed and wildland-use fires common to all alternatives.

Impact Analysis **Special Status Plant Species**
Fire Effects Common to Prescribed and Wildland Fire-Use Fires **Direct and Indirect Effects**
Soil

Prescribed and wildland fire-use fires would likely occur when there is more soil moisture than with suppression fires. Moist soils do not rise above 212°F (100°C), but water in the soil has good thermal mass and can retain heat longer than air (Bakker 2007). Mortality to otherwise regenerating underground plant structures is possible when there are extended periods of heat exposure to the soil. When soil is exposed to heat, physical, chemical, and biological properties can be altered (USFS 1979, Wohlgemuth et al. 2006), and if vegetation is consumed, nitrogen and phosphorus are often made available which could adversely indirectly impact special status plant species by facilitating invasion of invasive exotic plant species, but also beneficially directly impact special status plant species by freeing nutrients for their use.

Impact Analysis **Special Status Plant Species**
Fire Effects Common to Prescribed and Wildland Fire-Use Fires **Direct and Indirect Effects**
Vegetative Cover

Fire reduces canopy cover and understory vegetation cover to varying extents depending on fire severity. In the short term, small trees, shrubs, and herbaceous plants could be killed or entirely consumed by fire. Large trees may be killed, reducing canopy cover and increasing light levels on the forest floor. In the first growing season after fire, understory vegetative cover (of native or non-native species) may increase as disturbance-adapted species colonize burned areas. Depending on the habitat requirements of special status plant species, these changes in vegetative cover could be beneficial or adverse. Species that require open canopies and/or understories would be beneficially impacted, while species requiring denser forest or understory cover would be adversely impacted. Fire could negatively impact non-ruderal (species sensitive to disturbance, late-succession species) special status plant species due to increased competition from early-successional colonizers. In the long term, fire's reduction of vegetative cover could decrease probability of high severity fire outside the range of natural variability, resulting in a beneficial impact to special status plant species not adapted to high severity fire.

Impact Analysis | **Special Status Plant Species**
Fire Effects Common to Prescribed and Wildland Fire-Use Fires | **Direct and Indirect Effects**
Succession

Disturbance creates an environment where primary succession species become established; a indirect adverse impact if species becoming established are invasive exotic plants, or a direct beneficial impact if species becoming established are disturbance-adapted special status plants.

Impact Analysis | **Special Status Plant Species**
Fire Effects Common to Prescribed and Wildland Fire-Use Fires | **Direct and Indirect Effects**
Invasive Exotic Plant Species

Similar to suppression fires, disturbance created from prescribed and wildland fire-use fires could adversely impact special status species indirectly by creating habitat for exotic plant invasion. Exotic plants could out-compete special status plant species for habitat. Mitigation measures proposed to minimize this risk would benefit special status plant species. This indirect impact would be local to areas where fire would impact habitat and, depending on whether invasive exotic plant species are successful in populating the habitat, could have negligible to moderate long-term impacts. Invasive Exotic Plants, 4.2.3, provides a more detailed analysis on invasive exotic plant impacts.

Impact Analysis | **Special Status Plant Species**
Fire Effects Common to Prescribed and Wildland Fire-Use Fires | **Direct and Indirect Effects**
Fuels and Litter

Fire consumes coarse woody debris and litter to varying extents depending on fire severity. Plant species that require bare ground or litter layers for germination would be beneficially impacted by fire. Species requiring thick duff layers would be adversely impacted by fire consumption of duff and litter. Long term, fire's reduction of dead fuels could decrease probability of high severity fire outside the range of natural variability, resulting in a beneficial impact to special status plant species not adapted to high severity fire.

Impact Analysis | **Special Status Plant Species**
Fire Management Effects Common to Prescribed and Wildland Fire-Use Fires | **Direct and Indirect Effects**

Similar techniques are commonly used to manage prescribed and wildland fire-use fires. Management techniques could include pre-treating areas by installing firelines and removing trees, shrubs, and snags to protect resources or keep fires in designated boundaries. Direct impacts to special status plant species could include trampling by fire personnel, crushing or damaging with equipment, and/or crushing or damaging from fuels, trees, and snags being felled or dragged. For prescribed fire, impacts would be less likely due to required botany survey work prior to implementation.

Disturbances created from fire management (e.g. fireline construction) for prescribed and wildland fire-use fires could adversely impact special status species indirectly by creating exotic plant habitat and providing invasion vectors. Exotic plants could out-compete special status plants for habitat. Mitigation measures proposed to minimize this risk would benefit special status plant species. Indirect impacts would be local to areas where fire management activities would impact habitat and, depending on whether invasive exotic plant species are successful in populating the habitat, could have negligible to moderate long-term impacts.

Impact Analysis **Special Status Plant Species**
Fire Management Effects Common to Prescribed and Wildland Fire-Use
Manual and/or Mechanized Fuel Reduction Activities **Direct and Indirect Effects**

For all alternatives except Alternative 1, manual and mechanical vegetation treatment prescriptions are restricted to the primary WUI and to Highways 64 and 67 (escape routes). Many of these treatments are proposed in piñon-juniper habitat.

Direct impacts to sensitive species plants could result from trampling by fuel reduction crews, machinery, or fuels being felled or removed. Risks/impacts would be minimized by pre-treatment botany surveys and avoiding areas where special status plant species are found. The most important indirect adverse impact of this treatment would be habitat creation for, and potential introduction of, invasive exotic plants resulting from increased solar radiation from overstory removal, soil compaction, invasive exotic seeds inadvertently introduced by persons and/or machinery, and soil disturbance.

Impacts on vegetative cover from manual or mechanical reduction of live trees and shrubs would be similar to those of fire, as discussed above. Whereas fire generally decreases fuel loads and litter, depending on mechanical treatment type, slash and debris from treatments could remain onsite. Any species requiring an open forest floor would be negatively impacted by addition of slash and debris. Indirect impacts from invasive exotic plants would be similar to other fire treatments noted earlier.

4.2.2.12 Mitigation of Effects — Special Status Plant Species

In addition to mitigation measures acknowledged in 4.2.2.6, additional recommended mitigation measures proposed in other sections would also reduce adverse impacts to special status plant species.

Recommended mitigation measures include those for invasive exotic plant species, special status wildlife species, and soils. These mitigation measures reduce indirect adverse impacts, such as soil erosion and compaction, vegetative cover (for species that prefer crown cover), expansion and/or invasion of exotic plant species, and use of fire retardant during fire suppression.

4.2.2.13 Alternative 1 — No Action Current Program — Special Status Plant Species

This alternative continues current fire management as described in the 1992 FMP, as amended. Alternative 1 assumes that the same level of suppression, approximately 20,050 acres, will occur in future years. Some areas in GRCA have poor access and over 100 years of fire exclusion that could elevate acreage suppressed if ignition occurred. Prescribed fire treatments proposed in this alternative would occur primarily in ponderosa pine and mixed-conifer FMUs, at approximately 58,500 acres. Adaptive management has been the hallmark of the 1992 Fire Management Plan. Hence, there is a projection of a potential 55,000 acres treated by wildland fire use.

Fire treatments (prescribed and wildland fire use) will be implemented in mixed-conifer and spruce-fir vegetation types according to existing USFWS Biological Opinion (USFSW 2003a and 2003b) stipulations that require "low intensity fire only.” Thus, there is some likelihood that 1) the park would not meet treatment goals (total acres over the projected period) due to limited implementation windows (many days where fire weather and/or behavior are not conducive to low intensity fire), and/or 2) some proportion of acres treated would mimic natural historic fire regime for these vegetation types (mixed severity with some proportion of low, moderate, and high intensity fire), thus, would not meet low intensity stipulations (Rasmussen 2007).

Manual treatments would continue under this management plan at 400 acres, occurring primarily in piñon-juniper habitat. For a full description of Alternative 1, see Chapter 2.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**

Alternative 1 proposes the least amount of non-fire treatment and, of non-fire treatments, only manual is proposed. This would minimize any adverse impacts associated with machinery including potential soil compaction and invasive exotic plant introduction.

This alternative proposes a total of prescribed and fire-use fire treatments estimated at approximately 113,500 acres. This could especially impact special status plant species occurring in mixed-conifer where an estimated 64% of parkwide habitat would likely be treated with fire treatment (prescribed and wildland fire-use fire), and ponderosa pine, where 70-100% of parkwide habitat would likely be treated with fire treatments during the planning period. 19% of GRCA's spruce-fir habitat would also be treated with prescribed fire. Return of habitats toward the natural range of variability could greatly benefit special status plant species (Fites-Kaufman et al. 2006).

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
Ponderosa Pine

Since this vegetation type is considered to have low departure from historic fire regime, the majority of fires in this habitat type would support the trend toward natural range of variability. Approximately 70 to 100% of this vegetation type is anticipated to receive fire treatments and/or suppression fires. Special status plant species potentially impacted by this alternative in this habitat type follow.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
***Arabis gracilipes*, Flagstaff rockcress** **Ponderosa Pine**

SEINet lists five GRCA populations, three in current FMP boundaries. Populations are known from Yavapai Point and near Bright Angel Lodge on South Rim that, if not protected, could be adversely impacted. Flagstaff rockcress is rated as having apparently stable population status at this time (NatureServe 2006). Flagstaff rockcress in this alternative would receive little to no direct or indirect impact from planned management activities. In event of suppression or wildland fire-use fire, Flagstaff rockcress could receive direct, local, short- to long-term, minor, adverse impacts from suppression activities or from fire injury or mortality. Flagstaff rockcress has a slight woody caudex which would facilitate regeneration after consumption of aboveground parts by fire. Use of low intensity fire in this alternative would lessen potential harm from fire.

Manual treatments are planned for less than 1% of this habitat type and piñon-juniper, the other suitable forest type for this species. If undetected individuals were disturbed, injury or mortality could occur resulting in a direct, local, short- to long-term, minor, adverse impact. Pre-treatment botany surveys would minimize potential impacts to this species.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
***Arenaria aberrans*, Mt. Dellenbaugh sandwort** **Ponderosa Pine**

SEINet lists collections from 1892 to 1942 in GRCA, with populations found one mile east of Grand Canyon Village. With this alternative, Mt. Dellenbaugh sandwort could receive direct, minor, local, short-term adverse impacts through being consumed by prescribed or wildland fire-use fires. Trampling, due to manual treatments and associated fire management activities, could also produce adverse, minor, local, short- to long-term impact through injury or mortality. Direct adverse impacts could be intensified during growing and blooming stages. Depending on treatments, Mt. Dellenbaugh sandwort has a woody caudex (AGFD 2004) that could facilitate resprouting after fire or cutting; therefore, these impacts are expected to be short term with species repopulation expected.

Manual treatments are proposed for less than 1% of the Mt. Dellenbaugh sandwort's habitat type, imparting negligible, local, short-term, adverse impacts.

As noted in 4.2.1.10, continuation of fire treatment trends this habitat toward range of natural variability; therefore, Alternative 1 implementation would likely be a minor to moderate, beneficial, local, short- to long-term, direct impact by improving sandwort habitat conditions. All fire types would have beneficial impacts to this species since all would burn at relatively low fire severities and would continue the trend toward natural range of variability for the fire regime.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
***Clematis hirsutissima* var. *arizonica,* Arizona clematis** **Ponderosa Pine**

Because references are dated, uncertainty exists regarding exact locations for the four Arizona clematis GRCA populations (Center for Plant Conservation, undated). From broadly defined population locations, it appears that at least two populations may be impacted by proposed prescribed fire treatments. This alternative has potential to impact Arizona clematis with local, direct, adverse impacts associated with fire treatments. This could result in direct injury or mortality for individuals.

The relationship between canopy cover and seed production of Arizona clematis has been studied and clematis was found to have an adverse response to canopy removal (Smith 1994). The author speculated if species presence in a fire-adapted environment may indicate this species requires [low intensity] fire to remove dead stems, duff, litter, and limit competition. There is also possibility this species has benefited from dense canopies resulting from fire suppression. Treatments that decrease canopy cover could adversely affect habitat. Kaibab whitlowgrass has similar habitat requirements. For additional potential effects to Arizona clematis, note the fire severity discussion under Kaibab whitlowgrass below.

Direct impacts would be local to areas where fire management activities occur; impacts could intensify during growing and blooming stages. Direct impacts would be short term in favorable conditions where understory competition and thatch are reduced to facilitate seedling establishment, or long term in conditions where individuals and potential progeny are destroyed. Adverse direct impacts would be none to moderate, depending on Arizona clematis location in relationship to fire treatment areas.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
***Draba asprella* var. *stelligera*, rough whitlowgrass** **Ponderosa Pine**

Rough whitlowgrass has no known locations in treatment units. Undetected individuals could be adversely, directly impacted by associated fire treatment impacts, wildland fire-use or suppression fires through direct injury or individual mortality. This adverse, direct impact would be minor and local to areas where fire management activities occur, and intensified during growing and blooming stages. Direct impacts would be short term if individual plants are injured and able to recover, or long term if individuals are killed and population numbers decline.

As this species prefers openings in its habitat type, various treatments could have an indirect beneficial impact by enhancing and expanding its habitat.

This indirect, beneficial impact would be local to areas where fire management activities have impacted habitat and, depending on species location in relation to treatment areas, could have a minor to moderate long-term impact (as the species is not currently known from this area and treatment area comprises a small portion of species' range).

Direct and Indirect Effects Alternative 1 Special Status Plant Species
***Penstemon pseudoputus,* Kaibab Plateau beardtongue Ponderosa Pine**
***Hymenoxys subintegra*, Arizona rubberweed**

Both Kaibab Plateau beardtongue and Arizona rubberweed have populations in the extent of this alternative (and are noted adjacent to both ponderosa pine and spruce-fir vegetation types). Populations mostly occur in meadow settings not likely directly impacted by this alternative except during drought years when fire could burn through meadows. A mitigation measure incorporated in the alternative description requires meadow protection, which would further protect these species from direct adverse effects (from fire suppression activities).

Both species grow not only in meadows, but in disturbed areas. All fire and non-fire treatments resulting in some disturbance could have direct, minor, beneficial impacts by enhancing habitat for both species. There is a level of variability on how these species could respond depending on disturbance proximity to nearest populations for seed or propagules. Direct impacts would be local to areas where disturbances occur and intensified during growing and blooming stages. If these species enter into these disturbed areas, duration could be long term.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
***Chrysothamnus moslestus*, Arizona rabbitbrush Ponderosa Pine**

No known Arizona rabbitbrush populations exist in Alternative 1 treatment areas. Undetected individuals occupying areas of fire management activities could suffer direct adverse, minor, local, short-term impacts from injury or mortality. Arizona rabbitbrush responds positively to fall burns, but seedling establishment is greatly reduced during spring burning (Cobb et al. 1996). Depending on season prescribed fire projects are implemented in this vegetation type, and whether rabbitbrush is present, impacts could be beneficial (fall burn) or adverse (spring burn). Adverse impacts would be minor, local, short term if populations recover after spring burning. Beneficial impacts would be minor, local, short to long term after fall burns.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
Mixed-Conifer

Alternative 1 treats 57% of the mixed-conifer forest type with prescribed fire. In addition, approximately 7% of wildland fire-use acres and approximately 18% of suppression fire would occur in the mixed-conifer forest type (4.2.1.10). Currently 42% of the mixed-conifer forest type is in high level of departure from historic fire regimes. Alternative 1 has a low intensity fire constraint that would affect this vegetation type. This constraint would slowly trend this vegetation type toward the natural range of variability.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
***Draba asprella* var. *kaibabensis*, Kaibab whitlowgrass Mixed-Conifer**

One known population of Kaibab whitlowgrass, a GRCA endemic, could receive direct, adverse impact by prescribed (proposed in this alternative), wildland fire-use and/or suppression fires. This could result in direct individual injury or mortality. Depending on fire severity, Kaibab whitlowgrass has a small caudex that may allow regeneration after impact. Depending on plant population amount directly impacted, and fire severity in those areas, adverse impacts would be local, short term, and minor to moderate.

Kaibab whitlowgrass prefers a duffy, shady environment in mixed-conifer and spruce-fir habitat types (Brian 2000). Alternative 1 has the low intensity fire stipulation further decreasing adverse effects to this species. High severity fires could result in removal of canopy cover, and duff and litter layer consumption adversely impacting Kaibab whitlowgrass by altering its habitat. As fires (especially wildland fire-use fires) often burn in patchy spatial patterns, islands of suitable habitat could still be present. Depending on amount of high severity fire in the habitat (which would most likely occur during suppression fires), loss of crown cover could be a local, long-term, adverse impact that could be minor to moderate intensity.

There is potential that years of fire suppression in this forest type has resulted in duff and litter accumulation deeper than what Kaibab whitlowgrass prefers (Spence 2007). Low intensity fires could have a short-term, adverse affect on habitat by removing duff and litter, but long term could benefit habitat. Low intensity fire treatments could help reduce potential of catastrophic wildfire with potential higher fire intensities. As noted in 4.2.1.10, mixed-conifer is the most productive vegetation type and experiences the greatest fuel accumulation rates.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
***Castilleja kaibabensis,* Kaibab Indian paintbrush Mixed-Conifer**

Kaibab Indian paintbrush has populations in the extent of this alternative. These populations mostly occur in meadow settings, adjacent to the mixed-conifer vegetation type, which would not likely be directly impacted by this alternative, except during drought years when fire could burn through meadows. Impacts during drought years would be adverse, minor, short term, and local.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
Piñon-Juniper

Only 3% of piñon-juniper, parkwide, would be treated in Alternative 1 with prescribed fire and nominal manual treatments in the WUI. Little is known about the natural range of variability for this forest type.

Direct and Indirect Effects Alternative 1 Special Status Plant Species
***Astragalus cremnophylax* var. *cremnophylax,* sentry milk-vetch Piñon-Juniper**

Sentry milk-vetch is a mat-forming perennial herb found in sand-filled hollows of rocks, bedrock cracks, and gravelly soils of Kaibab limestone (USFWS 2006). There are four populations, all occurring in park boundaries along the rim. The USFWS only recognizes three South Rim populations belonging to variety *cremnophylax*. USFWS states that North Rim's Cape Final population is not only separated by the canyon, "suggesting gene flow between populations is unlikely," but difference in seed color, breeding systems, and genetic research (USFWS 2006). This species was listed as endangered on December 5, 1990; no critical habitat was designated. A Recovery Plan was released in 2006 (USFWS 2006). An additional species, *Astragalus septentriorema*, is located in North Rim's piñon-juniper at Cape Final. This population was previously thought to be the endangered sentry milk-vetch (*Astragalus cremnophylax v. cremnophylax*), but is being considered for species designation. This species will be treated as a GRCA rare plant (Special Status/Species of Special Concern), and may be a candidate species for Federal listing.

Two South Rim populations fall in current FMP boundaries, one at Lollipop and another at Grandview Point. GRCA has been operating under the premise that current fire management operations may affect populations, that stipulations to prevent adverse fire impacts are enforced, and that anthropogenic intrusions have been observed. Mitigation measures prevent prescribed fire and associated management activities from encroaching on known populations causing no impact to known populations. In event of either a wildland fire-use or suppression fire, fire could encroach into areas of unsurveyed potential habitat and may affect individuals in the population if they occur near vegetation that ignites. Areas where sentry milk-vetch occurs have low fire potential due to lack of continuous fuels, reducing likelihood of major adverse impacts to unknown populations. With adherence to mitigations, Alternative 1 would have negligible to minor, short-term, local, adverse impacts if undetected individuals were impacted.

Direct and Indirect Effects **Alternative 1** **Special Status Plant Species**
***Rosa stellata* ssp. *stellata*, Grand Canyon rose** **Piñon-Juniper**

There are no known Grand Canyon rose populations in Alternative 1 treatment areas. Undetected individuals occupying fire management activity areas could suffer direct adverse impacts from injury or mortality. Direct injury-causing impacts would be intensified during growing and blooming stages. Though little is known about Grand Canyon rose's fire response, it has a rhizome that, in other rose species, responds to fire by resprouting (Crane 1990, Reed 1993). If prescribed fire does not damage the rhizome, prescribed fire impact (should the species be present), would be negligible to minor short term local adverse.

Indirect impacts to Grand Canyon rose include minor disturbance associated with the nominal amount of manual thinning occurring in piñon-juniper habitat, disturbed soil, and potentially facilitating exotic plant species invasion. Spring surveys completed prior to manual treatments would minimize potential of adversely affecting these species.

Mitigation of Effects **Alternative 1** **Special Status Plant Species**

In addition to mitigation measures noted in 4.2.2.6, Alternative 1 includes mitigation measures that will also affect special status plant species, including

- Manage prescribed fires as low intensity to minimize negative effects on habitat and on primary constituent elements of MSO critical habitat
- Manage wildland fire-use fires as low intensity to minimize negative effects on habitat. GRCA's objective will be to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- Natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), but occasionally up to 10% mortality may occur in large trees

These mitigation measures, by limiting high severity fires, mainly provide a beneficial effect to Kaibab whitlowgrass which grows in mixed-conifer and spruce-fir vegetation types.

Mitigation measures proposed in 4.2.2.6 are part of, and would be implemented with, all alternatives. They are likely to decrease direct impacts from fire management activities, especially where special status plant species locations are found during pre-treatment surveys, or are known, and precautionary measures can be taken. Species that occur in sensitive habitats, such as meadows, are offered increased protection with mitigation measures to avoid such habitats. During fire suppression events, species in more common habitats (e.g. ponderosa pine forests) may not receive as much protection through mitigation measures. Mitigation measures are also likely to reduce indirect adverse impacts to special status plant species by reducing invasive exotic plant species introduction and spread.

Cumulative Effects **Alternative 1** **Special Status Plant Species**

GRCA is only a portion of the range for most special status plant species being analyzed, with the exceptions of *Astragalus cremnophylax* var. *cremnophylax, Ericameria arizonica,* and *Draba asprella* var. *kaibabensis;* therefore, events in neighboring areas could impact other populations, potentially affecting species status. Populations outside areas directly impacted by this alternative can act as reservoirs for initializing new populations, and, when proximal enough, can contribute to genetic diversity.

There are past, present, and reasonably foreseeable actions and projects described in 4.2.2.7 that may impact special status plant species or their habitat. The USFS Warm Fire impacted habitat shared with GRCA's special status plant species. This 39,000 acre fire (that included wildland fire use), combined with numerous other treatments in the adjacent Kaibab National Forest, are aimed at returning the landscape to its natural range of variability, and are likely beneficial to many special status plant species. Exceptions would be in areas where high severity fire and special status plants occurred. These areas could have adverse cumulative effects to special status plant species where habitat was changed long term. Arizona clematis and Kaibab whitlowgrass may be two species that would be adversely impacted cumulatively by treatments that reduce canopy cover.

There are also numerous small projects (usually less than one acre) in GRCA with local impacts. These often occur in high-use areas already heavily impacted by the public. Should these areas have individual special status plant species or habitat, these projects and uses would have cumulative adverse impacts.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in the project and/or use areas.

Conclusion **Alternative 1** **Special Status Plant Species**

Alternative 1 proposes prescribed and wildland fire-use fires would occur only as low intensity fires (no greater than 15% crown fire or 15% moderate/high to high severity fire would occur).

Direct and indirect impacts to special status plant from fire and fire activities in ponderosa pine forests would create adverse, negligible to moderate, local, short- to long-term impacts on special status plants. Beneficial fire effects from habitat improvement and movement toward the natural range of variability for the fire regime would be minor to moderate, local, short to long term. Direct and indirect impacts from manual thinning projects would be adverse, negligible, short term, and local.

Direct and indirect impacts to special status plants from fire and fire activities in the mixed-conifer forests type would create adverse, minor to moderate, local, short- to long-term impacts on special status plants.

Impacts to special status plants in piñon-juniper would be adverse, negligible to minor, short term and local. There would be no impacts to known populations of *Astragalus cremnophylax var. cremnophylax* as mitigation measures keep impacts out of known population areas.

Indirect impacts to special status species in all forest types from introduction or increase of exotic species could be adverse, negligible to moderate, long term and local.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat occurs in the project and/or use areas.

Impairment **Alternative 1** **Special Status Plant Species**

Since are no major adverse impacts in Alternative 1 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status plant species during Alternative 1 implementation.

Unacceptable Impacts **Alternative 1** **Special Status Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, appropriate use, and concessioner or contractor operations, there would be no unacceptable impacts on special status plants as a result of Alternative 1 implementation.

4.2.2.14 Alternative 2 Preferred Alternative Special Status Plant Species
Mixed Fire Treatment Program

Alternative 2 is identical to Alternative 1 with two exceptions, 1) an increase to 2,490 acres of non-fire treatment with the majority occurring through mechanized treatment, and 2) mitigation measures related to low intensity fire for prescribed and wildland fire-use fires are not included. Alternative 2 assumes the same level of suppression fire at 20,050 acres; 58,500 acres of prescribed fire treatments are proposed, primarily in ponderosa pine and mixed-conifer vegetation; and 55,000 acres treated by wildland fire use. Manual and mechanical prescriptions are restricted to the primary WUI in the proposed FMP. Exceptions are Highway 64 and Highway 67. Much of these treatments occur in piñon-juniper habitat. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
Ponderosa Pine

This forest type has the same treatment percentages as Alternative 1, with a slight (1%) increase in mechanical and manual treatment.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
***Arenaria aberrans,* Mt. Dellenbaugh sandwort Ponderosa Pine**
***Arabis gracilipes,* Flagstaff rockcress**

Alternative 2 is similar to Alternative 1 except for a minor increase in impacts associated with manual and mechanical treatments. The increase in treatment is near where these species would be expected to occur.

Alternative 2 direct and indirect impacts are similar to Alternative 1. Fire treatment continuation trends this habitat toward the range of natural variability; therefore, Alternative 2 would likely have a beneficial, direct impact by improving habitat conditions for reliant species. In addition, increased manual and mechanical treatments proposed in Mt. Dellenbaugh sandwort and Flagstaff rockcress habitat type could impart an increase of associated impacts (if the species actually occurs in treatment areas). Addition of mechanical vegetation treatment with Alternative 2 would increase risk (though low, due to little proposed treatment in ponderosa pine forest type) for invasive exotic plant species (exotic plant seeds on machinery prior to entering treatment area). These potential indirect risks/impacts would be minimized by invasive exotic plant mitigation measures included in the alternative, pre-treatment botanical surveys, and appropriate plant protections. Impacts would be adverse, minor, short to long term, local.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
***Draba asprella var. stelligera,* rough whitlowgrass Ponderosa Pine**

Rough whitlowgrass has no known locations in treatment units but potential habitat could be affected. Undetected individuals could be impacted by associated fire, and mechanical/manual treatments which could result in direct injury or mortality to individuals.

Direct and indirect impacts would be similar to Alternative 1. Direct adverse, minor, local impacts would be short term if individual plants are injured and able to recover; long term if individuals are killed and population numbers decline; and, since this species prefers habitat openings, various treatments could have indirect beneficial impacts to rough whitlowgrass by enhancing and expanding habitat.

This indirect, beneficial impact would be local to areas where fire management activities impacted habitat and, depending on species location in relation to treatment areas, could have a minor to moderate long-term impact (as the species is not currently known from this area and treatment area comprises a small portion of the species range).

Additional non-fire treatment acres could increase adverse effects in potential habitat. Again, this risk would be low since less than 1% additional acres are proposed in this vegetation type. As noted with Mt. Dellenbaugh sandwort above, additional impacts could be indirect and adverse due to potential invasive exotic plant species brought in with mechanical equipment. Risks of adverse impacts would be minimized through mitigation measures implementation and pre-implementation botanical surveys in proposed manual and mechanical treatment areas. Impacts would be adverse, minor, short to long term, local.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
***Chrysothamnus moslestus*, Arizona rabbitbrush Ponderosa Pine**

Direct and indirect impacts to undetected populations of Arizona rabbitbrush would be similar to Alternative 1. Depending on the season prescribed fire projects occurred in this vegetation type, and whether rabbitbrush is present, impacts could be beneficial (fall burn) or adverse (spring burn). Adverse impacts would be minor, local, short term if populations recovered after spring burns. Beneficial impacts would be minor, local, short to long term after fall burning.

Adverse, short-term impacts could increase due to additional manual and mechanical treatments proposed in potential habitat. Risk would be low since less than 1% additional acres are proposed in this vegetation type that could be potential habitat. In addition, risks of adverse impacts would be minimized through pre-treatment botanical surveys. As noted with Mt. Dellenbaugh sandwort and rough whitlowgrass above, additional impacts could be indirect, adverse, minor, short to long term, local due to potential of bringing in invasive exotic plant species on mechanical equipment. Impacts would be minimized through implementation of exotic plant mitigation measures.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
***Clematis hirsutissima var. arizonica*, Arizona clematis Ponderosa Pine**
***Penstemon pseudoputus*, Kaibab Plateau beardtongue**
Hymenoxys subintegra, Arizona rubberweed

Direct and indirect impacts to these species would be the same as Alternative 1. For Arizona clematis direct adverse impacts would be short term in favorable conditions where understory competition and thatch were reduced to facilitate seedling establishment, or long term in conditions where individuals and potential progeny were destroyed. Areas where habitat would be opened would also adversely impact this species. Adverse, direct impacts would be none to moderate, depending on Arizona clematis location in relationship to fire treatment and suppression fire areas.

For Kaibab Plateau beardtongue and Arizona rubberweed (which grow in meadows and disturbed areas), all fire and non-fire treatments resulting in some level of disturbance could have direct beneficial, minor, local, long-term impacts by enhancing habitat for both species.

Direct and Indirect Effects Alternative 2 Special Status Plant Species
Mixed-Conifer

Alternative 2 has the same percentages for prescribed fire and an increase to 30% of mixed-conifer vegetation type for wildland fire use when compared with Alternative 1. In addition, approximately 18% of the mixed-conifer vegetation type is assumed to burn from suppression fires. An increase in moderate/high intensity fire for mixed-conifer is anticipated (when compared to Alternative 1) due to the constraint for low intensity fire being removed.

Direct and Indirect Effects **Alternative 2** **Special Status Plant Species**
***Draba asprella* var. *kaibabensis*, Kaibab whitlowgrass** **Mixed-Conifer**

One known population of Kaibab whitlowgrass, a GRCA endemic, could receive the same direct, adverse impact by prescribed fire treatments proposed in this alternative as those in Alternative 1. See 4.2.2.13 for a full description of potential impacts.

Potential exists for an increased moderate/high severity fire areas with this alternative. This could result in reduced canopy cover which could have minor to moderate, local, adverse, short-term, indirect impacts. As mentioned above, depending on fire severity, Kaibab whitlowgrass has a small caudex that may allow regeneration after impact. This has an increased likelihood of being killed during all fire severities, because conditions like the time length of smoldering fuel, would influence underground plant parts. With likelihood of higher intensity fires during fire treatments, this adverse affect would likely cover a larger area (if plant populations are located in those areas). As with Alternative 1, impact would be local, short to long term, and adverse with minor to moderate intensity.

Direct and Indirect Effects **Alternative 2** **Special Status Plant Species**
***Castilleja kaibabensis,* Kaibab Indian paintbrush** **Mixed-Conifer**

Impacts to this species would be the same as Alternative 1. Species would not likely be directly impacted by this alternative except during drought years when fire could burn through meadows. Impacts during drought years would be adverse, minor, short term, local.

Direct and Indirect Effects **Alternative 2** **Special Status Plant Species**
***Astragalus cremnophylax* var. *cremnophylax,* sentry milk-vetch** **Piñon-Juniper**

Direct impacts to sentry milk-vetch from fire treatments would be similar to Alternative 1. There is a nominal increase in manual and mechanical treatments but, due to the open nature of sentry milk-vetch habitat, little, if any habitat would be targeted with these treatments. With mitigation measures, all known populations would be avoided causing no impact to known populations. This alternative would have a negligible to minor, short-term, local, adverse impact if undetected individuals were impacted.

Direct and Indirect Effects **Alternative 2** **Special Status Plant Species**
***Rosa stellata* ssp. *stellata*, Grand Canyon Rose** **Piñon-Juniper**

Direct and indirect impacts to undetected populations of Grand Canyon rose would be similar to Alternative 1, but could increase due to additional manual and mechanical treatments proposed in potential habitat. This risk would be low since less than 1% additional acres are proposed in this vegetation type that could be potential habitat. Risks for adverse impacts would be minimized with pre-treatment botanical surveys and, if the species was present, protection measures would reduce and/or eliminate direct impacts. As noted with Mt. Dellenbaugh sandwort and rough whitlowgrass above, additional impacts could be indirect and adverse from potential of invasive exotic plant species introduction with mechanical equipment. Impacts would be minimized through exotic plant mitigation measure implementation. Impacts would be minor, short term, local, and adverse.

Mitigation of Effects **Alternative 2** **Special Status Plant Species**

Mitigation measures proposed in 4.2.2.6 will decrease adverse impacts related to special status plants.

Cumulative Effects **Alternative 2** **Special Status Plant Species**

Overall, cumulative effects would not differ from Alternative 1 (see 4.2.2.7 for a full description of potential cumulative impacts) except the adverse impact to Kaibab whitlowgrass may be greater due to fire treatments higher than low intensity.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable*e actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in the project and/or use areas.

Conclusion **Alternative 2** **Special Status Plant Species**

Alternative 2 has impacts very similar to Alternative 1 except for additional non-fire treatment proposed in ponderosa and piñon-juniper vegetation types that could adversely impact special status plant species. Adverse impact risks would be minimized with completion of botanical surveys for special status plant species prior to project implementation (and protection measures added if species are found), and would allow for more accurate location and trend data.

In addition, mixed-conifer and spruce-fir fire treatments could burn at higher fire intensities than Alternative 1. This could cause additional adverse effects to Kaibab whitlowgrass if populations are in these fire treatment areas.

Direct and indirect impacts to special status plants from fire and fire activities in the ponderosa forest type would create adverse, negligible to moderate, local, short- to long-term impacts. Beneficial fire effects from habitat improvement and movement toward the natural range of variability for the fire regime would be minor to moderate, local, short to long term. Direct and indirect impacts from manual and mechanical thinning projects would be adverse, minor, short to long term, local.

Direct and indirect impacts to special status plant from fire and fire activities in the mixed conifer forest type would create adverse, minor to moderate, local, short- to long-term impacts on special status plants. Impacts to special status plants in the piñon-juniper forest type would be adverse, negligible to minor, short term, local. There would be no impacts to known populations of *Astragalus cremnophylax var. cremnophylax* as mitigation measures keep impacts out of those known population areas.

Indirect impacts to special status species in all forest types from introduction or increase of exotic species could be adverse, negligible to moderate, long term, local.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in the project and/or use areas.

Impairment **Alternative 2** **Special Status Plant Species**

Since are no major adverse impacts in Alternative 2 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status plant species during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Special Status Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, and concessioner or contractor operations, there would not be unacceptable impacts on special status plants from Alternative 2 implementation.

4.2.2.16 Alternative 3 Non-Fire Special Status Plant Species Treatment Emphasis

Alternative 3 emphasizes fuel reduction through mechanical/manual treatment. Approximately 4,000 acres would be treated in the WUI through mechanical/manual means. This alternative treats the lowest total acreage, with estimates of 25,400 acres for prescribed fire; 8,800 for wildland fire-use fire; and a projected 30% increase in fire suppression to 26,070 acres. The majority of these additional suppression acres are assumed primarily in North Rim forests. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 3 Special Status Plant Species

This alternative has the largest amount of suppression, mechanical/manual acres, and the lowest fire treatments acreage (prescribed and wildland fire use). Consequently there would be an increase in associated direct and indirect impacts of fire suppression which would be adverse and short to long term (additional information on general impacts from fire suppression is in 4.2.2.10). As this alternative has a reduction in overall acres treated, there would be fewer acres trending toward the natural range of variability. By not managing fuels, the trend could continue away from the natural range of variability at an individual and landscape level. This could result in adverse, long-term, indirect impacts of accumulated fuel that increases potential for large high severity fire areas due to suppression fires. The mixed-conifer habitat would be most affected because only 12% of this forest type would be treated with prescribed fire, and likely little to no fire-use fire would occur here.

Direct and Indirect Effects Alternative 3 Special Status Plant Species Ponderosa Pine

Ponderosa pine forest type would receive prescribed fire treatment on approximately 20% of parkwide acres; wildland fire use would have potential of treating 10 to 15%; fire suppression would affect 6%; and mechanical/manual treatment would treat 2%.

Direct and Indirect Effects Alternative 3 Special Status Plant Species
***Arenaria aberrans*, Mt. Dellenbaugh sandwort Ponderosa Pine**
***Arabis gracilipes*, Flagstaff rockcress**

Of the five alternatives, Alternative 3 would pose the greatest adverse impact, not only in potential direct adverse impacts from suppression fires (both the fires themselves and suppression activities), but also direct impacts from mechanical and manual treatments to species that may occupy the WUI. Mt. Dellenbaugh sandwort is only known from a historic location, and Flagstaff rockcress is known to exist in locations near South Rim's Bright Angel Lodge and Yavapai Point. These populations could be adversely impacted by associated mechanical and manual treatments unless protective measures were implemented. Pre-implementation botanical surveys and protection measures would minimize risk of adversely impacting undetected individuals or populations. Impacts would be adverse, minor to moderate, local, short to long term. Mechanized equipment could also inadvertently bring in invasive exotic plant species having an adverse, minor, short- to long-term, indirect, local impact.

The ponderosa forest has low departure from historic fire regimes, but with decreased fire treatments (prescribed and wildland fire-use fires), fuels would accrue over time. Though it could take the planning period or longer before this becomes high risk, fuel build-up could increase potential for higher severity suppression fires, which could have adverse impacts to this species. High severity fire areas could have direct and indirect, local, adverse, moderate, long-term impacts to the species. Though this alternative has greatest potential to adversely affect this species, impact intensity would still likely be minor to moderate because it is unknown where populations occur and whether they would be impacted.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Draba asprella var. stelligera,* rough whitlowgrass** **Ponderosa Pine**

Direct and indirect impacts to rough whitlowgrass would be similar to Alternative 1, although there could be a decrease in potential overall impacts as this species habitat occurs on North Rim where treatments are greatly reduced.

As with other special status species, if this alternative is implemented, over time risk for higher severity fires in ponderosa pine forest would increase. This could indirectly, adversely impact this species by changing habitat. Much proposed treatment in potential species habitat is reduced; therefore, potential for direct adverse impact to undetected species is reduced. Inversely, increased risk for high severity suppression fires, especially in rough whitlowgrass habitat, would cause the highest levels of adverse impacts associated with wildland fire and fire suppression activities (addressed in 4.2.2.10, Effects Common to All Alternatives). Impacts would be local and long term, and impact intensity would be negligible to moderate. Mitigation measures would decrease adverse impacts.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Chrysothamnus moslestus*, Arizona rabbitbrush** **Ponderosa Pine**

Alternative 3 would not continue the trend toward the natural fire regime for ponderosa pine vegetation. Because of this, there would likely be an indirect adverse, minor, short- to long-term, local impact to this species. For areas in the ponderosa pine vegetation type that receive fire treatment, effects would likely be beneficial, minor, local, and short to long term. As with Alternative 2, there would be a potential increase in adverse indirect and direct impacts to undetected individuals/populations due to mechanical/manual treatment proposed in preferred habitat. In addition, populations along Highway 67 may receive direct, local, minor, short-term adverse impacts from manual/mechanical and prescribed fire treatments in this corridor. Risks would be minimized with pre-implementation survey work in treatment areas. Any plants found during survey would receive protection measures.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Clematis hirsutissima var. arizonica,* Arizona clematis** **Ponderosa Pine**

Of the five alternatives, this alternative would have the least potential direct impact on this species because proposed treatment areas, that overlap where this species is thought to occur, would be reduced. Potential still exists for associated direct and indirect adverse impacts from fire treatments or suppression fires if they occur where this species exists. As noted in Alternative 1, direct impacts would be short term in favorable conditions where understory competition and thatch were reduced to facilitate seedling establishment, or long term in conditions where individuals and potential progeny were destroyed. Adverse direct impacts would be none to moderate, depending on Arizona clematis location in relationship to fire treatment and suppression fire areas.

As with Alternatives 2, 4, and 5, where mechanical and manual treatments would be conducted along Highway 67, Arizona clematis habitat would be impacted adversely by canopy cover reduction and other associated impacts. Arizona clematis often grows where canopy is dense. Direct adverse impacts would be local and possibly long term. Impacts would be minor due to size of area treated. Adverse impacts risks will be minimized by pre-treatment surveys.

The ponderosa pine forest type has a low departure from historic fire regimes, but with a decrease in fire treatments (prescribed and wildland fire-use fires) fuels would eventually build over time. Though it could take the planning period or longer before this becomes high risk, fuel build-up could increase higher severity suppression fire potential which could have adverse impacts to this species. High severity fire areas, with loss of crown cover, could have direct and indirect, local, adverse, moderate, long-term impacts to the species.

Direct and Indirect Effects Alternative 3 Special Status Plant Species
***Penstemon pseudoputus*, Kaibab Plateau beardtongue Ponderosa Pine**
***Hymenoxys subintegra*, Arizona rubberweed**

With decreased fire treatment, populations of Kaibab Plateau beardtongue and Arizona rubberweed in meadow habitat would have increased adverse indirect impacts due to higher risk for high severity suppression fires that could occur in adjacent forest types which could impact meadow habitat. In addition, Kaibab Plateau beardtongue populations along Highway 67 may receive direct, local, adverse impacts from manual/mechanical and prescribed fire treatments in this corridor. Risk would be minimized with pre-treatment surveys and, in those areas where species are found, protection measures would be included in the treatment prescription.

Kaibab Plateau beardtongue and Arizona rubberweed are often meadow species. Meadow boundaries are maintained by a combination of factors including fire. Fire treatment reductions in Alternative 3 could lead to tree encroachment in these species habitat, an adverse, local, indirect, long-term impact. In addition, this alternative provides the least disturbance, which could potentially impact the disturbance-colonizing Kaibab Plateau beardtongue and Arizona rubberweed. Impact intensity would be short term and negligible to minor.

Direct and Indirect Effects Alternative 3 Special Status Plant Species
Mixed-Conifer

Of the alternatives, Alternative 3 has the least amount of mixed-conifer treated with fire (12% prescribed and very little, if any, as wildland fire use). In addition, approximately 24% of this vegetation is assumed would burn as suppression fires. Because fire is a valuable restoration tool for this forest type, this alternative would reduce the trend, in the mixed-conifer forest type, toward natural range of variability.

Direct and Indirect Effects Alternative 3 Special Status Plant Species
***Draba asprella var. kaibabensis,* Kaibab whitlowgrass Mixed-Conifer**

One known population and undetected individuals and/or populations would potentially receive direct and indirect, adverse, minor, local, short-term impacts from fire treatments and suppression fires. Alternative 3 would have the least potential for indirect adverse impacts to this species associated with fire treatments when compared to the other alternatives, but could have the greatest adverse impacts due to suppression fires. Where mechanical/manual treatment is proposed along Highway 67, Kaibab whitlowgrass habitat would be impacted adversely by canopy cover reduction and other associated impacts. Kaibab whitlowgrass often grows where canopy is dense. Risk would be minimized with pre-treatment surveys. Should the species be found, protection measures would be developed.

As with other special status plant species, potential increase in suppression fire would have additional adverse indirect impacts because suppression fires are more likely to be high severity, removing overstory vegetation. Risk of high severity suppression fires occurring in mixed-conifer would be high due to existing high fuel loads. Should a high severity suppression fire occur, adverse impact to this species would be local, long term with moderate intensity.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Castilleja kaibabensis*, Kaibab Indian paintbrush** **Mixed-Conifer**

Because Kaibab Indian paintbrush populations mostly occur in meadows, impacts are the same as for Kaibab Plateau beardtongue and Arizona rubberweed. With increased potential for high severity suppression fires in adjacent forests, there is higher risk of potentially adversely affecting Kaibab paintbrush populations, should they be where fire occurs. Impacts would be minor to moderate, short to long term, local. Without the natural fire regime occurring in the forest types, this alternative could lead to tree encroachment in these species habitat, an adverse, moderate, local, indirect, long-term impact.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
Piñon-Juniper

Under Alternative 3, 2% of this forest type would receive prescribed fire treatment, less than 2% would receive manual/mechanical treatment, and less than 1% would burn due to suppression fires.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Astragalus cremnophylax* var. *cremnophylax,* sentry milk-vetch** **Piñon-Juniper**

Direct and indirect impacts would be minimized in Alternative 3, relative to other alternatives. Though there is an increase in manual/mechanical treatment, mitigation measures and pre-treatment surveys of potential habitat prevent equipment and persons from entering or disturbing known populations causing no impact to known populations. Impacts would be adverse, negligible, short term, local.

Increases in suppression fire and associated impacts could have the greatest adverse impacts on unknown populations. Prioritizing surveys of potential sentry milk-vetch habitat would minimize risk to this species by providing location information for fire suppression events. Impacts from suppression fire and activities would be adverse, minor, short term, local.

Direct and Indirect Effects **Alternative 3** **Special Status Plant Species**
***Rosa stellata* ssp. *stellata*, Grand Canyon Rose** **Piñon-Juniper**

Direct and indirect impacts to Grand Canyon rose would be similar to Alternative 1 except amount of prescribed fire treatment in this forest type would be less and, should individual species occur where no prescribed fire is proposed, adverse impacts from prescribed fire could be less. As with Alternative 2, there would be a potential increase of adverse indirect and direct impacts to undetected individuals/populations due to mechanical/manual treatment proposed in preferred habitat. Risks would be minimized with pre-implementation survey work. Plants found would receive protection measures. Impacts would be minor, short term, local, adverse.

Both treatment methods also risk potential for invasion and/or expansion of exotic plant species. Risk would be reduced by implementing mitigation measures included in the alternative description and proposed in 4.2.3.

Mitigation of Effects **Alternative 3** **Special Status Plant Species**

Mitigation measures proposed in 4.2.2.6 will decrease adverse impacts related to special status plants.

Cumulative Effects **Alternative 3** **Special Status Plant Species**

Cumulative effects would not differ from Alternatives 1 and 2 except effects could have less intensity due to decreased treatment acres.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in the project and/or use areas.

Conclusion **Alternative 3** **Special Status Plant Species**

Alternative 3 minimizes fire treatments and maximizes mechanical/manual treatments. Thus, forest vegetation types would have a decreased trend toward the natural range of variability for natural fire regimes. Indirect impacts to special status plants due to this trend, overall would be adverse. Adverse impacts from fire activities in population areas would be less than other alternatives, but indirect adverse impacts from suppression fires would be greater. Those areas treated with prescribed and wildland fire-use fire would have beneficial effects on special status plants from habitat improvement and movement toward the natural range of variability for the fire regime.

Direct and indirect impacts to special status plant from fire and fire activities in the ponderosa pine forest type would create adverse, negligible to moderate, local, short- to long-term impacts. Beneficial effects of fire from habitat improvement and movement toward the natural range of variability for the fire regime would be minor, local, short to long term. Direct and indirect impacts from manual and mechanical thinning projects would be adverse, minor, short to long term, local.

Direct and indirect impacts to special status plants from fire and fire activities in mixed-conifer forest type would create adverse, minor to moderate, local, short- to long-term impacts on special status plants.

Impacts to special status plants in piñon-juniper would be adverse, negligible to minor, short term and local. There would be no impacts to known populations of *Astragalus cremnophylax var. cremnophylax* as mitigation measures keep impacts out of known population areas.

Indirect impacts to special status species in all forest types from introduction or increase of exotic species could be adverse, negligible to moderate, long term, local.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in the project and/or use areas.

Impairment **Alternative 3** **Special Status Plant Species**

Since are no major adverse impacts in Alternative 3 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status plant species during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Special Status Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, and concessioner or contractor operations, there would not be unacceptable impacts on special status plants as a result of Alternative 3 implementation.

4.2.2.16 Alternative 4 Prescribed Fire Emphasis Special Status Plant Species

Alternative 4 would change direction of the current fire management program to expand the amount of prescribed fire, burning approximately 90,000 acres. There would be a projected 20% increase in suppression, to approximately 24,070 acres. Wildland fire-use fire would be least of all alternatives, at 5,500 acres. Mechanical/manual treatments would occur on 800 acres in top priority areas. Alternative 4 would emphasize prescribed fire in ponderosa pine habitat, continuing the trend towards the historic fire regime. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 4 Special Status Plant Species

Direct and indirect adverse impacts from increased suppression fires and associated activities would increase with this alternative compared with all alternatives except Alternative 3. These impacts could have long-term adverse effects, especially if suppression fires occurred during periods of extreme fire weather. This alternative has the highest number of miles for handline construction compared with other alternatives (see Chapter 2) which would have adverse direct impacts to species growing in areas of handline construction, and potential adverse indirect impacts from potential invading exotic species.

Direct and Indirect Effects Alternative 4 Special Status Plant Species
Ponderosa Pine

The greatest proportion of the ponderosa pine forest type (54%) would be treated with prescribed fire and mechanical/manual treatments under Alternative 4; however, total area treated would be less for all alternatives, except Alternative 3, due to limited acres proposed with wildland fire use. In addition, approximately 5% of this vegetation type would burn from suppression fires.

Direct and Indirect Effects Alternative 4 Special Status Plant Species
***Arenaria aberrans,* Mt. Dellenbaugh sandwort Ponderosa Pine**
***Arabis gracilipes,* Flagstaff rockcress**

Alternative 4 would have similar effects as Alternatives 1, 2, and 5 to Mt. Dellenbaugh sandwort and Flagstaff rockcress except to a lesser extent since fewer acres are treated. Species individuals/populations could receive direct, local, minor, adverse impacts through being consumed by prescribed fire and, to a lesser extent, wildland fire-use and suppression fires. Trampling due to manual/mechanical treatments and associated fire management activities could also produce adverse, minor, local species impact through injury or mortality. These direct adverse impacts could be intensified during growing and blooming stages. Depending on fire treatment intensity, both Flagstaff rockcress and Mt. Dellenbaugh sandwort have a woody caudex (AGFD 2004) that could facilitate resprouting after fire or cutting; therefore, impacts could be short term with repopulation expected.

Based on Table 4-5, 8 to 13% of fire of any type (prescribed, wildland fire-use or suppression), would burn at moderate/high to high fire severity. During the fire, individual plants could burn, a short-term, minor, adverse impact; beneficial habitat impacts would likely be local, long term with minor to moderate intensity. Fires would continue the trend toward natural range of variability for historic fire regime.

Areas not treated would trend away from natural fire regime, and over time, be at higher risk for higher severity suppression fires. Should this occur where this species occurs, there would be a local, long-term adverse impact. This could have no to minor impact depending on whether the species is directly affected.

Direct and Indirect Effects **Alternative 4** **Special Status Plant Species**
***Chrysothamnus moslestus*, Arizona rabbitbrush** **Ponderosa Pine**

Impacts to Arizona rabbitbrush would be similar to Alternative 1, depending on season prescribed fire projects are implemented in this vegetation type and whether rabbitbrush is present. Impact could be beneficial (fall burn) or adverse (spring burn). Adverse impacts would be local minor, and short term if populations recovered after spring burns. Beneficial impacts would be minor, local, short to long term after fall burning.

Direct and Indirect Effects **Alternative 4** **Special Status Plant Species**
***Draba asprella var. stelligera,* rough whitlowgrass** **Ponderosa Pine**

Direct and indirect impacts to rough whitlowgrass would be similar to Alternative 1. Direct adverse impact would be local, short term, negligible to minor if individual plants are injured and able to recover; local, long term, negligible to minor if individuals were killed and population numbers declined; and, since this species prefers habitat openings, various treatments and suppression fires could have an indirect, local, long-term, minor to moderate, beneficial impact by enhancing and expanding habitat. As with all alternatives, there is potential for exotic plant invasion/expansion. This adverse impact could be decreased through mitigation measure implementation proposed as part of the alternative and in 4.2.3.

Direct and Indirect Effects **Alternative 4** **Special Status Plant Species**
***Clematis hirsutissima var. arizonica,* Arizona clematis** **Ponderosa Pine**
***Penstemon pseudoputus*, Kaibab Plateau beardtongue**
***Hymenoxys subintegra*, Arizona rubberweed**

Direct and indirect impacts to these species would be the same as Alternative 1. For Arizona clematis, direct adverse impacts would be short term in favorable conditions where understory competition and thatch were reduced to facilitate seedling establishment, or long term where individuals and potential progeny were destroyed. In addition, opening the stand from treatments and/or suppression fires would have adverse impacts to this species since its preferred habitat is dense canopy cover. These adverse direct impacts would be none to moderate, depending on Arizona clematis location in relationship to fire treatment and suppression fire areas.

For Kaibab Plateau beardtongue and Arizona rubberweed (which grow in meadows and disturbed areas), all fire and non-fire treatments resulting in some level of disturbance could have direct beneficial impacts by enhancing habitat for both species. Impacts would be local, minor, long term.

Direct and Indirect Effects **Alternative 4** **Special Status Plant Species**
Mixed-Conifer

The greatest amount of area (62%) in the mixed-conifer forest type is proposed for prescribed fire with Alternative 4. In addition, approximately 22% of this vegetation would burn from suppression fires, and there would be limitations of wildland fire use occurring in this forest type during the planning period.

Direct and Indirect Effects **Alternative 4** **Special Status Plant Species**
***Draba asprella var. kaibabensis,* Kaibab whitlowgrass** **Mixed-Conifer**
***Castilleja kaibabensis*, Kaibab Indian paintbrush**

Direct and indirect impacts to these species are similar to Alternative 2. As with Alternative 2, there is potential for moderate/high severity fire areas. This could result in canopy cover reduction which could have minor to moderate, local, adverse, short-term, indirect impacts. Depending on fire severity, Kaibab whitlowgrass has a small caudex that may allow regeneration after impact. This has increased likelihood of being killed during all fire severities, as conditions, such as fuel smoldering time, would influence underground plant parts. With likelihood of higher intensity fires during prescribed and suppression fires, adverse effects would likely cover an area similar to Alternative 2 (if populations occur in those areas). Impact would be local, short to long term, adverse with minor to moderate intensity.

Kaibab Indian paintbrush populations are known to occur in this alternative's extent. Populations mostly occur in meadow settings, adjacent to mixed-conifer vegetation type, which would not likely be directly impacted by this alternative except during drought years when fire could burn meadows. Impacts during drought years would be adverse, minor, short term, local.

Direct and Indirect Effects Alternative 4 Special Status Plant Species
Piñon-Juniper

In this alternative, 9% of piñon-juniper will be treated with prescribed fire and less than 1% would burn from suppression fire. There is uncertainty about the historic fire regime, so whether this is a trend toward or a return to natural range of variability is unclear.

Direct and Indirect Effects Alternative 4 Special Status Plant Species
***Astragalus cremnophylax* var. *cremnophylax,* sentry milk-vetch Piñon-Juniper**

Direct impacts to sentry milk-vetch would be similar to Alternative 1. There is additional potential impact on the North Rim Cape Final species, *Astragalus septentriorema*. This population was previously thought a population of endangered sentry milk-vetch (*Astragalus cremnophylax v. cremnophylax*), but is being considered for species designation. This species will be treated as a GRCA rare plant (Special Status /Species of Special Concern), and may be a candidate species for Federal listing. As mentioned in the discussion in Alternative 1, project proposal mitigation measures will protect known populations near proposed prescribed fire units causing no impact to known populations. With adherence to mitigation measures, this alternative would have a negligible, to minor, short-term, local, adverse impact if undetected individuals were impacted.

Direct and Indirect Effects Alternative 4 Special Status Plant Species
***Rosa stellata* ssp. *stellata*, Grand Canyon Rose Piñon-Juniper**

Direct and indirect impacts to undetected Grand Canyon rose populations would be similar to Alternative 1 and 2, but could increase due to additional prescribed fire treatments proposed in potential habitat.

An indirect impact from prescribed fire to this habitat would be increased potential for cheatgrass introduction and spread. This exotic plant species, if spread over a large area, could significantly alter fire regime. Mitigation measures for exotic plants could decrease risk (see Invasive Exotic Plants this chapter). Impacts would be minor, short term, local, adverse.

Mitigation of Effects Alternative 4 Special Status Plant Species

Mitigation measures proposed in 4.2.2.6 will decrease adverse impacts related to special status plants.

Cumulative Effects Alternative 4 Special Status Plant Species

Overall, cumulative effects would not differ from Alternative 2. Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions/projects varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in project and/or use areas.

Conclusion **Alternative 4** **Special Status Plant Species**

Alternative 4 emphasizes prescribed fire treatments for the planning period. This alternative has the second lowest acres affected in ponderosa pine vegetation which could decrease the trend toward natural range of variability for fire regime (and have a long-term adverse affect on special status plant species in this vegetation type). Impacts to the two special status plant species in the mixed-conifer vegetation type would be the same as Alternative 2. Alternative 4 proposes the most fire treatment in piñon-juniper compared with other alternatives.

Direct and indirect impacts to special status plants in the ponderosa pine forest type would create adverse, negligible to moderate, local, short- to long-term impacts. Beneficial fire effects from habitat improvement and movement toward the natural range of variability for fire regime would be negligible to moderate, local, short to long term.

Direct and indirect impacts to special status plants from fire and fire activities in the mixed conifer forest type would create adverse, minor to moderate, local, short- to long-term impacts on special status plants.

Impacts to special status plants in the piñon-juniper forest type would be adverse, negligible to minor, short term and local; and no impacts to known populations of *Astragalus cremnophylax var. cremnophylax* or *Astragalus septentriorema* as mitigation measures keep impacts from known populations.

Indirect impacts to special status species in all forest types from introduction or increase of exotic species could be adverse, negligible to moderate, long term, local.

Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in project and/or use areas.

Impairment **Alternative 4** **Special Status Plant Species**

Since are no major adverse impacts in Alternative 4 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status plant species during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Special Status Plant Species**

Because impacts previously described are not inconsistent with park purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, appropriate use, and concessioner or contractor operations, there would not be unacceptable impacts on special status plants from Alternative 4 implementation.

4.2.2.17 Alternative 5 Fire Use Emphasis Special Status Plant Species

Alternative 5 shifts the fire management program to restore and maintain forest types with wildland fire use (totaling 88,000 acres). With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, the lowest of all alternatives. This alternative aims to de-emphasize prescribed fire treatments, with treatment of 29,900 acres. Mechanical and manual treatments would total 2,675 acres and would occur in the WUI and along Highway 67 on North Rim. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**

Alternative 5 would have a greater potential for direct and indirect adverse impacts due to wildland fire use than Alternative 4 where emphasis is on prescribed fire. Predicting where a wildland fire-use fire could occur is difficult, unlike a prescribed fire. Pre-project implementation surveys are impractical as they would include a good portion of North and South Rims. Thus, there is increased potential for associated wildland fire-use fire adverse impacts to undetected species. Fire-use fires are naturally ignited and primarily occur in later summer months (Figure 4-3). Adverse impacts from wildland fire use are decreased during this time because plants are generally finished flowering and growing (which makes them sensitive to injury). Decreased suppression acreage would also proportionally decrease adverse impacts associated with fire and fire suppression activities.

Wildland fire-use fires tend to have the greatest spatial complexity, leaving a patchy mosaic of mixed burn severity and unburned patches. This patchiness would have the potential effect of impacting only portions of a special status plant species population and leaving individuals to regenerate the site.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
Ponderosa Pine

23% of the ponderosa pine forest type will be treated with prescribed fire and manual/mechanical treatments. In addition, the majority of fire-use acres would likely be located in this forest type, and approximately 4% of this vegetation type would burn from suppression fires. Like Alternatives 1 and 2, treatment in this forest type could be 70 to 100%.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
***Arabis gracilipes,* Flagstaff rockcress** **Ponderosa Pine**
***Arenaria aberrans,* Mt. Dellenbaugh sandwort**
***Draba asprella var. stelligera,* rough whitlowgrass**
***Chrysothamnus moslestus*, Arizona rabbitbrush**
***Clematis hirsutissima var. arizonica,* Arizona clematis**
***Penstemon pseudoputus*, Kaibab Plateau beardtongue**
***Hymenoxys subintegra*, Arizona rubberweed**

As with Alternative 2, Alternative 5 would treat the majority of the ponderosa pine forest type (70 to 100%). The difference is the majority of Alternative 5 treatment would be wildland fire use. Based on the analysis provided in this chapter's Vegetation Section, fire severity would be very similar between prescribed and wildland fire use fire (Table 4-5). Because fire severity would likely be very similar, impacts to all special status plant species in this vegetation type would likely be the same as Alternative 2. Adverse impacts to special status plants in the ponderosa pine type would be negligible to moderate, local, short to long term. Continuation of fire treatments will help trend this habitat toward the range of natural variability; therefore, Alternative 4 implementation would likely have a minor to moderate, beneficial, local, short- to long-term direct impact by improving habitat conditions.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
Mixed-Conifer

Prescribed fire proposed in Alternative 5 is the lowest (24%) of all alternatives except Alternative 3. Based on historical data and knowledge of existing fuel condition, an estimated 47% of the mixed-conifer forest type is predicted to be treated with wildland fire use. In addition, approximately 17% of this vegetation type is assumed to burn from suppression fires.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
***Draba asprella var. kaibabensis,* Kaibab whitlowgrass** **Mixed-Conifer**

High fuel levels in this forest type make it more vulnerable to higher intensity fires and greater spatial complexity than the ponderosa vegetation type. Should higher fire intensities occur in habitat containing Kaibab whitlowgrass, impacts could include canopy cover loss which could have an adverse, minor to moderate, short- to long-term, local impact on Kaibab whitlowgrass. As discussed in Alternative 1, this species could benefit from reduction in understory duff and litter. Impacts to this species would be very similar to impacts from Alternative 2, but because total acres directly affected would be less, effects would be slightly less.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
***Castilleja kaibabensis*, Kaibab paintbrush** **Mixed-Conifer**

Direct and indirect impacts to this species would be the same as Alternatives 1, 2, and 4. Species would not likely be directly impacted except during drought years when fire could burn meadows. Impacts during drought years would be adverse, minor, short term, local.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
***Astragalus cremnophylax var. cremnophylax,* sentry milk-vetch** **Piñon-Juniper**

Impacts to sentry milk-vetch would be similar to Alternative 2. Adverse impact risks would be low due to implementation of species-specific mitigation measures (4.2.2.6). Due to the open nature of sentry milk-vetch habitat, little, if any habitat would be impacted. With mitigation measures, all known populations would be avoided causing no impact to known populations. This alternative would have a negligible, to minor, short-term, local, adverse impact if undetected individuals were impacted.

Direct and Indirect Effects **Alternative 5** **Special Status Plant Species**
***Rosa stellata* ssp. *stellata*, Grand Canyon Rose** **Piñon-Juniper**

Impacts to Grand Canyon rose would be similar to Alternative 2. Direct and indirect impacts to undetected populations would be similar to Alternative 1, but could increase due to additional manual/mechanical treatments proposed in potential habitat. Risk would be low since less than 1% additional acres are proposed in this vegetation type that could be potential habitat. In addition, pre-implementation surveys would be required and any species found would receive protection measures. As with Mt. Dellenbaugh sandwort and rough whitlowgrass, additional impacts could be indirect and adverse from potential of introducing invasive exotic plant species with mechanical equipment. Impacts would be minimized through implementation of exotic plant mitigation measures. Impacts would be minor, short term, local, adverse.

Mitigation of Effects **Alternative 5** **Special Status Plant Species**

Mitigation measures proposed in 4.2.2.6 will decrease adverse special status plants impacts.

Cumulative Effects **Alternative 5** **Special Status Plant Species**

Overall, cumulative effects would not differ from Alternative 2. Adverse cumulative impacts on special status plant species from past, present, and reasonably foreseeable actions/projects varies from none to moderate, local to regional, short to long term, depending on whether species are present and on whether individual species habitat is in project and/or use areas.

Conclusion **Alternative 5** **Special Status Plant Species**

Effects of implementing Alternative 5 would be the similar to Alternatives 1 and 2 for special status plant species with habitat in ponderosa pine vegetation type. This alternative would directly affect fewer acres in mixed-conifer vegetation type than Alternative 2, but impacts would be similar to special status plant species with habitat in this vegetation type.

Direct and indirect impacts to special status plants in the ponderosa pine forest type would create adverse, negligible to moderate, local, short- to long-term impacts. Beneficial fire effects from habitat improvement and movement toward natural range of variability for fire regime would be minor to moderate, local, short to long term.

Direct and indirect impacts to special status plants from fire and fire activities in the mixed conifer forest type would create adverse, minor to moderate, local, short- to long-term impacts on special status plants.

Impacts to special status plants in the piñon-juniper forest type would be adverse, negligible to minor, short term, local; no impacts to known populations of *Astragalus cremnophylax var. cremnophylax* or *Astragalus septentriorema* as mitigation measures keep impacts out of known populations.

Indirect impacts to special status species in all forest types from introduction or increase of exotic species could be adverse, negligible to moderate, long term, local.

Impairment **Alternative 5** **Special Status Plant Species**

Since are no major adverse impacts in Alternative 5 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status plant species during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Special Status Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, and concessioner or contractor operations, there would be no unacceptable impacts on special status plants as a result of Alternative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Special Status Plant Species**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether by implementing mitigation measures or by changing the nature of a proposed action. Thus unavoidable adverse impacts would persist throughout the action's duration.

Alternatives 1-5 would have adverse, negligible to moderate, local, short- to long-term, direct and indirect impacts to special status plants from fire and fire activities in ponderosa pine forests; adverse, minor to moderate, local, short- to long-term, direct and indirect impacts from fire and fire activities in mixed-conifer forests. Alternatives 1-5 would have adverse, negligible to minor, local, short-term impacts from fire and fire activities in piñon-juniper forests. Alternatives 1-5 would have adverse, negligible to moderate, long-term, local indirect impacts from introduction or increase of exotic species.

Alternatives 2-5 would have adverse, minor, short- to long-term, local impacts to special status plants from manual/mechanical thinning projects.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Special Status Plant Species**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during plan's life.

There would be no irreversible or irretrievable commitments of resources.

4.2.3 Exotic Plant Species

4.2.3.1 Guiding Regulations and Policies **Exotic Plant Species**

Existing law and management direction for invasive exotic plant species in GRCA include
- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Endangered Species Act of 1973 (as amended)

In addition, the Noxious Weed Act of 1974, as amended, requires that Federal agencies
- Develop a management program to control undesirable plants on Federal lands under the agency's jurisdiction
- Establish and adequately fund the program
- Implement cooperative agreements with state agencies to coordinate management of undesirable plants on Federal lands
- Establish integrated management systems to control undesirable plants targeted under cooperative agreements

EO 13112 (Invasive Species) requires Federal agencies prevent invasive species introduction, provide control, and minimize economic, ecological, and human health impacts caused by invasive species.

Management Policies 2006 direct park managers to understand, maintain, restore, and protect the inherent integrity of park natural resources, processes, systems, and values. Specific directions include
- Exotic species will not be allowed to displace native species if preventable
- In general, new exotic species will not be introduced
- All exotic plant species not maintained to meet an identified park purpose will be managed—up to and including eradication—if 1) control is prudent and feasible, and 2) exotic species interferences with natural processes and perpetuation of natural features, native species, or natural habitats; disrupts native species genetic integrity or accurate presentation of a cultural landscape; damages cultural resources; significantly hampers management of park or adjacent lands; or creates a hazard to public safety
- High priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controlled. Lower priority will be given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled. (Note: cheatgrass is considered a low priority species by GRCA due to control difficulty.) Where an exotic species cannot be successfully eliminated, managers will seek to prevent further spread.

NPS Invasive Species Management: A Strategic Plan (NPS 1996) states growth and spread of nonnatives can change fire patterns and intensities, altering ecosystems. Guidance includes

- Provide park managers and the public with acceptable native alternatives to nonnative plant materials
- Incorporate nonnative plant management issues in all appropriate policy documents and guidelines, including planning/design, maintenance, fire, law enforcement, construction, and resource management

4.2.3.2 Management Objectives — Exotic Plant Species

Proposed FMP goals and objectives related to invasive exotic plants include

Goal 2 Restore and maintain park ecosystems in a natural, resilient condition

- Maintain ecosystems within the range of desired conditions (see Chapter 2) through natural processes within policy constraints
- Restore ecosystems not within the range of natural variability to desired conditions (see Chapter 2) and maintain them through natural processes within policy constraints
- Set priorities for treatment activities based on site-specific information including departure from natural fire return intervals, desired conditions (see Chapter 2), and other relevant factors

Goal 3 Protect the park's natural, cultural, and social values

- Managing the ecosystem and natural processes are the primary objectives that will lead to healthy critical habitat for listed threatened, endangered and sensitive species
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species
- Minimize smoke impacts on air quality values including visibility

Goal 4 Promote a science-based program that relies on current and best-available information

- Conduct research to understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the Fire Management Program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, fuel reduction treatments) to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions (Chapter 2), fire treatment priorities and prescriptions as relevant data become available

4.2.3.3 Methodology for Analyzing Impacts — Exotic Plant Species

Tools and Methodology Used to Analyze Effects

To define which exotic plant species and their ecological attributes to analyze and investigate, information was gathered from several sources. Exotic species lists were obtained from park records (NPS 2003b, NPS undated, NPS 2004, NPS 2007). In the GRCA exotic plant control program planning document (2004 to 2007), 61 of 171 exotic species were identified as priority species for control. Of 61 species assigned high-priority rankings by park staff, 48 species were analyzed in this FMP FEIS/AEF due to their possible ranges in fire management areas.

In 2006, park exotic plant location information was collected from a species list and past known general park locations (North Rim, South Rim, Inner Canyon). Information was also gathered from the web-based data sources SEINet (Southwest Environmental Information Network online maintained by The

National Science Foundation) and SWEPIC (Southwest Exotic Plant Information Clearinghouse; online, USGS n.d.). These two sites have limited park exotic-plant documentation. After these data sources were investigated, researchers determined GRCA exotic plant locations or population ranges were not entirely available. Due to this lack, specific spatial analysis was not completed for each alternative.

Fire effects, reproductive traits, and documented fuel treatment experiments were gathered via the Fire Effects Information System (FEIS) (USFS 2007a) database and other available literature sources on each of the 48 priority exotic species known to occur on North and South Rims. The 48 species occur in four growth forms: 13 grasses, 31 forbs, 1 shrub, and 3 trees.

The 48 exotic plant species analyzed were broken into two groups based on biological and physiological characteristics and disturbance responses. Table 4-25 is made up of 26 species that reproduce only from seed. These 26 species include three life-span groups (annual, biennial, or annual/ biennial) and include two plant growth forms: grasses (7) and forbs (19). After disturbance, these species populations can 1) expand from their sole reproductive method (seed), and/or 2) recover to a pre-disturbance size population using natural adaptations (resprouting from the root collar). Due to their short life span, spread is based on seed distribution through wind, water, animals, and management actions. As listed in Table 4-25 some seeds from these species may survive all fire severities while some will be killed only in high severity fire; both scenarios depend micro-site conditions that vary in and between sites.

Table 4-26 includes 22 species that reproduce variously including by seeds, rhizomes, tillers, and sprouting from roots and other areas. The 22 species in Table 4-26 include plants in many growth forms: forbs (12), grasses (6), shrubs (1), and trees (3); and in life span groups (perennial, biennial/perennial, and annual/perennial). Species in this longer life-span group are able to recover after disturbance due to reproductive ability(s) and/or ability to sprout and resprout from root crowns and basal whorls, and/or ability to grow new plants or reproductive parts from rhizomes or tillers.

Variables make post-fire and post-non-fire treatment response predictions difficult for individual plants and plant communities for all 48 species, including

- Time of year treatment occurs
- Phenology of the plant species
- Live fuel moisture
- Plant available moisture
- Fireline intensity
- Fire effects severity
- Proximity of similar and competitive surrounding plant species and seeds
- Seed longevity
- Common seed dispersal mechanisms (wind, water, animals)
- Reproductive methods
- Soil productivity
- Proximity to other disturbance events
- Proximity of available prime or low quality habitat
- Human, mechanical equipment (including vehicle), and animal interactions

4.2.3.4 Impact Thresholds — Exotic Plant Species

Due to the number of exotic plant species that could affect the environment with FMP implementation, indirect and direct impacts from each species are not analyzed in detail. Overall invasive exotic plant indirect and direct impacts are similar and addressed generally (except for species that could have significant impact). This analysis focuses on significant vectors (causes) from FMP implementation and how these vectors would play a role in increasing adverse impacts.

Type of Impact

Adverse	May lead to native plant habitat loss and reduce or prevent native plant reproduction due to increased competition by invasive exotic plant species, or would create an environment for easy invasion of exotic plant species
Beneficial	May decrease potential for exotic plant species invasion or spread in native plant habitat. May eliminate or damage existing competitive exotic species populations
Intensity	
Negligible	Imperceptible or undetectable effects to native plant habitat
Minor	Slightly perceptible and local, no potential for exotic plant population expansion, if left alone. Mitigations necessary to offset adverse impacts would be minimal and effective
Moderate	Apparent and measurable increase in exotic plant species; potential for exotic plant population expansion, if left alone. Mitigation measures would probably be necessary to offset adverse effects and would likely be successful
Major	Substantial, highly noticeable, with potential for landscape-scale effects. Exotic plant populations dominate the habitat. Mitigation measures to offset adverse effects would be needed, extensive, and success would not be guaranteed
Context	
Regional	Regional impacts would affect a widespread area (generally greater than 40%) of a single plant habitat type or affecting multiple plant habitat types in and adjacent to GRCA
Local	Local impacts confined to a small percentage (generally less than 35%) of a park plant habitat type
Duration	
Short Term	One growing season up to one year
Long Term	More than one growing season and greater than one year
Timing	Vegetation generally more sensitive to impacts during growing season and drought

4.2.3.5 Mitigation of Effects — Exotic Plant Species

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description, address impacts from invasive exotic plants, and are addressed in other sections of this Chapter.

- Locate control lines, helispots, fire camps, and other soil-disturbing fire management activities to minimize damage to biological resources
- Rehabilitate affected sites (e.g., control lines, staging areas, and helispots) as soon as possible following disturbance. Develop BAER plans as appropriate
- Inspect helispots, staging areas, incident command posts/base camps, etc., periodically and minimize exotic species introduction
- Use Minimum Impact Suppression Techniques to reduce disturbances to soil and vegetation
- Clean fire vehicles, equipment, and clothing in compliance with parkwide policy

- Procure certified weed-seed-free mulching materials and native plant seed used in fire rehabilitation
- Ensure the GRCA Exotic Plant Management Program and Fire Management Program work together to prevent and/or manage invasive exotic plant populations efficiently and effectively. Where implementation of these programs overlap, track dates and dual treatment prescriptions (e.g. hand pull and prescribed burn), and map locations

In addition to these specific mitigation measures, fire and vegetation staff will develop a phased approach to address species known to have large ecological effects (such as cheatgrass [*Bromus tectorum*] and other brome species) but are difficult to manage due to widespread park distribution. Park managers are directed to focus management actions on those species that could pose substantial impacts to park resources, that can reasonably be expected to be successfully controlled, and for which undertaking the action is prudent and feasible (NPS, 2006). Cheatgrass is currently listed as low priority for direct management action because treatment feasibility of this and other brome species across the entire park is low. However, due to concerns about potential effects of this species on ecosystem integrity, fire and vegetation programs are initiating pro-active steps to minimize factors that would contribute to future expansion of this species.

During 2010, staff will develop a map layer using GIS (datum NAD83) that displays current cheatgrass distribution based on recent vegetation work, and whichwill be considered the baseline distribution. The most up-to-date cheatgrass distribution information will be obtained using 1502 vegetation plots and 696 observation points installed as part of the 2007 vegetation mapping project, data from the park's 148 fire monitoring plots, and from research collaborations. In addition, fire ecology program staff will analyze existing data from fire effects monitoring plots to determine whether cheatgrass distribution or abundance changed between pre- and post-fire measurements. This strategy will provide an overall landscape assessment.

After preliminary data are compiled, fire and vegetation program staff will work together to compare each vegetation type's current conditions to desired future conditions. Staff will set a threshold for invasive species composition pre-burn. The threshold will be represented as percent cover of individual species, with focus on the highest priority species that pose a significant threat to ecosystems, such as cheatgrass. If preliminary data suggest the threshold value has been reached, management actions may be taken to reduce cover of the highest priority species prior to burning and to continue treating the species after the burn.

The fire monitoring program will continue to provide information on invasive species, including cheatgrass, to the vegetation management program through landscape-scale fire monitoring plots; however, monitoring of specific burn units to quantify invasive species is not currently planned. Fire and vegetation program staff will seek research funds to answer specific questions relating to invasive species management (e.g. does burn severity determine how and to what extent invasive plants enter and persist?). An adaptive management process will determine whether invasive plant control strategies, burn strategies (such as season of burning), monitoring protocols, and/or threshold values should be adjusted to achieve desired results. To fully implement this program beyond the evaluation phase, additional resources and compliance will be necessary because extensive cheatgrass control actions are not included in the vegetation program's current budget, and fire program monitoring funds are limited.

4.2.3.6 Cumulative Impacts — Exotic Plant Species

Cumulative impacts on exotic plants and native plant habitat were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions. For this resource, analysis boundaries were north into the Kaibab National Forest on the Kaibab Plateau, south into the national forest where the ponderosa forest extends, east into Navajo Reservation lands, and west and south into the Havasupai Reservation. The boundary includes all of GRCA and most surrounding lands due to long-term activities and exposure to exotic plant seeds and other reproductive parts, and seed's ability to travel onto park lands by multiple vectors (animals, people, vehicles).

Events that contribute most to invasive exotic plant cumulative impacts include wildfires, prescribed fires, fire exclusion, and lack of fuel treatment areas (increasing risk of large, high severity suppression fires), trespass cattle grazing, and feral burros (NPS 2006d), GRCA's Exotic Plant Management program, people, machinery (including vehicles), and animals. Events are bound by occurrence timing and projected length of impact. In the alternatives' impact analysis, wildfire acres and fire severities are predicted based on previous events and knowledge of vegetation types.

Many impacts from other projects are local and regional (Appendix G). There have been several major fires (suppression, prescribed, and fire use) and fuel reduction treatments that contribute to cumulative impacts analysis.

In addition, many invasive exotic plant species also have physiological traits that enable them to benefit from aspects of global climate change. Exotics may continue to proliferate from changes such as increased levels of atmospheric carbon dioxide, average precipitation, and warmer minimum winter temperatures.

Table 4-25 Annual and Biennial Grasses and Forbs, Documented Location, and Some Treatment Effects

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Aegilops cylindrica	Jointed goatgrass	A	Grass		X		Burning may reduce seed germination, depending on seed location and soil temperatures. Mowing may help in specific season
Bromus diandrus	Ripgut brome	A	Grass		X	X	No information available via FEIS, TNC, Invaders, Cal EPPIC, Cal-IPC, Cornell, or Science Direct*
Bromus rubens	Red brome	A	Grass		X	X	Fire kills plant, but population usually recovers due to seed sources
Bromus tectorum	Cheatgrass	A	Grass	X	X	X	Fire kills plant when brown (standing dead), but population usually recovers due to seed source; seeds susceptible to heat kill, depends on proximity to heat
Carduus nutans	Musk thistle	B	Forb		X		May be killed in high severity fire, survives/reproduces in other fire types
Centaurea solstitialis	Yellow starthistle	B	Forb		X		Higher severity fire may kill plant; lower severity may resprout. Fire usually doesn't kill seed; may stimulate germination. Burning season and frequency key to complete species removal. Examples: Spring burning before flowering, burning with enough heat to stem girdle plants, repeated burning or plant removal after burning to deplete seeds in soil germinated by soil heat; single burn is likely to increase plant size and seed production
Chenopodium album	Lambsquarter, pigweed	A	Forb	X		X	Seed kill through heating; seeds mature late season, so early season burns help kill seeds; immature seeds germinate. Hand pulling or frequent hoeing of small plants in hot weather is effective
Cirsium vulgare	Bull thistle	B	Forb	X	X	X	Mixed mortality results to fire; plant has abundant seed that are wind dispersed and can remain dormant in soil up to five years; one study found even low severity fire could kill its seeds; wet soil could steam kill seeds, but may conflict with ability to kill adult green plant before seed dispersal

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Conium maculatum	Poison hemlock	B	Forb		X		No information on effects from fire; mechanical removal (hand pulling, grubbing, mowing) is effective if done prior to flowering; seeds adhere well to most things; are carried by water and wind; complete eradication is difficult because of reintroductions and viable seeds in soil
Conyza canadensis	Horseweed	A	Forb	X	X	X	No information via FEIS or TNC
Cynoglossum officinale	Houndstongue	B	Forb	X			Most fire will top-kill, high severity fire to kill plant entirely due to hardy taproot; multiple treatment study in ponderosa and Douglas fir in Montana: no response to burn-only, but population increase to thin-only and thin-burn treatment combination
Echinochloa crus-galli	Barnyardgrass	A	Grass		X	X	Probably killed by fire. No real fire effects information in FEIS
Erodium cicutarium	Filaree	A/B	Forb	X	X	X	Seeds driven into soil by styles usually protected from fire. Moderate fire kills mature plants. Very young seedlings can survive fires of light to moderate severity. Seeds survive fire as related to depth seed is buried and fire intensity; severe fires kill seeds unless buried 0.5 inches (1.25 cm) or more. Post-fire population changes:1st year post-fire density reduced but biomass increases, 2nd year post population peeks , 3rd year cover statistics decline, 12th year post plant isn't visible
Hordeum murinum ssp. *glaucum*	Smooth barley	A	Grass		X	X	Only general information for genus available (same as below species): moderate fires top-kill; hot fires may kill underground root system; genus is most sensitive to spring fires that coincide with active growing period; cool-season grasses reduced with late spring burns

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Hordeum muirnum ssp. *leporinum*	Leporinum barley	A	Grass		X	X	Only general information for genus available (same as below species): moderate fires top-kill; hot fires may kill underground root system; genus most sensitive to spring fires that coincide with active growing period; cool-season grasses reduced with late spring burns. Information from TNC: population percentage reduced from 90% to 5% post-burn for up to three years with no other management; mowing effective
Kochia scoparia	Kochia	A	Forb		X	X	Plant probably killed by fire, good invader skills due to tumbleweed travel form. Little FEIS information
Lactuca serriola	Prickly lettuce	A/B	Forb	X	X	X	In a Michigan study in mixed pine, percent cover increased from 0% at unburned sites, to 7% after one burn, and 14% after two burns. A multiple treatment Montana study in ponderosa and Douglas fir, it increased to burn-only and thin-burn combined, but no population increase to thin-only
Melilotus indicus	Annual sweet clover	A/B	Forb		X	X	See write up for *M. officinalis* (below) or the following as summarized from *M. alba*: fire usually causes seed scarification simulating germination and seedling establishment. Must burn during active growing season during late spring or fall during green up (when 2nd year plants are above ground or when shoot growth has begun). Use fire to suppress clover is possible, but probably requires several successive annual/ biennial burns to exhaust seed supply

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Melilotus officinalis	Yellow sweet clover	A/B	Forb	X	X	X	Fire can kill or injure stems at the base and severely retard new growth; early spring fires can kill crown buds, especially 2nd year plants, so no new stems produced. In an early May fire, species had less 2nd year plants, but more 1st year plants. A July fire decreased 1st and 2nd year plants; fall fire should be done at or before growth period, then was followed by increased winter mortality. In a different study the plants' response to fire was variable according to time and frequency. TNC recommends a two-year burn schedule: use dormant season (late fall or early spring) burn to stimulate germination followed by later spring burn to kill second year plants before they set seed. Also mowing is an alternative and replacement for second burn, in fall
Onopordum acanthium	Scotch thistle	B	Forb		X		No information via FEIS, nor TNC
Salsola tragus	Russian thistle	A	Forb	X	X	X	The following is summarized from *S. kali*: fire probably kills plant and some seeds retained in leaf axils. Plant colonizes burn site within 1 to 3 years; example at Mesa Verde Plateau (CO) it co-dominated with Bigelow's tansyaster at post-fire year 3. Plant known to retain dominance for average of 1 year. Prescribed burns will not control plant since colonizes from off-site and thrives in disturbed communities

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Salvia aethiopis	Mediterranean sage	B	Forb		X		No fire effects information found. Inferences from available information: fire may top-kill or damage plant, but will resprout at crown unless very severe fire or fuel layer buildup was present to sever or kill the top of taproot or area 2-3 inches below crown. Plant population will persist due to seeds in area or colonization via tumbleweed travel. Only able to kill if harm plant 2-3 inches below crown; damage at heights above this results in crown resprouting. Prevent seed dispersal by removing plants (at least flowering parts) before flowering; taproot easily develops in plant's seedling stage
Sisymbrium altissimum	Tumble mustard	A	Forb		X	X	Only top killed by fire if root crown not damaged, then can resprout. If older plant (has bolted) it can be burned and killed by fire. Fire probably generally doesn't affect the seed bank. Plant is generally shade intolerant, so colonizes early, then is shaded out or out-competed. Species flowers early, before many other species in area
Sonchus oleraceus	Common sowthistle	A/B	Forb		X	X	No information via FEIS or TNC
Tribulus terrestris	Puncturevine	A	Forb		X	X	No fire effects information found. General plant attributes: woody taproot; fruit is woody burr known to puncture (attach to) bike tires, shoe soles, animal fur and hooves, so can travel with animals; seed dormancy over colder months, can remain viable in buried soil many years; large seed production amount per plant. Recommend repeated cultivation (harvesting/ cutting) just after germination (before seeds/flowers produced) as effective control

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*
Verbascum thapsus	Common mullein	B	Forb	X	X	X	In a thin/burn study in Northern AZ in ponderosa pine forest with three treatment regimes and a control area: it was found in all three treatment level areas, with the highest frequency at sites of highest intensity treatments, greater than 5% frequency. It originated from seed bank storage and germinated after disturbance and canopy openings. Known to not persist for more than a few years as other more competitive species take over. In a multiple treatment study in ponderosa and Douglas fir in Montana, there was an increased plant population in response to all three treatment types of thin only, burn only, and thin-burn combination

*Abbreviations: A=annual, B=biennial
TNC=The Nature Conservancy Global Invasive Species Initiative, Element Stewardship Abstracts, online at http://tncweeds.ucdavis.edu/esadocs.html. Accessed March 2007.
FEIS=Fire Effects Information System online at: http://www.fs.fed.us/database/feis/
Invaders = Invaders Database System, University of Montana, Missoula. Online at: http://invader.dbs.umt.edu/
Cal EPPIC = California Exotic Plant Pest Council online at: http://www.caleppc.org/
Cal-IPC = California Invasive Plant Council online at: http://www.cal-ipc.org/
Cornell = Cornell University. Biological Control: A Guide to Natural Enemies in North America. Online at: http://www.nysaes.cornell.edu/ent/biocontrol/
Science Direct online at: http://www.sciencedirect.com

Table 4-26 Perennial Plants And Documented Location By Park Region And Some Treatment Effects

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*	Reproduce By
Acroptilon repens	Russian knapweed	P	Forb		X	X	Post-fire top killed only, resprouts from root buds, roots likely remain unharmed post burn; in one study seeds unharmed post fire, but no seedlings observed post-burn	seeds and rhizomes
Bromus inermis	Smooth brome	P	Grass	X	X	X	Top-killed only by fire, plant usually resprouts from rhizomes or tillers. A late spring fire has reported reductions in the species due to stage of development, but other season burns increased plant population	seeds, rhizomes, tillers

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*	Reproduce By
Cardaria draba	Whitetop, hoary cress	P	Forb		X	X	Generalized for genus: likely to survive even severe fire due to extensive perennial root system, underground buds and rhizomes, can sprout from multiple points some four feet or more down in soil; seed tolerance to heating unknown	seeds and rhizomes
Centaurea biebersteinii; C. maculosa	Spotted knapweed	B/P	Grass	X	X		Fire will top-kill and stress plant; survives fire if root crown not killed; large perennial taproot; large seed quantities can survive fire, but severe burns may reduce seed germination	seed only
Centaurea diffusa	Diffuse knapweed	B/P	Forb		X		High fire severity will kill root crown; plant has large perennial taproot and produces large seed quantities	seed only
Chondrilla juncea	Rush skeleton-weed	P	Forb		X	X	Fire likely to kill above ground portions, but deep roots survive even severe fire, plant known to resprout following injury; wind dispersed seeds can survive up to 18 months	seeds and rhizomes
Cirsium arvense	Canada thistle	P	Forb		X		Fire top-kills, but roots survive and resprout. In a multiple treatment study in ponderosa and Douglas fir in Montana: no response to burn-only or thin-only, but population increased with thin-burn treatment. Establishes post-fire if area seed source; could seed area post-treatment so less unseeded areas available for plant to take over. Tree areas may shade out/kill where plant has established; consider season of burn, dormant season or late spring	seed only (resprouts from root system)
Convolvulus arvensis	Field bindweed	P	Forb	X	X	X	No study-based data available; fire likely kills above-ground portion, and plant's root system and buried seeds will be undamaged, so will resprout. One study found severe fire will not kill seeds. In post-fire setting, if litter layer and plant competition present, it will not do as well	
Elaeagnus angustifolia	Russian olive	P	Tree		X	X	No specific fire effects data; probably only top-killed by fire. Known to resprout from trunk, root crown, and roots after damage/fire; seeds may require scarification for ger-mination, possibly from fire; stump burning may success-fully control sprouting, needs post-fire sprout monitoring	seeds, resprouts at root crown
Elymus repens	Quack-grass	P	Grass	X	X		Adapted to some seasonal fire due to rhizomes; cover can in-crease following fire. Late spring fire reduces cover, flowering, and biomass; early spring fire can increase these. Study found burning on biennial schedule for several years effective in erad-icating plant. Fall burns might help reduce cool-season grasses; some inconsistencies about effects based on burn season	seeds and rhizomes

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*	Reproduce By
Leucanthemum vulgare	Oxeye daisy	P	Forb	X			No information via FEIS or TNC	seeds and rhizomes
Linaria dalmatica	Dalmatian toadflax	P	Forb	X	X		Generalized for genus: Deep and extensive perennial, sprouting root system; likely to survive severe fire; fire top-kills, but then re-sprouts and can then out-compete weak plants in post-burn environment. In a Montana sagebrush study: burning seemed to in-crease biomass and seed production per plant. Burning not recommended for effective control, but can use propane burner to scorch floral stalks to prevent seed production	seeds and rhizomes
Linaria dalmatica	Dalmatian toadflax	P	Forb	X	X		Generalized for genus: Deep and extensive perennial, sprouting root system; likely to survive severe fire; top-killed by fire, but resprouts and can then out-compete week plants in post-burn environment. In a Montana sagebrush study: burning seemed to increase biomass and seed production per plant. Burning not recommended for effective control, but can use propane burner to scorch floral stalks to prevent seed production	seeds and rhizomes
Marrubium vulgare	Hore-hound	P	Shrub, forb	X	X	X	No information via FEIS or TNC	seed only
Medicago sativa	Alfalfa	A/P	Forb		X	X	Moderate severity fire top-kills plant, scarifies seed; narrow root crown survives most fires by sprouting. Severe fires damage or kill root crown causing mortality; prescribed fires may increase population productivity March-June; may do worst in late summer to early fall fires	seeds and rhizomes
Phleum pratense	Common timothy	P	Grass	X	X		Moderate severity fires top-kill. Severe fire may damage or kill root crown causing mortality. Fire stimulates repro-ductive tiller production. In Illinois, seed production in-creased post-fire; population did well 2-4 years post-burn	seeds, tillers

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*	Reproduce By
Poa pratensis	Kentucky bluegrass	P	Grass	X	X		Response to fire varies according to burn season and severity. Late spring/fall fires most damaging, especially lower basal cover and tiller density; burning enhances seed germination; fire can kill above-ground portion; rhizomes initiate new growth. Early spring, summer, fall burns may increase biomass/density or no affect. Dormant in summer, so summer burns may not affect or may increase popul-ation; post-burn population (even in good burn condi-tions) often returns to pre-burn levels 1-3 years. In a few studies population diminished after repeated spring burns; some otherwise. Another study: population recovered dep-ending on post-fire moisture. TNC: frequent late spring burning used to control plant; timing is critical, must be just prior to warm-season grass growth. Known to do well post-grazing/mowing; an increaser under grazing. Plant reduced by frequent clipping (2 inches tall or less); depend on defoliation timing to favor warm season competitors	seeds, rhizomes, tillers
Rumex acetosella	Sheep sorrel	P	Forb	X	X		Probably top-killed by fire; sprouts from rhizomes or roots post-fire, or regenerates from onsite seed; very severe fire may kill. Several studies show increase post-treatment (burn, cut, thin). In multiple treatment Montana study in ponderosa and Douglas fir: no response to burn-only or thin-only, but pop-ulation increased to thin-burn treat-ment. In Michigan study in mixed pine, plant cover increased from 0% at unburned sites to 10% after one burn; 13% increase after 2 burns	seeds and rhizomes
Solanum elaeagnifolium	Silverleaf night-shade	P	Forb		X	X	No direct fire effects data available. Seeds spread easily by water, machinery, animals, birds; root, crown, or base parts regrow via rhizomes. Seeds viable in ground up to 15 years; deep root system, likely survive most fire and drought. Can kill or prevent seed production with shade levels of 63 to 92%; shade is effective control tool, including turning plant into soil until another plant takes over; seeds survive scarification and digestive tracks of sheep; plant a problem in areas where vegetation removed; taproot sections remain viable up to 15 months; can regrow after being clipped; dried plants may blow like tumbleweeds	seeds and rhizomes

Scientific Name	Common Name	Life Span*	Growth Form	North Rim	South Rim	Inner Canyon	Summary Of Response To Fire And Management Considerations/Mitigations*	Reproduce By
Sorghum halepense	Johnson-grass	P	Grass	X	X	X	Plant survives fire, only top-killed then sprouts from rhizomes; fire may promote plant spread depending on timing; very high temperatures kill seed, it's documented to increase after disking and burning; spring burns without follow-up treatment not recommended; one study used gas torch and after 11 follow-up visits, plant stopped resprouting	seeds and rhizomes
Tamarix ramosissima	Salt cedar	P	Tree	X	X		Plant is top-killed post-fire, but resprouts; severe fire may kill root crown; low temperature with long duration or high temperature with short duration kills seeds; stress induced flowering; fire may facilitate plant invasion over less hardy species; consider season of burn and phenological stage	sprouts from root crown and stem parts; seeding
Taraxacum officinale	Common dandelion	P	Forb	X	X	X	Plant primarily adapted to fire by production of wind-dispersed seed and persistent viable seed bank; plant known to increase post-fire at least for first few years; in a Michigan mixed pine study, plant cover increased from 4% at unburned sites to 11% after one burn and 13% increase after 2 burns. In a Montana multiple- treatment study in ponderosa and Douglas fir, plant had no response to burn-only nor thin-only, but population increased to thin-burn treatment. Late spring burns, as compared to earlier spring, after growth initiation began is best for decreasing plant, but it's less effected by dormant season (fall and winter) burns	seeds, resprouts at root crown
Ulmus pumila	Siberian elm	P	Tree		X		Generalized by genus based on data for *U. rubra* (slippery elm) and *U. americana* (American elm): sprouts from root crown/base post-fire; low- to moderate severity fire can kill saplings and wound larger trees. Usually occurs in wet moist areas; seed is wind and water dispersed; fire can top-kill plant; cambium exposure to 140°F for 20 minutes caused tissue death	seed only

*Abbreviations: A=annual, B=biennial, P=perennial
TNC=The Nature Conservancy Global Invasive Species Initiative, Element Stewardship Abstracts, online at http://tncweeds.ucdavis.edu/esadocs.html. Accessed March 2007.
FEIS=Fire Effects Information System online at: http://www.fs.fed.us/database/feis/

4.2.3.7 Assumptions — Exotic Plant Species

Historical GRCA plant surveys show a steady increase in number of exotic plant species found in the park from 9 in 1930, to 29 in 1936, to 41 in 1947, to over 180 today; more are expected. People, machinery, vehicles, livestock, wildlife, fire, wind, and water contribute to exotic plant species establishment and spread. GRCA has an active Exotic Plant Management Program working to minimize further exotic plant spread and introduction.

The following is assumed about exotic plant response to disturbance

- Annual and biennial plants can easily invade
- Perennial plants with variable invasion adaptations can easily invade and expand
- Plants that sprout easily after disturbance are assumed to persist longer in an ecosystem
- Plant populations that only reproduce or survive by seeding, and live one to two years, have variable amounts of ecosystem persistence

There will be years when the annual acres treated by prescribed, wildland fire-use, and/or suppression fire will be much less or much greater than average.

4.2.3.8 Incomplete and/or Unavailable Information — Exotic Plant Species

Invasive exotic plant species populations' geographic locations, spatial spread across GRCA, or proximity to proposed fire management areas were not available for this analysis.

Invasive exotic plant species have a variety of fire responses. Some fire responses are documented and easily available while other species need further scientific research. When information was not available, species response was estimated based on reproductive traits and responses of similar species.

Quick exotic species invasion and establishment in some regions, like GRCA and the Colorado River watershed, may be too recent for research recommendations to fully assess or plan future effects on exotic and native species.

4.2.3.9 Impact Analysis — Exotic Plant Species

Impact analysis focuses on vectors that could bring or expand exotic plant species into GRCA by implementing the proposed FMP. Proposed activities (heavy machinery like feller buncher or brush masticator), four-wheel drive vehicles or off-pavement vehicles, estimated cut line and manual treatment acres, high and moderate/high severity fire, and indirect effects from public and animal use post-treatment) are the biggest vectors that can cause most change to plant habitat from invasive exotic plant species. These vectors are the focus of analysis and the basis of alternative comparison. General invasive exotic plant species impacts are addressed in Effects Common to All Alternatives, below.

4.2.3.10 Effects Common to All Alternatives — Exotic Plant Species

Direct and Indirect Effects — Effects from Invasive Exotic Plants

Many exotic plant species are stimulated to grow, reproduce, and spread by fire effects or other disturbances, an indirect adverse effect. Exotic plant presence could have substantial adverse effects on native plants, animals, and habitat, due to

- Resources competition: light, water, nutrients, growing space
- Wildlife habitat degradation by exotic competition with native plants used as food sources, nesting, or resting habitat
- Genetic integrity disruption of native plants if crossbreeding occurs

- Fire regimes changed by converting vegetation types (annual exotics like cheatgrass; forbs like yellow star thistle and filaree, cure and become more flammable earlier in the year than some native plants)
- Disruption or change to general known vegetation-type successional pathways, such as changing species composition and competition levels in a plant community, so community or ecosystem trajectory has a different climax state or differently paced successional timeline

One well-known exotic plant species that could significantly impact GRCA ecosystems is cheatgrass (*Bromus tectorum*). Cheatgrass, an annual, highly invasive, exotic grass has been well studied and is recognized by GRCA as difficult to manage. Fire enhances cheatgrass establishment and spread, and since cheatgrass dries in early summer and is highly flammable, fires spread with unusual rapidity which, in turn, perpetuates spread. Cheatgrass will likely persist in ecosystems and spread to other areas (Keeley 2006, Klinger et al. 2006, Huisinga et al. 2005, Crawford et al. 2003). Under worst-case circumstances, fire regime could change with early, more frequent summer wildland fires. More frequent and/or early summer fires would change natural habitat vegetation. Because of this, cheatgrass will continue to be a threat to GRCA's native vegetation types (especially in piñon-juniper). This adverse impact could be long-term, regional, and moderate to major. Very little fire treatment is proposed in the piñon-juniper vegetation type in all alternatives; therefore, adverse impacts due to cheatgrass in this type would be minimized.

Effects Common to All Alternatives **Exotic Plant Species**
Factors in Establishment of Invasive Exotic Plant Species **Direct and Indirect Effects**

Proposed treatments will open forest canopy and expose bare soil providing additional sunlight to soil substrates. Additional sunlight might allow fast growing or invading exotic plants to become established in new micro-sites.

Time of year treatment occurs, plant species phenology, live fuel moisture, plant-available moisture, fireline intensity, and fire severity are variables that affect exotic plants after a fire event. Additional variables include proximity of similar and competitive surrounding plant species and seeds; seed longevity; common seed-dispersal mechanisms (wind, water, animals); reproductive methods; soil productivity; proximity to other disturbance events; proximity of available prime- or low-quality habitat; and human, mechanical equipment (including vehicles), and animal interactions.

Vectors noted below are considered of greatest risk for encouraging exotic plant species invasion and/or expansion into areas impacted by proposed FMP implementation.

Factors in Establishment **Exotic Plant Species**
Vehicles **Effects Common to All Alternatives**

Vehicles entering treatment and/or post-treatment areas, or involved in fire suppression and/or post-fire suppression activities could introduce or expand invasive exotic plant species populations. Introduction would occur if seeds or plant parts are attached to vehicles, people in the vehicle, and/or tools or equipment. Seeds and/or plant parts could fall on recently disturbed soils vulnerable to exotic plant propagation. Vehicles could also physically contribute to a suitable environment for exotic plant species propagation by leaving tire tracks and off-road parking-area disturbance.

Adverse impact extent depends on amount of exotic plant material carried, deposited, and contacted; amount of vehicle disturbance and fire project disturbance to soil layers. Extent of effect is also dependent on wind and water travel for seeds and/or plant parts to reach an area vulnerable to propagation. Vehicles include: two-wheel, four-wheel, and all-terrain vehicles, and helicopters.

All 48 exotic plant species acknowledged earlier have potential to impact disturbed areas. Plants in Table 4-26 would not have an advantage over those in Table 4-25 because vehicle use would not add to reestablishment of existing populations. Mitigation measures incorporated in 4.2.3.5 will decrease impacts related to invasive exotic plant species.

Factors in Establishment **Exotic Plant Species**
Handline Construction and Manual Treatment **Effects Common to All Alternatives**

Impacts of handline construction and manual treatments vary between and in a vegetation type and may include: disturbance of native plants, exotic plants, and soil layers; transportation of reproductive plant parts; burying and mixing soil and vegetation parts that either inhibit or encourage future exotic plant growth; and soil layer exposure to erosion and invasive exotic plant colonization.

Accumulation of dead plant parts in taller or thicker piles or layers than naturally found could shade or inhibit underlying plants and seeds from receiving necessary resources; physically move existing exotic plant seed or plant parts to another location; and change fuel loading to increase fire intensity and severity at these sites (burn piles or random wildfire occurrences). Human-caused movement of slash and cut plants would also cause soil layer and plant disturbance when dragged, walked on, or driven to another site. These disturbance sites create micro-habitats for exotic plants to pioneer faster than native plant recovery in newly forming litter and duff layers.

Slash pile burning has two adverse effects that may increase exotic plants 1) moderate/high to high severity effects on underlying soil substrates, 2) another entry made to burn each pile, adding a second vector (human impacts). Some manually treated acres are proposed for prescribed burn treatments which increases the times acres may be exposed to humans and equipment impacts due to dual treatments.

Handline construction could act as a corridor for exotic plant species expansion.

These vectors could provide added advantage to Table 4-26 exotic plants because these species have a longer life span and recover after disturbance due to reproductive ability(s) and/or ability to sprout or resprout from root crowns and basal whorls, and/or grow new plants or reproductive parts from rhizomes. Both vectors assist in seed and plant part dispersal through wind, water, and animal movement. Mitigation measures incorporated in 4.2.3.5 will decrease impacts related to invasive exotic plant species.

Factors in Establishment **Exotic Plant Species**
Moderate/High to High Post-Fire Severity Effects **Effects Common to All Alternatives**

Moderate/high and high severity fire effects kill some to all above-ground plant portions, often substantially changing forest vegetation structure. Logs and organic material are mostly to completely consumed with spatial area ranging from patches to all ground areas consumed. Mineral soil can be nearly too completely exposed due to consumption of vegetation and duff, but remain relatively intact at shallow depths. Patchy areas where fire has burned for longer periods, especially surrounding downed logs and stumps, may become reddish, bare, and sterilized resulting in temporary viability loss. In addition, biological soil crust may be affected by fire severity on South Rim. When crust is damaged, arid plant ability to resist erosion and receive nutrients is limited. In these areas, native plant community health is diminished and exotic plants could invade.

Moderate/high and high severity fire effects have direct and indirect effects on exotic plants and native plant growth. Plants may respond with vigorous regrowth or be stunted in ability to grow, reproduce, and spread. Invasive exotic plant species tend to recolonize and invade sites burned at moderate/high and high severity fire. Often the most common invasive plants are exotic plants, and these exotics could already inhabit or live adjacent to these areas. Fire effects may kill native and exotic plant species seeds, tap roots, and rhizomes. Fire effects include short- to long-term changes in canopy cover, shade-to-sun ratios, plant-available moisture, soil productivity, erosion rates, litter and duff depths and accretion rates, and viability of other organic substrate constituents. Effects on different invasive exotic species in and between sites could be both adverse and beneficial and variable depending on micro-habitat, time of year, and density and proximity of other species.

As mentioned in Affected Environment, spruce-fir is bordered in a patchwork or mosaic pattern with mixed-conifer forest and montane-subalpine grassland types. Annual exotic grasses (*Poa pratensis, Bromus tectorum*, *B. rubens*) and exotic forbs *(Chenopodium murale, C. album, Cirsium vulgare*, *Erodium cicutarium, Lactuca serriola, Taraxacum officinale, Tragopogon dubius, Verbascum thapsus*) are known to occur in vegetation types that border spruce-fir, and threaten ecotones (Crawford et al. 2003, Huisinga et al. 2005). Though many plants, including exotics, are limited in elevational growth range due to temperature and moisture constraints, sometimes a particular area's physical environment may provide enough resources for a species to survive, marginally, in areas where it has not been surveyed (or documented) before. Though only a few studies have documented exotic plants in the spruce-fir forest type, their currently minimal occurrences may still be adverse in terms of future healthy native vegetation.

Due to spruce and fir tree characteristics (thin bark and branches that extend to the ground), fire effects of any fire type may be more severe, and more mortality may occur when compared with other vegetation types. After dead trees loose branches or fall, canopy openings occur and create habitat where exotic plant species could invade and/or expand. In addition, suppression fires have the highest amount of moderate/high to high severity on average for all vegetation types (43%), wildland fire use has 26%, and prescribed fire 22%. With higher fire severity, fire effects correlate to increases in exotic plant invasion and/or expansion (Omi et al. 2006); suppression acres have greatest potential for adverse impact due to exotic plants spread when compared to the three fire management types.

Perennial exotic plant species listed in Table 4-26 could have added advantage over exotic grasses and forbs listed in Table 4-25. If individual plants survive in moderate/high to high severity fire areas, they could propagate through sprouting, resprouting from root crowns, basal whorls, rhizomes, and/or grow new plants from seed. For many exotic species (annual grasses and forbs), revegetate speed is faster than some native vegetation. Mitigation measures in 4.2.3.5 will decrease impacts related to exotic plant.

Factors in Establishment **Exotic Plant Species**
Increased Human and Animal Activity **Effects Common to All Alternatives**

New vegetation openings often create a spacious vegetative environment where animals and people visit (walk, bicycle, horseback, and/or drive) for the first few years or as long as vegetation is not overgrown. This is especially true near trails, buildings, roads, and most WUI areas where people travel and spend time. The footprint caused by visitors and animals are indirect impacts that could spread exotic plant seeds or exotic plant parts (animals, people, and their gear are vectors) and/or damage native plants and soil layers, which further opens the area to invasive exotic plant species.

Areas directly affected by FMP implementation would likely see an increase in biological material travel. Animals and some humans are naturally attracted to newly established or restored plant communities for forage and wildflower/wildlife viewing affecting both native and exotic plant species.

All 48 exotic plant species acknowledged earlier have potential to impact these areas. Plants in Table 4-26 would not have an advantage over species in Table 4-25 because increased human and animal activity would not add to existing population reestablishment. Mitigation measures in 4.2.3.5 will decrease impacts related to invasive exotic plant species.

4.2.3.11 Effects Common to Alternatives 2 through 5 **Exotic Plant Species**
Direct and Indirect Effects
Factors in Establishment

Alternatives 2 through 5 include mechanical treatment as a non-fire treatment option. Equipment used during mechanical fuel treatment projects is a vector as noted in 4.2.3.9.

Factors in Establishment **Alternatives 2-5** **Exotic Plant Species**
Heavy Equipment/Mechanical Treatments **Direct and Indirect Effects**

Mechanical treatments would only occur in WUI management units and along the two main highways accessing the park. These areas receive more human impacts and activities than GRCA's proposed wilderness areas. Equipment examples being considered for mechanical treatments include chainsaws, grapples attached to Bobcat-type[1] equipment, clippers, or sheers attached to Bobcat-type equipment, bole skidding by Bobcat or other similar equipment, and a brush masticator.

Effects noted under Handline Construction and Manual Treatment above also exist for mechanical treatments. Mechanical equipment can be the biggest vector causing most change to plant habitat through close interaction and/or mixing of soil and vegetation layers. Due to mechanical equipment weight, some adverse impacts include soil compaction and soil porosity loss. Reduced porosity could result in increased root death, resistance to root penetration, decreased water infiltration, decreased plant-available water, and increased erosion. Grapplers and skidders, and dragging of tree boles and bushes, could also cause soil compaction and remove soil organic horizons. Adverse impacts could provide an environment that would discourage native plant revegetation and encourage invasive exotic plants.

Nutrients, including nitrogen and phosphorus, are critical for maintaining healthy plant communities. When soil layers and/or vegetation layers mix, areas are exposed to seed establishment and movement, and seeds are exposed to damaging conditions or increased resource availability for germination. Canopy cover and litter/duff levels often change as a result of mechanical treatments, and open forest with open soil is open to exotic invasion. Equipment use may also create short-term skid trails that may have similar adverse effects as handlines (acts as a corridor for exotic plant species invasion and expansion).

Slash left behind, such as masticated brush or trees, changes live standing fuel to dead and down fuel on herb, grass, and litter/duff substrates. As mentioned in manual treatments, increased surface fuels may cause adverse effects by increasing risk of higher fire severity effects on current standing and future native plant communities, possibly encouraging invasive exotic plants (Bradley et al. 2006). In addition, dead fuel on the ground would have beneficial effects by decreasing potential for understory vegetation (native or exotic) to germinate and/or revegetate for the first years or until burned, removed, or decomposed. Some mechanically treated acres are also proposed for prescribed burn treatments, which would increase exposure to various vectors over a longer time due to dual treatments.

Mitigation of Effects **Alternatives 2-5** **Exotic Plant Species**

In addition to mitigation measures in 4.2.3.5 additional mitigations proposed below are common to Alternatives 2 through 5 and relate to mechanical treatment.

- Include collection of exotic plant data. Data will be user friendly and available to managers for tracking growth or reduction of exotic plant populations before and after fuel or fire treatment and/or incident
- Consider mechanical treatment work during winter plant dormant season and/or during times when snow pack will minimize impacts to soil and vegetation
- Use qualified personnel to periodically inspect, map or document, and remove exotic plants from treatment areas, slash loading sites, and/or skid trails created and/or disturbed by mechanical equipment during treatment. If removal is not feasible, at a minimum work with GRCA Vegetation Program to document and map extent of exotic species encroachment

[1]A Bobcat is a small dozer considered to cause limited damage compared to a full-size dozer (D-4 or greater) or other heavy equipment.

4.2.3.12 Alternative 1 No Action Existing Program Exotic Plant Species

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same suppression level at approximately 20,050 acres; 58,500 acres treated with prescribed fire (primarily in the ponderosa pine and mixed-conifer FMUs); 55,000 acres treated with WFU; and 400 acres manually treated (primarily in piñon-juniper habitat). Manual treatment includes chainsaw use with cut vegetation chipped, piled, or disposed off-site. For a full description of Alternative 1, see Chapter 2.

Factors in Establishment Alternative 1 Exotic Plant Species
Vehicles

There is very little manual and no mechanical treatment encouraging off-road vehicle use. In addition, wildland fire-use fire would not cause high vehicle traffic. The majority of traffic from this alternative would be from prescribed fire and fire suppression activities. GRCA exotic plant species population locations in and adjacent to the boundary are not entirely known. Based on the area proposed for prescribed fire, and what could be expected with suppression fires, the adverse affect of introducing and/or expanding exotic plant species caused by vehicles would be minor to moderate and local. Depending on vehicle-use amount on native (unpaved) surface roads adjacent to treatment areas or suppression areas, road sides could be vulnerable to exotic plants. As in the 2000 North Rim Outlet Fire, drop point areas (often roadside pullouts and parking areas) contained the highest exotic plant percentage during all five years of the study (Crawford and Straka 2004). The study acknowledged these same drop points, being roadside pullouts, have maintained disturbance from visitor use. Depending on what species would invade or expand due to vehicle traffic, this adverse impact could be long-term.

Factors in Establishment Alternative 1 Exotic Plant Species
Handline Construction and Manual Treatment

Alternative 1 proposes approximately 100 miles of handline construction and 400 acres of manual treatment over the life of the plan. As noted earlier, these activities could act as vectors bringing in or expanding invasive exotic plants in treated areas. Manual treatment acres or handlines could act as an exotic plant species corridor. Another effect exists, as found in a study of the Outlet Fire where handline areas had no significant vegetation recovery in the first five years post-fire (Crawford and Straka 2004). Depending on variables noted earlier, adverse impacts caused by these activities could be minor to moderate and very local (acres affected would be minimal over the planning period). Depending on what species invade or expand due to treatment activities, this adverse impact could be long-term. Mitigation measures are proposed to reduce this adverse impact (rehabilitate affected sites as soon as possible; use fire suppression tactics that reduce disturbances to soil and vegetation, especially if creating fire lines; periodically inspect handlines; and take appropriate measures when exotic plants are found).

Factors in Establishment Alternative 1 Exotic Plant Species
Moderate/High to High Post Fire Severity Effects

This alternative has the low intensity constraint for prescribed and wildland fire-use fires. This analysis interprets this to mean fire treatments would not burn more than 15% overall area at moderate/high to high severity fire. With this constraint, risk of this vector causing adverse effect from exotic plant species is lowered. The majority of moderate/high to high severity fire would occur with suppression fire. Based on predictions, 18% mixed-conifer, 36% spruce-fir, and 4% ponderosa pine vegetation types would burn as suppression fire. These fires would burn more area classified as moderate/high to high severity fire than fire treatment types. Based on this information, fire severity effects that could increase risk of exotic plant species invasion and/or expansion would be minor to moderate, local. Depending on what species invade or expand due to these fire effects, this adverse impact could be long term.

It is estimated that fire treatments in Alternative 1 would affect 60-65% of mixed-conifer, 70-100% of ponderosa pine, and 3% of piñon-pine vegetation. In addition, its assumed that approximately 20,050 acres will burn under a suppression response. If cheatgrass invades or expands into burned areas (regardless of severity), this species could cause moderate, long-term, adverse effects. If annual exotic grasses, such as *Bromus* (12 species in the park, including cheatgrass), *Avenas* (one park species), and *Poas* (three in park; NPS 2007) change the fire regime, and if fires occur during a longer fire season—and more frequently in some vegetation types—there could be regional adverse effects. Mitigation measures are proposed to reduce these adverse impacts. Examples include rehabilitating affected sites as soon as possible, using weed-free mulching materials, designing erosion control structures, instituting a monitoring program, and mapping exotic communities and treatments.

Factors in Establishment **Alternative 1** **Exotic Plant Species**
Increased Human and Animal Activity

WUI treatment is minimal; therefore, increased human activity in the WUI due to treatments, which would cause an adverse effect on potential invasion and/or expansion of exotic plant species, would also be negligible to minor.

Animal activity would likely increase in burned areas. Animals could bring or spread noxious weeds in vulnerable, newly burned areas. Adverse impacts caused by these activities would be negligible to minor, local, possibly long term.

Factors in Establishment **Alternative 1** **Exotic Plant Species**
Heavy Equipment/Mechanical Treatments

No mechanical treatment is proposed; therefore, there is no risk from mechanical equipment to encourage exotic plant species invasion and/or expansion.

Mitigation of Effects **Alternative 1** **Exotic Plant Species**

Mitigation measures in 4.2.3.5 will decrease adverse impacts related to invasive exotic plant species. Alternative 1 also includes the following mitigation measures that will affect invasive exotic plant species

- Manage prescribed fires as low intensity fires to minimize negative effects on habitat and on primary constituent elements of MSO critical habitat
- Manage wildland fire-use fires as low intensity to minimize negative effects on habitat. GRCA's objective will be to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- Natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), but occasionally up to 10% mortality may occur in large trees

Monitoring, future research, and adaptive management will be key in affecting exotic plant populations.

Cumulative Effects **Alternative 1** **Exotic Plant Species**

Events that contribute most to invasive exotic plant cumulative impacts include wild and prescribed fires; fire exclusion and lack of fuel-treatment areas; trespass cattle grazing and feral burros (NPS 2005); the parkwide Exotic Plant Management Program; and impacts from vehicles, visitors and animals.

Alternative 1 is a mix of prescribed and wildland fire-use fire treatments with very little manual treatment (400 acres) and no mechanical treatment. In addition, prescribed and wildland fire-use fires overall would burn at low intensities.

Alternative 1 would likely have minor change to cumulative adverse effects from invasive exotic plant species when compared with past, present, and reasonably foreseeable future projects. Cumulative adverse effects are expected to be minor to moderate and possibly long-term and regional (depending on which invasive exotic plant species invade or expand due to these projects).

Conclusion **Alternative 1** **Exotic Plant Species**

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same suppression level of approximately 20,050 acres; 58,500 acres treated with prescribed fire (primarily in ponderosa pine and mixed-conifer FMUs); 55,000 acres treated through wildland fire use; and 400 acres treated manually (primarily in piñon-juniper habitat).

Vehicle use could cause minor to moderate local possibly long-term adverse impacts; handline construction and manual treatment could cause minor to moderate local possibly long-term adverse impacts. Moderate/high and high severity fire could cause minor to moderate local possibly long-term adverse impacts; increased human and animal activities could cause negligible to minor local, possibly long-term, adverse impacts caused by invasive exotic plant species introduction and/or expansion. Heavy equipment/mechanical treatments would have no effect since this treatment is not proposed. Cumulative effects associated with Alternative 1 could be minor to moderate regional possibly long term adverse.

Main risks are related to low intensity fire criteria for prescribed and wildland fire-use fires. Indirect effects would be higher risk of larger, high severity suppression fires with time. The highest concentrated areas of moderate/high to high severity fire would be caused by suppression fires and manually treated acres with burn piles. Moderate/high to high severity fires are vectors for exotic plant species invasion and expansion. Another risk relates to vehicle use and handline construction as potential vectors and corridors for exotic plant species. Implementation of established and newly proposed mitigation measures would decrease adverse effects.

Impairment **Alternative 1** **Exotic Plant Species**

Since are no major adverse impacts in Alternative 1 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts from exotic plants would not impair resources during Alternative 1 implementation.

Unacceptable Impacts **Alternative 1** **Exotic Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts from exotic plants as a result of Alternative 1 implementation.

4.2.3.13 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Exotic Plant Species

Alternative 2 is similar to the existing GRCA fire management program (Alternative 1). Changes in Alternative 2 include use of mechanical fuel reduction methods in addition to manual treatment in Primary and Secondary WUI, and removal of low intensity fire requirements to protect MSO habitat. Acres affected by implementing this alternative are similar to Alternative 1 except for addition of approximately 2,100 mechanical treatment acres. A description of this alternative is in Chapter 2.

Factors in Establishment **Alternative 2** **Exotic Plant Species**
Vehicles

Adverse effects caused by vehicles as the vector for exotic plant species invasion or expansion would be slightly higher than Alternative 1 due to additional mechanical treatment proposed. Use of mechanical equipment would increase vehicle traffic in treatment areas (ferrying people, tools, and fuel to and from treatment sites). Additional treatment proposed (over Alternative 1) is focused in South Rim WUI where heavy human activity exists. Because so many human activities occur in the WUI, additional vehicle traffic from Alternative 2 would not increase risk of bringing in or expanding invasive exotic plant populations.

For Alternative 2, adverse effects of introducing and/or expanding exotic plant species by vehicle would be minor to moderate, local. Depending on vehicle use amount on dirt roads adjacent to fire treatment or suppression fire areas, road sides could be vulnerable to exotic species. Depending on which species invade or expand due to vehicle traffic, as noted in Alternative 1, this adverse impact could be long term.

Factors in Establishment **Alternative 2** **Exotic Plant Species**
Handline Construction and Manual Treatment

There is no significant difference in acres treated with manual thinning when compared to Alternative 1. Potential adverse effects these activities would have on invasive exotic plants invasion and/or expansion would be the same as Alternative 1.

Depending on variables noted earlier, adverse impacts caused by these activities would likely be minor to moderate and very local. Depending on which species invade or expand due to treatment activities, this adverse impact could be long term.

Factors in Establishment **Alternative 2** **Exotic Plant Species**
Moderate/High to High Post-Fire Severity Effects

Alternative 2 allows higher intensity fires for prescribed and wildland fire-use fires when compared with Alternative 1. The lessened constraint in fire treatment relates specifically to treatments in mixed-conifer and spruce-fir vegetation types. With Alternative 2, up to 31% of mixed-conifer could burn as moderate /high to high fire intensities for both prescribed and wildland fire-use fires (Table 4-7). Moderate/high to high severity fire in mixed-conifer for suppression fires is predicted at 42% (Table 4-7). In addition, approximately 19% of spruce-fir is proposed for prescribed fire, and it is assumed 36% of this vegetation type would burn as suppression fire.

Of vegetation types adversely affected by this vector, mixed-conifer has greatest risk for fire severity effects that could cause exotic plant invasion and/or expansion. Under worst-case circumstances, 34% of this vegetation type would have moderate/high to high severity fire areas vulnerable to exotic plant species invasion and/or expansion. In addition, if annual exotic grasses invade the sites and change the fire regime, fires could occur more frequently during a longer fire season.

40 to 69% of spruce-fir could burn at moderate/high to high severity fire with prescribed, wildland fire-use, and suppression fires. (Table 4-9). Although exotics currently in the spruce-fir type are limited as mentioned previously, exotics may invade these ecotones.

Depending on variables noted earlier, if exotic plants invade or expand populations after fire, adverse impacts caused by fire severity would likely be minor to moderate, local. Depending on which species invades or expands due to these treatment activities, this adverse impact could be long term.

Factors in Establishment **Alternative 2** **Exotic Plant Species**
Increased Human and Animal Activity

Alternative 2 includes mechanical/manual treatments in South Rim WUI. In areas where slash material is removed, treatment in the WUI would open forest stands and could encourage human and animal activities. Because treatment areas are close to or in high public use areas, this potential adverse impact could be minor, local, long term. Leaving slash or masticated material on less than half the acres treated would discourage people from walking in these sections, decreasing this risk.

Animal activity in burned and/or treatment areas could also play a role in invasion and expansion of exotic plant species if animals bring in plant parts or seeds that can propagate. There is no known effective way to prevent this from occurring. Animal activities' affect on exotic plant invasion and/or expansion would likely be adverse, negligible to minor, local, long term.

Factors in Establishment **Alternative 2** **Exotic Plant Species**
Heavy Equipment/Mechanical Treatments

Alternative 2 proposes approximately 2,100 acres of mechanical treatment, mostly in South Rim WUI. Mechanical equipment and treatments could act as a vector bringing in or expanding populations of exotic plant species. Potential adverse impacts from mechanical equipment could be minor to moderate, local, and long term. Leaving chips or masticated material in the treatment unit could decrease potential for exotic plant seeds or plants propagating (reducing bedding area for germination or revegetation), while discouraging public use in these areas. Scattered, cut material left behind could also cause adverse impacts by increasing risk of suppression fires with higher fire severities and intensities.

Mitigation measures to ensure equipment is free of seeds and plant parts before entering areas where no exotic plant populations exist, and cleaning equipment when leaving areas where exotic plant species exist, would decrease this adverse effect. In addition, mitigation measures to reduce other vectors or their impacts in the WUI would further reduce risk.

Mitigation of Effects **Alternative 2** **Exotic Plant Species**

Mitigation measures in 4.2.3.5 and 4.2.3.11will decrease adverse impacts related to invasive exotic plant species. Monitoring, future research, and adaptive management will be key in affecting exotic plant populations.

Cumulative Effects **Alternative 2** **Exotic Plant Species**

Cumulative effects would be similar to Alternative 1. The exception would be that fire severity in mixed-conifer and spruce-fir would be higher, and additional mechanical treatment would occur. These effects would not add to cumulative effects from all projects. Overall, it is anticipated cumulative adverse effects of implementing Alternative 2 with other projects discussed earlier, would be minor to moderate, adverse, possibly long term, and regional.

Conclusion **Alternative 2** **Exotic Plant Species**

Alternative 2 would have similar adverse effects as Alternative 1 related to vehicles, handline construction, manual treatments (minor to moderate, adverse, possibly long term, local). Alternative 2 would have added adverse effects due to potential for moderate/high and high fire severities (but still minor to moderate, local, long term), increased human/animal activity (but still negligible to minor, local, long term), and use of mechanical equipment (minor to moderate, local, long term). Cumulative impacts would be adverse, minor to moderate, long term, regional.

Impairment **Alternative 2** **Exotic Plant Species**

Since are no major adverse impacts in Alternative 2 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts from exotic plants would not impair resources during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Exotic Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts from exotic plants as a result of Alternative 2 implementation.

4.2.3.14 Alternative 3 Non-Fire Treatment Emphasis Exotic Plant Species

Alternative 3's emphasis would be non-fire, mechanical/manual treatments in WUI. This alternative treats the highest acreage through mechanical/manual treatment: approximately 3,950 acres in the WUI, about 40% more than Alternative 5, which has the second highest acreage of proposed non-fire treatments. This alternative treats the lowest number of total acres, with acreage estimates of 25,400 for prescribed fire primarily in the WUI; 8,800 acres for wildland fire-use fire; and a projected 26,070 acres in fire suppression (the highest suppression amount of the five alternatives). The majority of these additional suppression acres are assumed to be primarily in North Rim forests. A detailed description is in Chapter 2.

Factors in Establishment Vehicles **Alternative 3** **Exotic Plant Species**

The majority of acres are proposed for treatment with prescribed fire, but the alternative's emphasis is on non-fire treatment. Based on the alternative description and map in Chapter 2, vehicle traffic would be focused in South Rim's Primary and Secondary WUI, and along North Rim's Highway 67. Proposed South Rim treatment areas likely already have heavy vehicle traffic, so added traffic proposed with these treatments would be minor. The majority of North Rim proposed prescribed fire is along Highway 67 where traffic is already concentrated. Increased vehicle traffic due to fire suppression activities would most likely occur on dirt roads. Depending on vehicle use amount on dirt roads adjacent to treatments and suppression fires, road sides could likely be vulnerable to exotic species. The majority of adverse effects caused by vehicles to exotic plant species invasion and expansion would be related to suppression fires, and far less than from treatments. Adverse effects are anticipated to be minor to moderate, local, and long term. Mitigation measures noted in previous alternatives (cleaning vehicles, inspecting parking and staging areas) could decrease adverse impacts.

Factors in Establishment Handline Construction and Manual Treatment **Alternative 3** **Exotic Plant Species**

This alternative proposes the most manual treatment: 590 acres. The majority of manual treatments are proposed in the WUI, a vulnerable location since the area also receives the most human activity—a possible exotic plant vector. Incorporating mitigation measures for manual treatment and other vectors in WUI would reduce adverse effects from manual treatments to exotic plant invasion and/or expansion.

This alternative proposes approximately 110 miles of handline (of which less than ten miles is proposed with planned fire treatment; the majority is tied to fire suppression estimates). This alternative has the highest amount of estimated suppression acres, an approximate 30% increase over Alternatives 1 and 2 (6,000 additional acres), with its associated handline. It is unknown where these lines would be, but proposed mitigation measures would reduce adverse effects constructed handlines would have on invasion and/or expansion of exotic plant species. Potential adverse impacts from these treatments would be minor to moderate, local and long term.

Factors in Establishment **Alternative 3** **Exotic Plant Species**
Moderate/High to High Post Fire Severity Effects

This alternative proposes the least acres treated with prescribed and wildland fire-use fires, but the most acres for suppression fires, as compared with other alternatives. Only a few prescribed fire treatment areas are proposed in mixed-conifer (12%) and spruce-fir (15%) vegetation types. Because of this, amount of moderate/high to high severity acres would likely be comparable to Alternative 1 for these fire treatments.

Prescribed fire would have an average 22% moderate/high to high severity acres, and wildland fire use would have an average 26% of these higher severity acres. Based on suppression fire assumptions, approximately 24% of mixed-conifer and 46% of spruce-fir would burn as suppression fire. Suppression fires' fire severity is difficult to predict, but it is assumed 42-69% of the fire would burn as moderate/high to high severity fire (Tables 4-7 and 4-9). Many high-risk exotic plant species do not occur at spruce-fir elevations; therefore, risk of exotic plant species invading spruce-fir is much lower than other vegetation types. Yet, ecotones that connect spruce-fir to mixed-conifer and grassland vegetation are important areas for exotic plant introduction and spread and would act as corridors.

Based on available information noted above, fire severity effects that could increase risk of exotic plant species invasion or expansion would be minor to moderate and local. Depending on which species invade or expand due to these fire effects, this adverse impact could be long term.

Factors in Establishment **Alternative 3** **Exotic Plant Species**
Increased Human and Animal Activity

This alternative proposes the most treatment in South Rim WUI. As with Alternative 2, treatment in the WUI would open forest stands and encourage human and animal activities. Because these treatment areas are close to or in high public use areas, this potential adverse impact could be, minor, local, and long term.

Animal activity in burned and treatment areas could also play a role in invasion and expansion of exotic plant species if animals bring in plant parts or seeds. There is no known effective way to prevent this from occurring. Animal activities' adverse affect on invasion and/or expansion of exotic plants would likely be negligible to minor local long term.

Factors in Establishment **Alternative 3** **Exotic Plant Species**
Heavy Equipment/Mechanical Treatments

This alternative proposes over 3,350 acres of mechanical treatment, the highest amount compared with other alternatives. All mechanical treatment is proposed in WUI. As noted earlier, the WUI is vulnerable because this area receives the most human activity (vectors for exotic plant species). Leaving chips or masticated material in the treatment area could decrease potential for exotic plant seeds or plants propagating (reducing bedding area for germination or revegetation), but as mentioned earlier, could increase risk of suppression fires that have higher fire severity and intensity. Mitigation measures to ensure equipment is free of seeds and plant parts before entering areas where no exotic plants exist, and cleaning equipment when leaving areas where exotic plant species exist, would decrease this adverse effect. In addition, mitigation measures to reduce other vectors or their impacts in WUI would further reduce risk. With implementation of mitigations measures listed above and in 4.2.3.5, overall effects of mechanical treatment would be adverse, minor to moderate, local, and long term.

Mitigation of Effects **Alternative 3** **Exotic Plant Species**

Mitigations in 4.2.3.5 and 4.2.3.11 will decrease adverse impacts related to invasive exotic plant species. Monitoring, future research, and adaptive management will be key in affecting exotic plant populations.

Cumulative Effects **Alternative 3** **Exotic Plant Species**

Direct cumulative effects from activities of this alternative would be less than those addressed in Alternatives 1 and 2. Amount of treatment proposed is less than half the acres proposed when compared with any other alternative. The majority of treatment occurs in and around South Rim WUI.

With decreased fire treatments, there is a greater risk of high severity suppression fires in areas where fuel loads are already high (mixed-conifer and spruce-fir vegetation types). The indirect adverse effect could be far more damaging, due to fire severity, from invasion and expansion of exotic plants if this was to occur. This Alternative, with other projects noted earlier, would have minor to moderate adverse, long-term, regional cumulative effects during the planning period.

Conclusion **Alternative 3** **Exotic Plant Species**

Alternative 3 focuses treatment in and around South Rim WUI through prescribed fire and non-fire treatments. This area is already impacted by public use, with or without treatment, and has public and animal activities that could bring in or expand invasive exotic plant species. Because this alternative focuses treatment in WUI areas, mitigation measures proposed would likely be more successful, and expansion of exotic plants populations would occur less, through proposed treatment and more fire suppression. Based on a review of alternatives, Alternative 3 would have the least adverse effect from invasion and/or expansion of exotic plant species throughout the park due to the concentrated location and least acreage proposed for treatment.

Vehicles use could cause minor to moderate, local, long-term, adverse impacts; handline construction and manual treatment could cause minor to moderate, local, long-term, adverse impacts, and moderate/high and high severity fire could cause minor to moderate, local, long-term, adverse impacts. Increased human and animal activities could cause negligible to minor, local, long-term, adverse impacts; heavy equipment /mechanical treatments could cause minor to moderate, local, long-term, adverse impacts through introduction and/or expansion of invasive exotic plant species. Cumulative impacts would be adverse, minor to moderate, long term and regional.

Impairment **Alternative 3** **Exotic Plant Species**

Since are no major adverse impacts in Alternative 3 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts from exotic plants would not impair resources during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Exotic Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts from exotic plants as a result of Alternative 3 implementation .

4.2.3.15 Alternative 4 Prescribed Fire Emphasis Exotic Plant Species

In Alternative 4, fire management program emphasis would be through prescribed fire, burning approximately 90,000 acres. Approximately 24,070 acres would burn with suppression fires; wildland fire-use fire would be used least of all alternatives, at 5,500 acres; and mechanical/manual treatments would occur on approximately 800 acres in top priority areas. A detailed description is in Chapter 2.

Factors in the Establishment Alternative 4 Exotic Plant Species
Vehicles

Anticipated vehicle use would occur with non-fire and prescribed fire treatments and suppression fire activities. This alternative focuses on prescribed fire treatment scattered on both North and South Rims. Potential for vehicle traffic is highest with this alternative since treatments are scattered and many roads would be used. In addition, this alternative has the second highest acreage proposed for suppression fires. Added traffic in these areas would increase the adverse effects vehicles could have on exotic plant species invasion and expansion. Expected adverse impacts would be minor to moderate, local, and long term. Depending on amount of vehicle use on dirt roads adjacent to treatment areas or suppression fire areas, it is likely roadsides could be vulnerable to exotic species.

Factors in the Establishment Alternative 4 Exotic Plant Species
Handline Construction and Manual Treatment

This alternative proposes the most handline construction (approximately 125 miles), closely followed by Alternative 3. Additional miles are primarily for prescribed fire, though the majority of handline is for fire suppression activities. As noted earlier, handlines could act as corridors for invasion and/or expansion of exotic plant species. It is unknown where lines would be located but proposed mitigation measures would reduce effects constructed handlines would have on invasion and/or expansion of exotic plant species.

This alternative proposes the least amount of manual treatment (120 acres). The majority of manual treatments are proposed in the WUI, a vulnerable location since this area also receives the most human activity, a possible exotic plant species vector. Incorporating mitigation measures for manual treatment and other vectors in the WUI would reduce adverse effects from manual treatments to invasion and/or expansion of exotic plant species. Potential adverse impacts from these treatments would be minor to moderate, local, and long term.

Factors in the Establishment Alternative 4 Exotic Plant Species
Moderate/High to High Post-Fire Severity Effects

This alternative proposes the most treatment through prescribed fire. 62% of mixed-conifer is proposed for prescribed fire treatment; an additional 22% would burn as suppression fire. As noted earlier, amount of moderate/high to high severity in this vegetation type would be 30-42% (Table 4-7) under prescribed or suppression fires. With approximately 85% of this vegetation type likely affected by fire, approximately 25% could receive moderate/high to high severity fire effects that would increase risk of exotic plant species invasion and/or expansion. This adverse effect could be minor to moderate, local, and long term in this vegetation type, depending on which exotic plant species invade or expand due to this vector.

About 54% of ponderosa pine and 27% of spruce-fir vegetation types are proposed for prescribed fire treatment over the life of this plan. In addition, approximately 5% of ponderosa pine and 43% of spruce-fir are assumed to burn as suppression fire. For ponderosa pine, amount of moderate/high to high severity in this vegetation type would be 10-13% (Table 4-5) under prescribed or suppression fires. For spruce-fir, amount of moderate/high to high severity in this vegetation type would be 40-69% (Table 4-9) under prescribed or suppression fires. These areas would be at risk for exotic plant species invasion and expansion. Area amount affecting ponderosa pine vegetation type would be minimal. Because spruce-fir is at a high elevation there are fewer exotic plant species that could take advantage of these sites, but effects would be adverse, minor to moderate, local, and potentially long term.

Factors in the Establishment Increased Human and Animal Activity **Alternative 4** **Exotic Plant Species**

This alternative proposes the second least amount of WUI treatment (Alternative 1 has the least). WUI treatment would open forest stands and could encourage human and animal activities. Because treatment areas are close to or in high public use areas, potential adverse impact could be negligible to minor, local, and long term. Leaving slash, masticated, and/or chipped material on some proposed non-fire treated acres would discourage people from walking in these areas, decreasing this risk.

As noted earlier, animal activity in burned and treatment areas could also play a role in invasion and expansion of exotic plant species if animals bring in plant parts or seeds. There is no known effective way to prevent this from occurring. Depending on which seeds and plant parts are brought by animals, it is anticipated adverse impacts would likely be negligible to minor, local, and long term.

Factors in the Establishment Heavy Equipment/Mechanical Treatments **Alternative 4** **Exotic Plant Species**

This alternative proposes the second least amount of mechanical treatment compared with all alternatives (approximately 680 acres). All mechanical treatment is proposed in WUI. As noted earlier, the WUI is vulnerable because this area also receives the most human activity, a possible vector for exotic plants. Potential adverse impact from mechanical equipment could be negligible to minor, local, long term. Leaving chips or masticated material covering parts of the treatment area could cause a beneficial effect by decreasing potential for exotic plant seeds or plants to propagate (reducing bedding area for germination or revegetation) on these portions of treatments. As mentioned earlier, scattered slash or chipped material could also provide adverse effects by increasing risk of suppression fires burning with increased fire behavior and intensity until it decomposes. Mitigation measures to reduce other vectors or their impacts in the WUI would further reduce risk.

Mitigation of Effects **Alternative 4** **Exotic Plant Species**

Mitigation measures in 4.2.3.5 and 4.2.3.11will decrease adverse impacts related to invasive exotic plant species. Monitoring, future research, and adaptive management will be key in affecting exotic plant populations.

Cumulative Effects **Alternative 4** **Exotic Plant Species**

Cumulative effects would be similar to Alternative 2. Overall, acreage burned by fire would be similar to Alternative 2 with similar fire severities. There would be fewer acres mechanically and manually treated but the decreased adverse effect would be minor. Cumulative adverse effects when combining Alternative 4 implementation with projects noted earlier would be minor to moderate, regional, and long term.

Conclusion **Alternative 4** **Exotic Plant Species**

Alternative 4 would have similar adverse effects as Alternative 2 from invasion and/or expansion of exotic plant species. Vehicles could cause minor to moderate, local, long term, adverse impacts; handline construction and manual treatment could cause minor to moderate, local, long term, adverse impacts, and moderate/high and high severity fire could cause minor to moderate, local, long term, adverse impacts. Increased human/animal activities could cause negligible to minor, local, long term, adverse impacts; and, heavy equipment/mechanical treatments could cause negligible to minor, local, long-term, adverse impacts caused by introduction and/or expansion of invasive exotic plant species. Cumulative adverse effects when combining implementation of Alternative 4 with projects noted earlier would be minor to moderate, regional, and long term.

Impairment Alternative 4 Exotic Plant Species

Since are no major adverse impacts in Alternative 4 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts from exotic plants would not impair resources during Alternative 4 implementation.

Unacceptable Impacts Alternative 4 Exotic Plant Species

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts from exotic plants as a result of Alternative 4 implementation.

4.2.3.16 Alternative 5 Fire Use Emphasis Exotic Plant Species

In Alternative 5, the fire management program emphasis is to restore and maintain forest types with wildland fire use (88,000 acres). With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative deemphasizes prescribed fire treatments, with treatment of 29,900 acres. Mechanical/manual treatments would be approximately 2,700 acres and would occur in the WUI and along Highway 67 on North Rim. A description is in Chapter 2.

Factors in Establishment Alternative 5 Exotic Plant Species
Vehicles

The majority of treatment with this alternative is through wildland fire use. Overall, wildland fire-use fires would create minimal vehicle traffic when compared with other treatment options. Prescribed fire acres treated would be similar to Alternative 3, and additional treatment areas do not add new roads. Similar to Alternative 3, the focus of prescribed and non-fire treatment is in South Rim WUI and in a concentrated area in the Secondary WUI. These areas already receive heavy public traffic, and added traffic in these areas from alternative implementation would be minor. In addition, this alternative proposes the least amount of suppression fire where additional traffic could occur. Based on this information, Alternative 5 is believed to have the least effect from traffic to invasion and/or expansion of exotic plant species when compared with other alternatives. Adverse impacts would be negligible to minor, local, and long term. Mitigation measures noted earlier for this vector would decrease this adverse impact.

Factors in Establishment Alternative 5 Exotic Plant Species
Handline Construction and Manual Treatment

Alternative 5 proposes the least handline (approximately 90 miles), and manual treatment in amounts similar to Alternative 2. As noted earlier, handline construction could be a vector and corridor for invasive exotic plants. This alternative would have the least amount of handline but, due to the potential corridor, it is believed the adverse effect will still be minor to moderate, local, and long term.

Factors in Establishment Alternative 5 Exotic Plant Species
Moderate/High to High Post-Fire Severity Effects

Because this alternative proposes the most wildland fire use, most would occur in the ponderosa vegetation type. Little moderate/high to high severity is predicted in ponderosa pine from WFU (8%, Table 4-5). Based on this alternative, 24% of mixed-conifer is proposed for prescribed fire, an estimated

47% as WFU and 17% as suppression fire. Based on this data, 88% of the mixed-conifer vegetation type would receive some form of fire. The amount of moderate/high to high severity area for mixed-conifer would be more than Alternatives 1 and 3, likely less than Alternatives 2, and similar to Alternative 4. For spruce-fir, 16% of the vegetation type is proposed for prescribed fire, approximately 32% is assumed would burn from suppression fire, and an unknown amount would burn as WFU. In general the amount of moderate/high to high severity acres is less in WFU than suppression fires for all of these vegetation types. As noted in Alternative 4, mixed-conifer would likely be at highest risk for invasion and expansion of exotic plant species. The adverse effect caused by fire severity from invasion and/or expansion of exotic plant species would be minor to moderate, local, and long term.

Factors in Establishment **Alternative 5** **Exotic Plant Species**
Increased Human and Animal Activity

Amount of treatment in the WUI is similar to Alternative 2; therefore, impacts from increased human activity would be similar. Because treatment areas are close to or in high public use areas, this potential adverse impact could be moderate to major, local, and long term. As with Alternative 2, leaving slash or masticated material on non-fire treated acres would discourage people from walking in these treatment areas, decreasing this risk.

Animal activity in burned and/or treatment areas could play a role in invasion and expansion of exotic plant species if animals bring in plant parts or seeds. There is no known effective way to prevent this from occurring. Animal activities affect on invasion and/or expansion of exotic plants would likely be negligible to minor, local, and long term.

Factors in Establishment **Alternative 5** **Exotic Plant Species**
Heavy Equipment/Mechanical Treatments

Alternative 5 proposes mechanical treatment in WUI in amounts similar to Alternative 2; therefore, effects would be similar. Potential adverse impacts from mechanical equipment could be minor to moderate, local, and long term. Leaving chips or masticated material covering mechanically treated areas could have beneficial effects by decreasing the potential adverse effect in those locations, for exotic plant spread. Scattered cut or chipped material would cause an adverse effect by increasing risk of suppression fire that would burn with increased fire behavior and intensity until the material decomposes. In addition, mitigation measures to reduce other vectors or their impacts in the WUI would further reduce risk.

Mitigation of Effects **Alternative 5** **Exotic Plant Species**

Mitigation measures incorporated into 4.2.3.5 and 4.2.3.11will decrease adverse impacts related to invasive exotic plant species. Monitoring, future research, and adaptive management will be key in affecting exotic plant populations.

Cumulative Effects **Alternative 5** **Exotic Plant Species**

Cumulative effects would be similar to Alternative 2 except there would be less vehicle traffic, less handline construction, and less acres of moderate/high to high severity fire effects.

Overall, it is anticipated cumulative adverse effects of implementing Alternative 5 with other projects discussed earlier, would be minor to moderate, regional, long term.

Conclusion **Alternative 5** **Exotic Plant Species**

Alternative 5 has the least amount of vehicle traffic and handline construction, less fire severity impacts than Alternatives 2 and 4, and similar acres proposed for manual/mechanical treatment to Alternative 2. Reviewing adverse impacts, Alternative 5 would have the second least adverse effect caused by invasion and exotic plant species (with Alternative 3 having the least). Vehicles could cause negligible to minor, local, long term, adverse impacts; handline construction and manual treatment could cause minor to moderate, local, long term, adverse impacts; and moderate /high and high fire severity could cause minor to moderate, local, long term, adverse impacts. Increased human/animal activities could cause negligible to minor, local, long term, adverse impacts; and heavy equipment/mechanical treatments could cause minor to moderate, local, long term, adverse impacts caused by introduction and/or expansion of invasive exotic plant species. Cumulative adverse effects, when combining Alternative 5 implementation with other projects noted earlier would be minor to moderate, regional, and long term.

Impairment **Alternative 5** **Exotic Plant Species**

Since are no major adverse impacts in Alternative 5 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts from exotic plants would not impair resources during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Exotic Plant Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts from exotic plants as a result of Alternative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Exotic Plant Species**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether by implementing mitigation measures or changing the nature of a proposed action. Thus, unavoidable adverse impacts would persist throughout the action's duration.

Alternatives 1-4 would have adverse, minor to moderate, local, long-term impacts from vehicle use through potential introduction of exotic plants or through ground disturbance and further spread.

Alternative 5 would have negligible to minor impacts from vehicle use through potential introduction of exotic plant species or through ground disturbance and further spread of these species.

Alternatives 1-5 would have adverse minor to moderate local long-term impacts from introduced exotic plants from handline construction and manual thinning. Alternatives 1-5 would have adverse minor to moderate local long-term impacts from moderate/high and high severity fire if exotics entered the area.

Alternatives 2-5 would have adverse, minor to moderate, local, long-term impacts from introduction or expansion of exotic plants from mechanical thinning equipment use.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Exotic Plant Species**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the plan's lifespan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

There would be no irreversible or irretrievable commitments of resources.

4.2.4 Wildlife

4.2.4.1 Guiding Regulations and Policies Wildlife

Special status animal species are addressed in 4.2.5; this section focuses on general wildlife species and habitat. Existing management direction for general wildlife resources (not including threatened, endangered, proposed, and candidate species and their habitats) in GRCA include

- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Clean Air Act of 1955
- Wilderness Act of 1964
- Wild and Scenic Rivers Act 1968
- Noise Control Act of 1972 (as amended)
- Noxious Weed Act of 1974, as amended
- Aircraft Overflight in National Parks Act of 1987
- Federal Cave Resources Protection Act of 1988
- Executive Orders 13112 (Invasive Species)
- Migratory Bird Species Action of 2001 (Migratory Bird Guidance)
- Healthy Forest Restoration Act of 2004
- Director's Orders # 12, 18, 41, 46, 47, 60, and 77
- Species management guides or conservation strategies

In addition, NPS Management Policies 2006 direct park managers to understand, maintain, restore, and protect the park's inherent integrity of natural resources, processes, systems, and values. To the extent possible, the NPS will allow natural processes, including species evolution, to control landscape and population level dynamics, assuming all components of natural systems remain intact. Preservation of fundamental physical and biological processes, as well as individual species, plant communities, and other components of naturally evolving ecosystems, is inherent in management direction. Management Policies 2006 state the park service will successfully maintain animals by

- Preserving and restoring natural abundance, diversities, dynamics, distributions, genetic and ecological integrity, and behaviors of animal populations and the communities and ecosystems in which they occur
- Restoring animal populations in parks when extirpated by past human-caused actions
- Minimizing human impacts on animals, communities, and ecosystems, and processes that sustain them

4.2.4.2 Management Objectives Wildlife

Goals and objectives for the proposed FMP related to wildlife include

Goal 2 Restore and maintain park ecosystems in a natural, resilient condition

- Ecosystems within the range of natural variability or desired conditions should be maintained through natural processes within policy constraints
- Ecosystems not within the range of natural variability should be restored to desired conditions and subsequently maintained through natural processes, within policy constraints
- Set priorities for treatment activities based on site specific information on departure from natural fire return interval, desired conditions, and other relevant factors

Goal 3 Protect the park's natural, cultural, and social values

- Maintain critical habitat elements for listed Threatened, Endangered, and Sensitive Species

- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species
- Minimize the impact of smoke on air quality related values including visibility

Goal 4   Promote a science-based program that relies on current and best-available information
- Conduct research to understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the fire management program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, and fuel reduction treatments), to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions, prescriptions, and fire treatment priorities, as relevant data becomes available

4.2.4.3 Methodology for Analyzing Impacts Wildlife
Tools Used To Analyze Effects

In this analysis, effects to wildlife and their habitats are characterized 1) generally, 2) addressed as common to all alternatives, and 3) for each alternative, based on impact thresholds presented below. Emphasis in information gathering and analysis focused on wildlife groups, a few species, and their habitats described in Chapter 3, Affected Environment. Impacts to wildlife and their habitat are related to manual/mechanical thinning, and prescribed, wildland fire-use, and suppression fires. Impacts on wildlife were analyzed using the best site-specific data available for GRCA species locations and distributions. This information included, but was not limited to, inventories and research conducted by GRCA biologists, personal communications with resource specialists, and data from Arizona Game and Fish Department, Kaibab National Forest, Fire Effects Program, and independent researchers.

It should be noted there is a distinct lack of fire disturbance and habitat alteration impact research specific to Grand Canyon wildlife species; therefore, considerable use was made of research conducted in other areas and extrapolated to present GRCA conditions. This scientific literature was used to determine the most susceptible aspects of a particular species' or group of species' life cycle and habitat use areas. This information was then used to direct collection of quantitative and qualitative data regarding presence and status of these features in GRCA. In the absence of hard data, best professional judgment was used after consulting with technical experts. In some cases, anecdotal information provided by technical experts was used in analysis. Historical fire occurrence data was used in assessing some alternatives. Additional models, particularly fire behavior modeling, were used in analyzing effects resulting from implementing each of the five alternatives (see Appendix F).

Analysis of an impact to a particular species or species group and their habitats involves a complex examination including interaction of context, duration, timing, and intensity of each identified impact. These measures are defined below in 4.2.4.4.

4.2.4.4 Impact Thresholds Wildlife

Type of Impact

Adverse Impacts are classified as adverse if they would negatively affect size, continuity, or integrity of wildlife habitat outside the normal range of variability, or move areas away from desired conditions. Adverse impacts can be either short term or long term

Beneficial Impacts are beneficial if they would positively affect wildlife habitat size, continuity, or integrity in reaching the desired condition, or returning habitat parameters within the normal range of variability. Beneficial impacts are normally considered long term

Intensity

Negligible	Impacts to wildlife and/or habitat would not be perceptible or measurable. Impacts would not be of any measurable or perceptible consequence to wildlife populations or the ecosystem supporting them
Minor	Impacts to wildlife and/or habitat would be perceptible or measurable, but severity and timing of changes to parameter measurements would not be expected outside natural variability and would not be expected to have effects on populations or ecosystems. Population numbers, population structure, genetic variability, and other demographic factors for species might have slight changes but characteristics would remain stable. Key ecosystem processes might have slight disruptions within natural variability, and habitat for all species would remain functional
Moderate	Animals of concern are present and could be impacted. Impacts to wildlife and/or habitat would be perceptible and measurable but not cause significant impacts. No threats to species viability are expected. Key ecosystem processes might have slight disruptions outside natural variability, but would be expected to return to natural variability, and habitat for all species would remain functional. For adverse impacts: severity and timing of changes to parameter measurements would be expected to sometimes fall outside natural variability, and changes within natural variability might be long term or permanent; population numbers, population structure, genetic variability, and other demographic factors for species would have measurable changes creating declines, which could be from displacement, but would be expected to rebound to pre-impact numbers; animals are present during particularly vulnerable life stages (e.g. breeding season)
Major	Impacts to wildlife and/or habitat would be clearly perceptible and measurable. For adverse impacts: severity and timing of changes to parameter measurements could be outside natural variability for long time periods, and changes within natural variability might be long term or permanent; population numbers, population structure, genetic variability, and other demographic factors for species might have large, short-term declines with long-term population numbers considerably depressed; in some cases, species viability might be threatened and in extreme cases some species might be extirpated; and key ecosystem processes like nutrient cycling might be disrupted, or habitat for one or more species may be rendered unsuitable

Context

Regional	Regional impacts affect a widespread area of suitable habitat in the population or species GRCA range and possibly some areas immediately adjacent to treated areas
Local	Local impacts confined to a small part of the population or a small percentage of park habitat or range such as in a single project treatment area or plateau

Duration

Short Term	To individual, population, or habitat would last from one growing season up to five years
Long Term	Impacts would be five years or longer
Timing	Impacts can occur year-round, but wildlife resources would typically be most sensitive during spring and summer months when mating (breeding), incubation, and hatching occur. In some cases, certain species may even exhibit high sensitivity levels while rearing young. Some species may also be more vulnerable during late fall or winter when heavy snowfall limits food supplies or otherwise places them in a weakened state. Most species also exhibit a diurnal activity pattern which may make them more sensitive to disturbance

during day or night depending on their particular ecology (e.g. owl and bat most active feeding is at night while passerine birds are most active during daylight hours)

4.2.4.5 Mitigation of Effects — Wildlife

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description, address impacts to general wildlife species, and are addressed in other sections of this Chapter.

- Manage fire incidents using natural barriers to fire spread when safe and feasible
- Employ MIST in fire management techniques
- Protect aquatic habitat, riparian and wetland areas, meadows, and other sensitive resource areas during suppression fires by defining and avoiding these areas
- Restrict fire retardant use during fire management operations where possible
- Retain snags, particularly large snags (over 24 inches dbh), to provide wildlife habitat. Generally, snags will not be cut during fire management activities unless they present a threat to human life, safety, property, or a valued resource
- Lop and scatter debris from cut vegetation (slash) to a depth of no more than 12 inches and burn during subsequent prescribed fire, or pile and burn
- During prescribed burning, drip torch fuel will not be applied directly to large, down, woody debris greater than ten inches diameter
- Establish trigger points (geographic locations that, if reached by fire, trigger action to mitigate) if sensitive biological areas are located in MMA that require some mitigation during wildland fire-use fires. Implement mitigation plans when fire reaches trigger points
- Rehabilitate disturbed sites (control lines, staging areas, and helispots) where and when safe to do so, by pulling soil, duff, litter, woody debris, and rocks back onto the line to bring it up to grade and blend with the surrounding area
- Practice best management practices for smoke mitigation and emission reduction techniques to reduce health risks and visibility impacts to Class I airshed
- Implement best management practices for exotic species spread reduction and control during fire management operations
- Use resource advisors on fire management projects and incidents
- Use resource specialists in preparation of contract fire management activities (scope of work, mitigation measures) as well as contract work implementation on the ground
- Implement management response strategies to affect least disturbance possible in known occupied territories during breeding season

4.2.4.6 Cumulative Impacts — Wildlife

In determining cumulative effects to wildlife, the boundary considered included all of Grand Canyon National Park and appropriate portions of the Kaibab National Forest, Arizona Strip and Kingman BLM Districts, the Hualapai and Havasupai Indian Reservations, and any Arizona state lands which intermingle or be adjacent to the park and could thereby contribute cumulative impacts to wildlife and their habitats.

Many species identified in this document are not isolated to GRCA. Many have a much boarder range and distribution than the Congressionally designated GRCA boundary. Many vegetation types such as piñon-juniper, mixed-conifer, spruce-fir, shrub, grasslands, and riparian are widespread and occur over much of the Kaibab and Coconino Plateaus. Fire played a significant role in crafting and maintaining vegetation mosaics across the landscape and did not recognize administrative boundaries. Likewise, wildlife species associated with these vegetation types can range beyond GRCA. Analysis areas may vary by species and will be identified to suitably address cumulative effects for species or habitats selected for assessment.

Management activities such as vegetation treatment, recreation, livestock operations, transportation systems, and other resource development activities on adjacent lands have no doubt affected and will continue to affect wildlife populations in and around GRCA. Many impacts from other projects are local and regional (see Appendix G).

Assumptions **Wildlife**

All proposed fire and non-fire projects are planned above the rim. No fire management projects are planned below the rim. Thus, it is assumed no aquatic wildlife species will be impacted; therefore they are not addressed in this analysis.

Assumptions that specifically relate to alternatives and their effects on wildlife are

- Wildlife species are mobile, have evolved with habitat disturbances over time, and can avoid most direct negative impacts from fire disturbance
- Wildlife species have evolved with fire as a disturbance factor that maintains habitats over time
- Fire is a critical disturbance process to renew and maintain wildlife habitat
- General impacts of each treatment type (prescribed and wildland fire-use fire, and mechanized/manual treatment) are the same throughout all alternatives
- Primary differences of each alternative's anticipated wildlife impacts relate to acreage treated, expected potential burn severity, action timing, and treatment location relative to essential wildlife habitat areas
- Present vegetative or habitat conditions may be outside the range of historical conditions and vary in degree by major habitat type (Covington and Sackett 1984, 1986, Fulé et al. 2003, 2004, Lang and Stewart 1910, Vankat et al. 2005, White and Vankat 1993)
- Ecosystem conditions have changed primarily due to human-caused influences, with wildland fire suppression being most prevalent (Fradkin 1981)
- Based on fire history, prescribed and wildland fire-use fires have potential to modify habitats
- Based on fire history, prescribed and wildland fire use fires will have short-term adverse effects on some wildlife species and specific habitat components
- Based on fire history, prescribed and wildland fire-use fires will have long-term beneficial effects on many wildlife species and habitats
- Suppression fires hold the greatest potential for adverse impacts to wildlife and wildlife habitats due to 1) greater extent of high severity burn areas and 2) potential for more ground disturbance and other potentially adverse activities from suppression activities (fire lines; retardant use; potential for greater chainsaw, mechanized equipment, and aircraft use; and greater disturbance from fire-fighting resources, support staff, and equipment)
- Because it is impossible to predict when, where, or to what extent suppression fires will occur, this assessment does not attempt to make predictions for site-specific impacts. This analysis does assume suppression fires burn during more extreme fire-behavior periods resulting in larger burned patches from stand-replacement type fire. Based on the past 25 years of fire history, this analysis assumes that for all alternatives, percentage of suppression-impacted acres per vegetation type are
    - Mixed-conifer 34%
    - Spruce-fir 31%
    - Ponderosa Pine 13%
    - Piñon-Juniper 9% (Rasmussen 2007)
- Depending on vegetation type, elevation, and lightning occurrence, there exists a history of fire occurring on plateaus March through October

Incomplete and/or Unavailable Information **Wildlife**

- Little GRCA-specific data are available on fire's effects on wildlife species, species groups, or habitats
- Little site-specific information is available on current numbers of most wildlife species that occur in GRCA. Wildlife species distribution is somewhat better known

- Limited research data exists from areas surrounding GRCA, areas in the Southwest U.S., and other areas with similar vegetation types that can serve as surrogate information extrapolated to GRCA
- GIS modeling is used to predict suitable habitat and assist in evaluating impacts on habitats and populations

4.2.4.8 Impact Analysis Wildlife
Effects Common To All Alternatives

Beneficial and adverse effects of fire on wildlife vary greatly depending on timing, size, frequency and severity of fire event(s). The following is an overview of general ecology of fire effects on various wildlife habitats and species which may be involved in implementation of any FMP alternative. The majority of this information was taken from Effects of Fire on Fauna (Smith 2000). These effects would be common to all alternatives. Each alternative will be assessed further in this section to provide added information useful in determining relative differences of effects by alternative.

Animal species native to areas with a centuries-long fire history, such as GRCA, can obviously persist in habitat shaped by fire; many species actually thrive in fire's influence. An animal's immediate response to fire may include mortality, movement, or other behavioral actions influenced by fire intensity, severity, rate of spread, uniformity, and size. Long-term faunal response to fire is determined by habitat change, which influences feeding, movement, reproduction, and shelter availability. Alteration of fire regimes alters landscape patterns and change rate on landscapes; these changes affect habitat and can produce major changes in faunal communities.

All treatments would have long-term, beneficial effects by minimizing potential for large, high severity suppression fires. Reduced risk varies by alternative and habitat type.

Impact Analysis Effects Common To All Alternatives Wildlife
General Direct Effects

Ambient temperatures over 145°F are lethal to small mammals (Howard et al 1959), and it is reasonable to assume the threshold does not differ greatly for large mammals and birds. Animals with limited mobility living above ground appear to be most vulnerable to fire-caused injury and mortality, but occasionally even large mammals are killed by fire. The large fires of 1988 in the Greater Yellowstone Area killed approximately 1% of the area's elk population. However, fire effects on habitat influenced the population more than did direct mortality (Singer and Schullery 1989).

The direct adverse fire effect on mortality depends on animal mobility and fire's uniformity, severity, size, and duration (Wright and Bailey 1982). Most small mammals seek refuge underground or in sheltered places in the burn, whereas large mammals must find a safe location in unburned patches or outside the burn. Lyon et al (1978) observed small animals are more likely to panic in response to fire than large, highly mobile animals that tend to move calmly about the fire's periphery. Most small mammals avoid fire by using underground tunnels, pathways under moist forest litter, stumps, root holes, and spaces under rock, talus, and large dead wood (Ford et al. 1996). Burn season is often an important variable in fauna mortality. Burning during nesting season appears to be most detrimental to bird and small mammal populations (Erwin and Stasiak 1979).

Small mammals that construct surface-level nests are more vulnerable to fire-caused mortality than deeper nesting species, especially because their nests are constructed of dry, flammable materials (Kaufman et al. 1988, Quinn 1979, Simons 1991). Woodrats are particularly susceptible to fire mortality due to their reluctance to leave their dens even when fire is actively burning (Simons 1991).

Large mammal mortality is most likely when fire fronts are wide and fast moving, actively crowning, and during thick ground smoke. Singer and Schullery (1989) report that most large animals killed by the 1988

Yellowstone Fires died of smoke inhalation. Because large mammal mortality rates are low, direct fire-caused mortality has little influence on populations of these species as a whole (French and French 1996); therefore, direct adverse impact due to large mammals mortality would likely be negligible to minor and local (depending on fire behavior). Animal mortality would have a direct, local, beneficial effect by providing food for scavenger fauna (including eagles and condors) and some carnivores.

Fire-caused bird mortality depends on burn season and severity (Kruse and Piehl 1986, Lehman and Allendorf 1989, Robbins and Myers 1992). Adult songbird mortality is usually considered a negligible, local, adverse effect, but nestling and fledgling mortality can occur depending on species and nesting behavior. In addition, a review by Finch et al. (1997) points out reproductive success may be reduced in the first post-fire year due to food reductions from spring fires. In forested areas, fire effects on birds depend largely on fire severity. Young of birds nesting on the ground and in low vegetation could be adversely impacted by understory fire during nesting season. Canopy-nesting species could be injured by intense surface fire and crown fire. This potential adverse impact would be minor and likely local.

Fire will generally displace most wildlife, but many individuals will return within hours or days to a dedicated habitat such as young-rearing areas. Large mammals, such as elk and deer, depend on vegetation for forage, bedding, cover, and thermal protection. These animals abandon burned areas if fire removes needed habitat features. Depending on vegetation recovery, ungulates will return to burned areas for foraging. Burned areas promote early vegetation response compared to surrounding unburned areas, encouraging wildlife use.

Many animals are attracted to fire, smoke, and recently burned areas. The beetles of the subgenus Melanophila (dark loving), for instance, use infrared radiation sensors to find burning trees where they mate and lay eggs (Hart 1998). Different wildlife species have been observed on burned areas as soon as new vegetation growth appears as this vegetation is higher is nutrients.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Noise and Visual Disturbance **General Direct Effects**

General disturbance from noise and human activity (fire-fighting hand crews, vehicle traffic, aircraft) is possible. The majority of noise and visual disturbance would be from non-fire treatments and fire suppression activities.

Animal responses to noise are either physiological or behavioral in nature (Knight and Gutzweiller 1995). Physiological adverse effects may include temporary or permanent hearing threshold shifts, auditory signal masking, increased respiration and heart rate, and increased corticosteroid levels. Reported hearing threshold shifts were related to noise sources of much greater duration (minutes and hours) than a typical Grand Canyon aircraft overflight (a few seconds to a minute). Direct, local, adverse effects would cause behavioral responses, such as animals becoming alert and turning toward the sound source, running from the sound source, changes in activity patterns (e.g. interrupted feeding), nest abandonment, or changes in habitat use. If changes are sufficiently severe, an individual animal's health and survival may be reduced. If a large number of animals are affected, then population declines could result.

Human presence (firefighters) and equipment (vehicles) in occupied habitats could induce adverse effects through behavioral changes in juveniles and adults but, for some species, extent of this impact is largely unknown. No study directly analyzes fire suppression activities, but fire crew presence could increase flush (avoidance) response in wildlife species, but to what degree is unknown.

Limited studies have evaluated effects of human-induced disturbance and noise on raptors. Raptor responses to noise and disturbance in these studies varied. Most studies reported relatively minor impacts, and many found effects short term (Lamp 1987). In the few cases where reproductive success was evaluated, reproductive parameters were sometimes affected, but not to a large degree. Studies evaluated noise sources from ground-based activities as well as aircraft. Frazer et al. (1985) and Grubb and

King (1991) reported that nesting raptors were more sensitive to ground-based activities compared to aircraft. Grubb and King (1991) also reported that animals show a greater adverse response to helicopters than fixed-wing aircraft. In certain studies discussed below, general research findings on ground-based noise are provided to further show general raptors responses to noise.

Anderson et al (1990) evaluated responses of red-tailed, Swainson's, and ferruginous hawks, and golden eagles to ground-based military training activities in August in southeastern Colorado. The authors reported home-range size generally increased during military training. They also noted one of two ferruginous and the Swainson's hawk left the area and did not return until the following spring. The authors speculated changes in home range may increase energy needed by the birds and reduce reproductive success if training occurs during nesting season.

Marzluff et al (1994) concluded that Army National Guard training in the Snake River Birds of Prey National Conservation Area was correlated with increased foraging distances and temporary training-area avoidance in prairie falcons. It is probable that increases in foraging distances may result in stress to birds by increasing foraging's energetic costs.

In a study involving peregrine falcons and military aircraft (Ellis 1981), birds were observed during more than 1,000 overflights with noise levels of 82 to 114 A-weighted decibels (dBA). Responses usually included abandoning current behavior and watching aircraft, but alarm behavior occurred when aircraft were between 500 feet (nearest reported distance) and 1,600 feet above ground level. Birds did not respond appreciably to aircraft beyond 1,640 feet. When responses did occur with aircraft passing at closer distances, responses were temporary and did not result in reproductive failures. Ellis also collected limited physiological data on prairie falcons, concluding that elevated heart rates caused by aircraft overflights were temporary and within the species' normal response parameters.

In a follow-up study, Ellis et al (1991) evaluated effects of low-level military aircraft flights on 18 peregrine falcon nest sites and nearly 40 breeding attempts of several other raptor species including prairie falcons. Raptors responses were observed for more than 1,000 overflights that ranged from 220 feet to 1,500 feet from nests and generally resulted in Sound Exposure Levels (SEL) greater than 90 dBA (SEL is a single event composite measure that takes into account the maximum noise level associated with a noise event and event duration). Of the 1,000-plus flights, 482 were within 500 feet of nests. Of the 482 passes within 500 feet, 52 (4%) resulted in cowering or flight responses. The remaining 430 flights (96%) resulted in birds temporarily stopping activities, orientating and observing the aircraft, or exhibiting no response. In addition, the authors noted all responses to aircraft were temporary and minor. Fledgling success for all raptor nests observed was 89% (34 of 38 nests), and peregrine falcon fledgling success was similar to general stated trends. Similarly, 21 of the 22 peregrine falcon nests used for observations during the study were occupied the following year, with 19 positively identified as active nests. The authors stated that extrapolation of results estimating long-term productivity impacts was not feasible.

Studies that specifically address effects of aircraft noise and visual stimuli on MSO are limited. Delaney et al (1999) studied effects of helicopter noise and chainsaws on MSO in the Lincoln National Forest. They compared noise stimulated plots and control plots, and found that "manipulated and non-manipulated nest sites did not differ in reproductive success (P = 0.59) or number of young fledged (P = 0.12)." They recommend 315 feet (105 meter) buffer zones around nest sites for helicopter overflights.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Collisions with Aircraft **General Direct Effects**

Bird strikes occur with significantly greater frequency than is generally imagined. Conover et al. (1995) compiled reported statistics and estimated that annual U.S. losses totaled $200 million to civilian aircraft, $45 million to military aircraft, and seven human fatalities. Bird strike data are difficult to accumulate and analyze given the only sources are voluntary pilot reports (FAA Form 5200-7). It has been estimated that only 20 to 30% of all bird strikes are reported by pilots (Conover et al. 1995). Avian collisions with aircraft have been documented for a variety of species (Krivitski 1991; Linnell et al. 1996; Garber 1998). Linnell et al. (1996) determined that of the 526 bird strikes between 1990 and 1994 at Lihue (Hawaii) Airport, 43 (8.2%) involved barn owls and 23 or 4.4% involved short-ear owls.

No data are available documenting number of collisions between birds and aircraft over GRCA or at Grand Canyon Airport, let alone collisions with fire management aircraft. Because of the low number of flight hours anticipated with fire management aircraft in GRCA (approximately 160 hours annually), this potential adverse impact is anticipated to be local and negligible. Impacts would be more pronounced during breeding season.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Smoke **General Direct Effects**

GRCA is a Mandatory Federal Class I area for air quality under the Clean Air Act, making GRCA subject to ADEQ air quality standards. Mitigation measures related to air quality include using best management practices for smoke dispersal and emissions reduction techniques during planned management activities.

A lack of scientific literature exists detailing smoke effects on wildlife. Given that many species have evolved with Southwestern fire-adapted ecosystems, there may be some tolerance of a certain amount of smoke or behaviors to avoid dense smoke. As with other fire effects, young are more likely affected than adults who can more easily move away from smoke.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Effects On Wildlife Habitat **General Indirect Effects**

The Leopold Report of 1963 (Leopold et al 1963), established the concept that wildlife habitat is not a stable entity that persists unchanged in perpetuity, but rather is a dynamic entity; suitable habitat for many wildlife species and communities must be renewed by fire. Policy began to shift away from the assumption that all wildland fires are destructive (Pyne 1982). In 1968, NPS fire policy changed drastically as managers began to adopt Leopold Report recommendations. Policy officially recognized fire as a natural process to be managed for maintaining ecosystems and improving wildlife habitat. Thus began the current era of fire management in which fire is recognized as an integral part of ecosystems, including those aspects relating to fauna (Habeck and Mutch 1973).

The literature demonstrates great local variation in fire effects on habitat, even within small geographic areas in a single fire regime. Variable and broken topography and sparse fuels are likely to produce patchy burns, while landscapes with little relief and homogeneous fuels may burn more uniformly. Fires shape a complex mosaic of vegetation size classes, vegetation structure, and plant species occurrence across the landscape, and this variety has profound influence on animals that live there.

The major habitat components in forested habitats affected by fire are trees, snags, and dead-and-down wood. It would be difficult to overestimate the importance of large trees, snags, and dead-and-down wood to birds and small mammals. According to Brown and Bright (1997), "The snag represents perhaps the most valuable category of tree-form diversity in the forest landscape." Fire and snags have a complex relationship. Fires convert live trees to snags, but fires also burn into the heartwood of old, decayed snags and cause them to fall. Fire may facilitate decay in surviving trees by providing an entry point for fungi, which increases likelihood trees will be used by cavity excavators. Fire may also harden wood of trees killed during a burn, causing outer wood to decay more slowly than that of trees that die from other causes. This case-hardening reduces immediate availability of fire-killed snags for nest excavation, but slows decay after they fall.

Snag usefulness to fauna is enhanced or reduced by surrounding habitat, since cavity nesters vary in need for cover and food. Many cavity excavators require broken-topped snags because partial decay makes them easier to excavate than sound wood (Caton 1996). Some bird species nest only in large, old snags that are likely to stand longer than small snags (Smith 1999) (e.g. pileated woodpeckers). Some excavators and secondary cavity nesters prefer snag clumps to individual snags, so spatial arrangement of dead and decaying trees influences wildlife usefulness (Saab and Dudley 1998).

Dead wood on the ground is an essential habitat component for many birds, small mammals, and even large mammals, including bears (Bull and Blumton 1999). Large dead logs harbor many invertebrates and are particularly productive of ants; they also provide shelter and cover for small mammals, amphibians, and reptiles. Fire can burn existing woody debris on the ground while creating additional woody debris over time. While the direct, immediate effect from fire might be adverse in retaining large, down logs, the indirect, longer term impact would be beneficial because fire-killed trees eventually fall and become woody debris. Dead-and-down wood from fire-killed trees often decays more slowly than wood of trees killed by other means (Graham et al. 1994).

Stand-replacing fires and understory burns severe enough to top-kill shrubs and young trees seem more likely to trigger high emigration rates in large mammals, such as elk and deer, than patchy or low severity fires. Wildlife may avoid areas because required food and cover are unavailable after a burn. Impact duration (length of time) before these species return depends on how much fire-altered habitat structure and food supply remain, and how quickly the burned area responds to disturbance. If recent burns provide some habitat requirements, animals may be able to stay in the area and use remaining habitat islands near burn edges. Immediately following stand-replacing fires in chaparral, Ashcraft (1979) reported mule deer graze no further than 300 feet from cover.

Most mammals travel at least occasionally to seek food and shelter, and some make lengthy yearly migrations. Mammal species can readily move into burned areas. Some use burned areas exclusively, and some use them seasonally or as part of their home range. Predator visibility may be a reason large ungulates such as deer, elk, and bighorn move into burned areas. Desert bighorn abandoned areas from which fire was excluded (Etchberger 1990). Mazaika et al (1992) recommend prescribed burning in the Arizona's Santa Catalina Mountains to reduce shrub cover and maintain bighorn diet quality.

Impact Analysis — Effects Common To All Alternatives — Wildlife
Direct And Indirect Effects
General Wildlife Species Groups Of Interest

Chapter 3 provides a list of selected species that account for over 400 of the more common GRCA species. That list is subdivided into groups and individual species. Analysis of groups and representative individual species is intended to show the impact spectrum expected as a result of proposed FMP implementation.

Impact Analysis — Effects Common To All Alternatives — Wildlife
Invertebrates — Direct And Indirect Effects

Invertebrate fire response can be highly variable, depending on where they spend most of their time (ground dwelling, shrub or tree inhabiting) and their functional feeding role (Warren et al. 1987). Other factors influencing invertebrate fire responses include burn intensity, duration, and timing. Timing is important to arthropod developmental stage and ability to escape or survive in soil as fire passes over (Warren et al 1987). Some species may be less vulnerable during the dormant season because they are in a resistant life stage; others may be less vulnerable during the growing season because they are more mobile and can escape (Ahlgren 1974). Species mobility is also important to recolonization success after a fire. Insects and other invertebrates are most vulnerable to adverse fire effects during life stages in surface litter or plant stems or leaves. Stages occurring in soil, as well as mobile adults, are much less vulnerable.

A literature search revealed no references for fire effects on flying insects in local Southwestern forests; thus, studies from other geographic areas with similar vegetation were used to estimate potential effects.

Studies conducted in the Southwest on fire effects on arboreal insects show that arboreal insects, such as bark beetles (Coleoptera: Scolytidae), ground beetles (Coleoptera: Carabidae), and wood-boring beetles (Coleoptera: Buprestidae and Cerambycidae), may be adversely affected during fire, but tend to thrive in burned areas following a fire. Ground beetle populations were found to increase in diversity following fire in ponderosa pine forest in northern Arizona (Villa-Castillo and Wagner 2002). Burned trees are known to be susceptible to bark beetle and wood borer infestation, with likelihood of infestation increasing with amount of crown scorch (Bradley and Tueller 2001, McHugh et al. 2003, Wallin et al. 2003).

Numerous studies in other geographical areas showed significant increases in species richness, composition, and diversity following fire at both the local (small scale) and regional (large scale) level (Smith 2000). Evans (1971) found at least 40 arthropod species attracted to fire. In monitoring prescribed fire in Yosemite National Park, Huntzinger (2003) found two to three times as many butterfly species occur in forest burns as controls, 13 times as many in fuel breaks as controls, and twice as many in riparian burns as controls. In comparing study plots having, 1) multiple fires, 2) a single fire, and 3) unburned control over a 30-year period, Moretti et al. (2004) demonstrated that fire enhanced overall biodiversity. Furthermore, they found that overall species richness and/or abundance were significantly higher in plots with repeated fires than in unburned controls. Moretti et al. (2004) concluded that fire frequency had a significant positive effect on species richness of open forest guilds of [invertebrate] species and forest edge [invertebrate] species, without affecting interior forest [invertebrate] species. Moretti and Barbalat (2003) attribute this to the mosaic of forest areas burnt with different frequencies and at different times which appear to be important factors influencing species richness and species composition at the large spatial scale. Although abundance of insects and other invertebrates decreases immediately after a fire, it usually increases again as vegetation starts to grow, and both surviving individuals and migrants from the surrounding unburned area recolonize the burn site. In monitoring ecological restoration treatments in Arizona, Meyer and Sisk (2001) found that some butterfly species have a positive response to changes in microclimate resulting from fire. In addition, Waltz and Covington (2001) found butterfly species richness was two to three times greater in restoration treatment units than adjacent non-treatment units.

McHugh et al. (2003) and Ganz et al. (2003) found significant increases in bark beetles. Increases in borer and engraver beetle populations were related to fire-induced stress to conifers.

Impacts to invertebrates generally take the form of shifts in species richness, diversity, and biomass at the local scale in the short term, and at the large scale in the long term. These changes are a result of direct or indirect vegetation changes resulting from fire. There may be some mortality experienced by life stages associated with surface litter plant stems or leaves during the fire event. However, most species populations can recuperate quickly as fresh, young plant growth and down woody debris becomes available (Robbins and Myers 1992).

Fire severity and resulting habitat modifications will have major influences on local invertebrate populations. Areas experiencing high and moderate/high severity fire may have a high percentage of surface and aerial vegetation removed (grass, leaf litter, twigs, tree and shrub crowns). Invertebrates found in ground litter may be adversely impacted during fire and until post-fire recovery occurs (one to three years). Furthermore, reduction in arboreal invertebrate populations may be noticed on these same acres immediately after fire where canopy loss occurs. Burned and stressed trees are susceptible to bark beetle and wood borer infestation, with infestation likelihood increasing and thus population rebound.

Impact Analysis Vertebrates | **Effects Common To All Alternatives Direct And Indirect Effects** | **Wildlife**

Impacts to vertebrates are generally shifts in habitat condition (either adverse or beneficial); direct mortality; or direct disturbance (e.g. flushing animals). Direct effects could arise from fire and disturbance from hand crews, equipment, and aircraft. Indirect impacts would include shifts in habitat condition (loss or change in such components as ground litter, snags, down woody debris, or overhead cover (shrub or tree), and possible establishment/expansion of invasive species (both plant and animal) from treatments.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Herpetofauna (Amphibians and Reptiles) **Direct And Indirect Effects**

Little is known about ectotherm response to ponderosa pine restoration treatments or fire effects on herpetofauna. In a literature review, Russell et al (1999) found of the little research done, most studies were anecdotal, had no baseline data, no replication or controls, and had inherent differences in edaphic conditions between plots. Changes in sunlight penetration to the forest floor and increased herbaceous productivity in restoration-treated ponderosa pine stands is suspected to benefit native herpetofauna, but research is lacking. Literature found is not Southwest-specific, but provides an indication of how native species would likely be affected by proposed treatments and suppression fires in the proposed FMP.

Potential adverse effects to herpetofauna from proposed FMP implementation include modification or loss of habitat or habitat components, and direct loss of individuals. Direct effects can result from wildland fire-use, prescribed, and suppression fires, and mechanical and/or manual vegetation treatment. Habitat effects may vary between dominant vegetation types and location, time of year, and location. Lyon et al (1978) suggest that smaller and less mobile vertebrates, such as amphibians and reptiles, were most likely to exhibit panic and experience relatively high rates of direct mortality from fires. Also, amphibians' moist, permeable skin and eggs increase vulnerability to direct adverse impacts such as heat, and indirect adverse impacts such as sedimentation, pH changes, and microhabitat drying (Stebbins and Cohen 1995). There is no known literature available regarding smoke's physical effects on herpetofauna.

Fire-caused changes in plant species composition and habitat structure influence reptile and amphibian populations (Means and Campbell 1981; Russell et al. 1999). In chaparral, reptiles were more abundant in recently burned areas than in areas with mature, dense cover. Individual populations responded to developing vegetation structure (Simovich 1979). Species populations that preferred open sites increased slightly during the first three years after fire. During the same time, species populations that used or could tolerate dense vegetation decreased but were not eliminated. Amphibians in forested areas are closely tied to debris quantities (litter and woody material that accumulate over time). In British Columbian forests, proportion of non-mammalian vertebrates (mainly amphibians) using woody debris was positively correlated with length of fire rotation (Bunnell 1995). Many herpetofauna populations show little response to understory and mixed severity fire. A review by Russell et al. (1999) explains that fire in isolated wetlands usually increases open water areas and enhances vegetation structure favored by many aquatic and semi-aquatic herpetofauna.

Many reptiles and amphibians live in mesic habitat. Many amphibians use riparian sites having moist vegetative litter. Amphibian species, such as the Arizona tiger salamander, Rocky Mountain toad or canyon tree frog show little evidence of seasonal movement away from moist breeding areas. Many of these species use burrows to escape drying effects of higher summer temperatures. These sites are likely to burn less severe than upland sites. Resulting microsite variation in burns may account for observations that fire typically has little effect on these species populations. Wetlands may provide refuge from fire, and activities such as breeding by aquatic species may be carried out with little interruption by fire (Russell et al. 1999). Other species, such as the Great Basin spadefoot toad and turtles, may disperse from breeding habitat to forage and seek summer habitat if water is unavailable. Summer habitat could include burrows or spaces under boulders or rock and organic debris such as downed trees or logs. These species could be adversely impacted by summer fires or non-fire treatments if these activities occur in occupied habitat.

Some herpetofauna, such as many lizards and snakes, prefer open, early successional habitats with a high proportion of bare sand or soil, conditions historically maintained by frequent understory fires (Russell et al. 1999). For example, current research shows that lizards of the Sceloporus genus (northern sagebrush and northern plateau lizard) are more abundant in areas with lower ponderosa pine density. Therefore, restoration should enhance thermoregulation options for these lizards by opening the forest floor to more sunlight and providing easier burrow access by decreasing litter accumulations. However, restoration treatments and subsequent habitat structure alterations could also have negative indirect effects.

Attraction of predatory birds and mammals to burns, and decreased cover, could increase predation. Reduced food availability post-disturbance could also have negative impacts on lizard and snake populations; however, primary prey species tend to rapidly increase post-burn disturbance.

While monitoring prescribed fire effects on western fence lizards, Kahn (1960) reported fence lizards survived a serious chaparral fire by remaining in the soil beneath rocks, entering animal burrows, or retreating under woody material. Similarly, mountain short-horned lizards, plateau lizards, black-collared lizards, and side-blotched lizards could survive fire by using the same escape mechanism. Komarek (1969) states animals appear to respond to fire with adaptive behaviors that minimize mortality. He reports experiments with different types of prescribed fire resulted in no discernible amphibian mortality.

Organisms living in a fire-prone habitat have developed unusual sensory abilities to detect fires. Using acoustic cues to detect approaching fires may give slow-moving animals a head start when fleeing. Grafe et al. (2002) demonstrated that juvenile reed frogs could detect the sound of fire and respond adaptively by escaping toward fire-resistant cover.

Many of the studies above discuss potential species ability to avoid fire's physical effects, having evolved in a fire-adapted environment. Effects to habitat from moderate/high burn severity may limit or preclude area use after a fire event, and potentially change population levels at the local scale. Fire, or fire-associated activities, would have little to no effect on species occupying rocky, bare, and open landscapes.

Those species occupying a variety of habitats, such as the California kingsnake, Great Basin gopher snake, and plateau and northern sagebrush lizards, have greater potential to be adversely affected by fire due to wide distribution. Effects are dependent on vegetation type and burn severity.

Indirect adverse effects can occur from increased water temperatures as thermal cover is removed, or from ash and sediment input in streams in occupied habitat and within short distances (approximately ½ mile) downstream of treated areas. Disturbance from ground crews or equipment could also cause local, direct, adverse impacts by short-term local species movements to avoid activities, although these movements are typically of very short-term duration.

Non-fire treatments (mechanical/manual vegetation treatment) could lead to indirect effects also. Non-fire fuels treatments can remove standing and/or down woody material. Dense younger stands (high risk fire stands) can provide cooler, damper micro-site conditions used by frogs during dispersal and uplands use. Fuels reduction would result in a more open stand condition. This open stand condition would tend to result in warmer, drier conditions inhospitable to amphibians.

Indirect adverse and beneficial prescribed fire effects would include loss of streamside vegetation and duff layers due to fire in riparian areas, resulting in sedimentation increases. Increases in sedimentation from ephemeral drainages may result in loss of downstream pool habitat for species such as frogs that use deeper pools for breeding and escape habitat. However, some species such as toads, may actually experience enhanced breeding habitat as they may use sediment-filled habitat for breeding purposes. All such impacts are of minimal magnitude compared to the same types of impacts resulting from expected higher burn severity suppression fires.

Impact Analysis Effects Common To All Alternatives Wildlife
Birds Direct And Indirect Effects

Non-fire treatments, and prescribed, wildland fire-use, and suppression fires could affect forest bird composition and diversity because these disturbances directly influence forest structure and landscape patterns. Ecological restoration using prescribed and wildland fire-use fires will directly alter habitat, opening habitat for some species while eliminating or reducing habitats required by others (Finch et al. 1997). Bird populations respond to changes in food, cover, and nesting habitat caused by fire, as do other vertebrates. Burn season and species residency will determine effects to bird populations. Fires during nesting season may reduce recruitment in some bird populations; migratory populations may be affected indirectly or not at all depending on burn timing and severity and migratory schedules (Brown et al. 2000).

After fire, some bird species are beneficially impacted and return to take advantage of altered habitat. A few bird species are attracted to active burns and many increase in the days and weeks that follow fire. In the Southwest, raptor and scavenger species are attracted to fire or use recent burns for hunting including northern harrier, American kestrel, red-tailed hawk, red-shouldered hawk, Cooper's hawk, and turkey and black vultures (Dodd 1988). Predators and scavengers are often attracted to burns because food is more abundant or more exposed than in unburned sites (Tewes 1984). Several studies show that woodpeckers are particularly attracted to burned areas. Abundant prey attracted golden eagles and peregrine falcons to recently burned areas in New Mexico and southern California (Lehman and Allendorf 1989). California condors have been observed to move into recently burned areas in northern Arizona and roost adjacent to burned habitat due to potential increase in food availability (Parish 2007).

Other bird species are adversely impacted and abandon burned areas because the habitat does not provide structure or foods required to survive and reproduce. While some raptors are attracted to fire, others move out of an area immediately after fire. The same species may react differently depending on fire location, season, and severity.

Birds in GRCA breed in a wide variety of habitats, ranging from open areas to densely vegetated forests and woodlands. (See Table 3-6 for a representative list of species by major vegetation type). Fire management activities near breeding birds may have adverse impacts by disrupting breeding or harming young by direct mortality or injury, loss of nesting substrate or cover, and disruption of feeding and brooding activities. Extent of direct adverse impacts to breeding birds would depend on habitat, nesting behavior of each species, timing of disturbance, and burn severity. Habitat alteration, as the result of fire, may force adults to relocate to nearby habitat, but displaced adults may not be able to establish breeding territories if suitable territory locations are already occupied. Populations that experience decline through reduced reproductive success or as a result of individual mortality would likely recover following impact if habitat conditions remain suitable or individuals are able to establish breeding territories elsewhere. Some species would not be affected depending on timing of fire management activities.

Species composition and community structure would be altered by fire management activities depending on species habitat preferences. Species that prefer open habitat would benefit from fire management activities, and species that prefer moderately dense to dense habitats may be adversely impacted depending on extent and pattern of habitat disturbance. In the short term, a temporary decrease in snags could adversely affect cavity nesters and secondary cavity nesters (e.g. violet-green swallow, pygmy nuthatch, western bluebird, brown creeper, white-breasted nuthatch).

An increase in snags over time from fire-killed trees would result in an increase in cavity nesters, secondary cavity nesters, and species that feed on insects found in snags and downed woody debris.

During the breeding season, blue grouse inhabit mixed-conifer and adjacent shrub and aspen habitats and could be directly affected by fire management activities in these areas. Blue grouse are ground nesters and rely on fallen logs or vegetation to conceal their nests; thus, fire that consumes ground cover would adversely affect habitat by reducing area suitability. Adult blue grouse may be able to relocate to nearby habitats, depending on suitability and availability. Grouse populations may be affected by reduced reproductive success in the short term, but will benefit from complex habitat components created or maintained through proposed activities.

As discussed in the vegetation analysis, wildland fire-use, prescribed, and suppression fire, and manual/ mechanical treatments would decrease canopy closure and create open forest areas, beneficial in effect because openings are important to blue grouse for breeding displays and foraging. An increase in new vegetative growth following fire would benefit grouse by increasing food supplies. Dense cover used by wintering grouse may be decreased by fire management activities.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Bats **Direct And Indirect Effects**

GRCA bats (see Chapter 3) roost in a wide variety of habitats including cliff and rock faces, caves, trees cavities, tree foliage, and under loose bark. Bats in forest habitats could be disturbed and forced to relocate during fire incidents or fire management activities. Forest dwelling bats could also be directly affected short term by fire management activities that alter forest structure, snag components, or availability of prey populations.

Long term, fire management activities would have beneficial effects by increasing large snags number (by promoting large tree development) and reduce likelihood of large, high severity fires that alter habitat over a large area. In addition, openings created by fire could be beneficial for bat species that forage in forest openings. Fire management activities may affect insect populations, food for most bat species.

Impact Analysis **Effects Common To All Alternatives** **Wildlife**
Small Mammals **Direct And Indirect Effects**

A number of small mammals inhabit GRCA (Chapter 3). Deer mice inhabit virtually all vegetation and typically avoid direct fire impacts by escaping into burrows or rocky crevices. However, they could experience indirect effects, and be adversely affected, by fire intensity that consumes habitat components and leaves them more vulnerable to predators and decreased foraging opportunities (Goodwin and Hungerford 1979).

Botta's pocket gophers primarily use South Rim desert scrub, piñon-juniper, and ponderosa pine where more friable soils exist for successful burrowing. As they rely on grasses and forbs for foraging, fire and/or non-fire treatments that open dense timbered areas, allowing more grasses and forbs, would provide beneficial impacts. It could be expected that their densities would increase from less than one per acre, as found in ponderosa pine forests around Flagstaff (Goodwin and Hungerford 1979), to potentials of eight to ten per acre as reported by Ingles et al. (1949).

As described in Chapter 3, the brush mouse, Mexican woodrat, bushy-tailed woodrat, and rock squirrel are found in a variety of GRCA vegetation types but are typically associated with rocky habitats less fire susceptible than areas with deeper soils. This rocky-habitat association provides added opportunity to avoid fire impacts; however, woodrats, due to twigs and other flammable woody material used in nest construction, would be negatively impacted by fire incidents. Woodrats often refuse to leave their nests (Simons 1991), making them more vulnerable to fire and fire management activities.

Several other small mammals are associated with forest edges throughout various GRCA timber types. Uinta and least chipmunks, golden-mantled ground squirrels, and Nuttall's cottontails reside only on North Rim. All of these species tend to be more prevalent around campgrounds, near overlooks, and other more-open areas and forest-edge habitats. While fast-moving ground fire could cause local, short-term, adverse impacts, these species would tend to experience local, long-term, beneficial impacts from dense ground cover removal and openings and edges created by fire. Chipmunks and tree squirrels, which forage in trees and bushes, would experience adverse impacts from loss of structural components following fire. Nuttall's cottontail primarily occur in mixed-conifer and ponderosa forests and are dependent on grasses and other herbaceous vegetation potentially consumed by lower intensity ground fire. They could experience local, short-term, adverse impacts from initial food source loss, but could also experience local, long-term, beneficial effects by opening of dense multiple layered timber stands to allow grass and herbaceous ground cover to prevail.

Voles, shrews, and other small rodents may be adversely impacted by habitat loss through burning. Local populations may experience decline immediately following fire. Initial declines in rodent populations following disturbance are short in duration due to their high reproductive potential.

Impact Analysis | **Effects Common To All Alternatives** | **Wildlife**
Carnivores | **Direct And Indirect Effects**

Large carnivores, such as mountain lions, and omnivores, such as black bears are opportunistic species with large home ranges. These species tend to thrive in areas where preferred prey or forage is most plentiful—often, in recent burns.

Fire management activities could have direct, adverse impacts on young mountain lions due to human or machine disturbances, loss of some hiding cover, and stress. Most mountain lions would be able to avoid or escape fires and could relocate during fire management activities, depending on availability of nearby habitats. Because mountain lions occur in a variety of habitats, most would likely be able to avoid disturbed areas affected by fire management activities.

Prescribed, wildland fire-use, and suppression fires would have indirect beneficial effects on mountain lions by improving foraging habitat for primary prey species such as mule deer and elk. Increased forage for prey species in a burned area could increase or concentrate prey populations and increase hunting opportunities or efficiency for mountain lions. Mountain lions may shift their home ranges following a fire, either to avoid areas with little cover or to follow shifts in prey populations (Tesky 1995). Some may be attracted to recent burn edges where prey could be found. Fire management activities would decrease potential for large, high severity fires providing long-term benefits in habitat maintenance and protection.

Badgers occur in South Rim piñon-juniper, and ponderosa pine habitat on both rims. Badgers are mid-sized, mobile animals. Deeply burrowed, well-vented dens protect them from most fires (Smith 2000), though they could experience direct adverse effects from temporary displacement through habitat loss.

Fire management activities would have indirect effects on badgers by altering habitat for small rodents, badger's primary prey. Fires generally result in an initial decline in small mammal populations and then an increase, as herbaceous vegetation production in burned areas increases in subsequent growing seasons. Badgers would receive local, indirect, long-term benefits over several years from increasing prey populations, but could be adversely affected (local and short term) by the initial decline in prey abundance immediately following a fire (Smith 2000). Fires that create or maintain open areas would improve habitat for badgers and their prey species. Fire management activities would decrease potential for large, high severity fires providing long-term benefits in habitat maintenance and protection.

Long-tailed weasels prefer open, grassy, or brushy areas, live in burrows, and are primarily nocturnal which minimizes adverse impacts from fire and related activities. Direct adverse impacts to weasels from fire and related activities would include injury or displacement.

Fire management activities could have indirect effects on long-tailed weasels by altering habitat and prey species distribution or abundance (mice, voles, and other small rodents). Prey species would likely decrease in burned areas immediately following fire and then increase as herbaceous cover increases in subsequent growing seasons. Long-tailed weasels tend to avoid dense forest and prefer open, brushy, or grassy areas; fire management activities could be beneficial by decreasing vegetation density and making habitat more suitable for weasels. Fire management activities would decrease potential for large, high severity fires providing long-term benefits in habitat maintenance and protection.

Impact Analysis | **Effects Common To All Alternatives** | **Wildlife**
Ungulates | **Direct And Indirect Effects**

Mule deer and elk use a variety of habitats in and adjacent to GRCA. Mule deer and elk could be disturbed during fire management activities, but most could relocate to nearby habitat, depending on activity extent and habitat availability. Mule deer and elk populations could experience a slight decline, depending on impact severity and timing and habitat type affected. Most individuals would likely be able to relocate during fire management activities to avoid disturbed areas. Mule deer and elk mortality rates resulting from fire are generally low; therefore, direct impacts from fire management activities would have little direct adverse effect on populations as a whole (Smith 2000).

Wildland fire-use, prescribed, and suppression fires could all have indirect beneficial effects for mule deer and elk by increasing available forage in the first several growing seasons following fire. Non-fire treatment could also increase available forage by opening canopy cover. Fire and non-fire treatment could improve herbaceous groundcover in densely vegetated areas. Mule deer and elk have been observed feeding in burned areas; however, large patches of high severity burn could negate benefits of increased forage due to vulnerability to depredation. Fire management activities would decrease potential large, high severity fires providing long-term benefits in habitat maintenance and protection.

Desert bighorn occupy GRCA desert scrub slopes where fire management activities would not occur, and some rim habitat where limited fire management activities could occur. Helicopters accessing GRCA for fire management activities could have direct adverse effects by disturbing bighorn and reducing their foraging efficiency by causing the animals to expend more energy reacting to these flights while foraging (Stockwell et al. 1991). Reduced foraging efficiency as a result of helicopter flights during mating season may slightly adversely affect bighorn populations by reducing reproductive success, but data have not been collected to verify this relationship. Bighorn populations would be negligibly affected by this short-term and very local activity. In addition, expected flight time for all alternatives is similar (158 to 167 hours per year); therefore, this negligible impact would be the same for all alternatives.

4.2.4.6 Effects Common to Action Alternatives 2 through 5 Wildlife
Direct and Indirect Effects

Effects common to all alternatives (4.2.4.8) would be the same for Action Alternatives 2-5, but added mechanical treatments could increase area potentially affected. In addition, the low intensity fire constraint is not included in Alternatives 2-5. Fire and non-fire impacts to representative wildlife species would be the same by vegetation type, but would vary in size depending on specific alternative. According to Tables 4-9 and 4-11, there would be minor to no differences in moderate/high to high severity in mixed-conifer and spruce-fir vegetation types between prescribed and wildland fire-use fires. In addition, suppression fires in ponderosa pine for all alternatives would likely be within the natural range of variability, producing low intensity fire (Table 4-5). Because of this, suppression fires in ponderosa pine would have effects similar to fire treatments in this habitat type and are not addressed separately.

Because of the little treatment proposed in piñon-juniper for all alternatives, effects to general wildlife species would be negligible; therefore, no specific analysis is addressed for these wildlife groups.

In addition, mitigation measures are proposed to further reduce adverse effects to a variety of general wildlife species. These mitigation measures were not designed specifically for this resource, but general wildlife species and habitat would benefit.

Effects Common to Alternatives 2 through 5 Wildlife
Mitigation of Effects

Mitigation measures developed to decrease adverse effects to MSO habitat could also decrease adverse effects to general wildlife species. These mitigation measures (4.2.5.14) are

- Assess the amount of moderate/high and high severity fire through composite burn index monitoring after each managed fire in the mixed-conifer vegetation type above the rim. Use the adaptive management process to adjust burn prescription, ignition pattern, burn seasonality, and/or pre-treatment to ensure no more than 30% of the mixed-conifer vegetation type and MSO mixed-conifer restricted habitat burns with moderate/high and high severity. This includes high and moderate/high

fire severity from past fires (2000 to present) (Table 4-15a), and all fires that will occur within the scope of this planning document.
- When burning in the mixed-conifer vegetation type, fire prescriptions or objectives should create a mosaic of openings spread through this vegetation type

4.2.4.10 Alternative 1 No Action (Existing Program) Wildlife

Alternative 1, No Action, proposes to maintain the present fire management strategy. There would be approximately 20,050 acres of suppression; 55,000 acres of wildland fire use; 58,500 acres of prescribed fire; and 400 acres of non-fire manual treatment. See Chapter 2 for a description of this alternative.

Direct and Indirect Effects Alternative 1 Wildlife
Invertebrates

As noted in 4.2.1, it is assumed the majority (70-100%) of the ponderosa pine vegetation type would receive some form of fire treatment. With treatment there would likely be a beneficial trend toward lower tree densities and increased resilience due to stand thinning (understory and some overstory). This would reduce risk of insect infestation in these forest stands as well as reduce subsequent burn severity over time. Where treatment is proposed in mixed-conifer (assumed 64% of this vegetation type) and spruce-fir (19% of this vegetation type), there would be a slight stand density decrease and a possible spatial complexity increase (lessened by the low intensity fire constraint in treatment areas for this alternative). Where there is treatment, there would likely be negligible effect to bark beetles and wood-boring insects. Where no treatment is proposed, there would be a heightened risk of insect attack to stands due to stressed conditions from high tree densities.

Because very little manual treatment is proposed with this alternative (400 acres), and all fire treatments are proposed at low intensity fire, treatments in these areas would likely have little direct adverse effect on invertebrates. Negligible to minor, direct, local, short-term adverse effect would occur during these activities with a minor to moderate, local, beneficial effect one to three years after treatment. Invertebrate populations would initially decline, but would increase in composition and diversity soon after the burn. Invertebrates that use tree crowns would likely receive negligible effect from treatments because so little crown fire would occur in all forest vegetation types. There would be overall increased risk of crown fire because fuel is expected to accumulate faster than fire processes can reduce it under this alternative.

Where suppression fires occur, particularly in mixed-conifer (assumed 18%) and spruce-fir (assumed 36%) habitat types, fires would exhibit higher burn severity, increasing burned patch size, and likely increasing vegetation stress adjacent to high severity burn patches. Recently killed trees would provide prime habitat and encourage population growth of certain insect species. Invertebrates that use crowns would also receive adverse population effects due to tree mortality. Negligible short-term local adverse effects are expected from fire suppression activities due to increased potential for habitat loss through high severity fire.

Direct and Indirect Effects Alternative 1 Wildlife
Herpetofauna Vertebrates

Herpetofauna (e.g. Arizona tiger salamander, Rocky Mountain toad, canyon tree frog, Great Basin spadefoot toad, turtles) that use mesic habitat (moist areas) would be adversely affected by fire and non-fire treatments that decrease dead-and-down debris and open stands to sunlight. These species often use burrows during summer, and breed in moist areas (ponds, marshes, meadows); therefore, depending on fire severity and season, many individuals may not be directly adversely impacted. Since Alternative 1 proposes only low intensity fire with all fire treatments in all forest habitat types, local, direct, adverse effects (mortality, stress) would be negligible and local. Indirect adverse effect (to habitat) would be short term and negligible to minor. With low intensity fire, there would likely be areas to which these species could easily move that still meet habitat needs. Where suppression fires occur in mixed-conifer and spruce-fir vegetation types, direct and indirect adverse effects would likely be greater due to higher burn severity and, depending on high severity amount and size, adverse impacts could be local, minor to moderate, short to long term, especially in spruce-fir where up to 70% of suppression fires could burn at moderate/high to high severity. These species have alternative microhabitats (burrows, spaces under boulders or rocks, meadows, wet areas) that would also minimize adverse effects of removing forest groundcover and opening forest canopy.

For herpetofauna that prefer open, early successional habitats (northern sagebrush lizard, northern plateau lizard, Great Basin gopher snake), proposed treatments would likely have indirect, local, negligible, beneficial effects. As noted in (4.2.4.8), there could be an adverse effect of making these species more available to predation, but with this alternative, the effect would be negligible. In addition, there would be a negligible, direct, adverse mortality impact due to fire and/or non-fire treatment since these species can enter burrows and hide beneath soil under rocks. Suppression fires would likely have a more direct, adverse mortality effect compared to fire treatments, particularly in mixed-conifer and spruce-fir habitat where fire severity would be higher. Depending on high severity burn area size, there could be short-term beneficial effects (first one to three years) to these species due to increased amount of preferred habitat, but adverse impact due to increased openness to predation. Fire suppression activities would likely have negligible to minor adverse impacts to herpetofauna.

These species could avoid physical disturbance by fleeing or hiding from activities. After treatment, there would likely be more light fuels on the ground than what would occur after fire. This would likely have local, negligible, beneficial effects to species that prefer open, early successional habitats and those that prefer mesic habitats.

Direct and Indirect Effects Alternative 1 Wildlife Birds

Alternative 1 proposes low intensity fires in all forest habitat types for fire treatments. Effects to forests would be few openings (it is assumed less than 15% of the area would burn at moderate/high to high severity fire and 15% crown fire—mainly through passive crown fire), few snags destroyed and few snags recruited, and pockets of understory vegetation removed. This would have local, indirect, negligible, short- to long-term, beneficial effects to most raptors (e.g. Cooper's hawk, turkey vultures, red-tailed hawk, American kestrel) since these species use forest openings and open understory (to a lesser extent) for foraging. A more detailed impact description is in 4.2.5.13 and 4.2.5.15 for bald eagle and Swainson's hawk. Raptors in occupied nests may not be directly affected by mortality depending on egg/nestling developmental stage, fire proximity, and vegetation surrounding the nest tree.

This alternative would also have little effect on cavity nesters (e.g. hairy woodpecker, northern flicker) and secondary cavity nesters (e.g. violet-green swallow, pygmy nuthatch, western bluebird, brown creeper, white-breasted nuthatch) because of little snag turnover. Beneficial impacts would be local, indirect, negligible, and short term. These bird groups could be directly affected through mortality from heat, smoke, or snag burning if occupied nests are in the treatment area. Smoke and heat from flames may produce local, negligible adverse effects to young, but effect would be short term.

Birds that nest in and inhabit understory (hermit thrush, mountain chickadee, dark-eyed junco) could be adversely affected by this alternative. Depending on treatment season and whether species are migratory, there could be local, negligible to minor, direct, adverse effects to occupied nests and/or habitat. Because of low intensity fire in all forest habitat types, this adverse impact would likely be short term.

Birds that live and nest on the ground (e.g. blue grouse) would be adversely affected. Blue grouse inhabit mixed-conifer and spruce-fir forest stands. Where ground cover would be reduced in mixed-conifer, breeding habitat would be reduced; where ground and canopy cover would be reduced in spruce-fir, wintering habitat would be reduced. Due to the low intensity fire constraint in treatment areas, these adverse impacts would be local, negligible to minor, and short term. Openings created by this alternative would be minimal. Beneficial effects of increasing habitat for forage and breeding display would be negligible to minor, local, and long term.

Bird species that prefer multi-storied high-density stands (e.g. pygmy owls) would be adversely affected by this alternative. Due to the low intensity fire constraint in treatment areas, adverse impacts would likely be negligible, local, and short term.

All birds would be directly and indirectly affected by suppression fires in mixed-conifer and spruce-fir habitat types. Those that prefer open forest stands (most raptors) would receive minor beneficial impacts both short to long term and local due to the relatively high amount of moderate/high to high severity fire areas (40-70%) as long as prey return. Cavity nesters would likely have negligible, short-term beneficial impacts (by having a larger insects prey source in dead and dying trees), and secondary cavity nesters would likely have negligible, local, short-term adverse impacts immediately after the fire (with snag removal); negligible to minor, local, long-term beneficial impacts with snag buildup for several years after the fire; and negligible local adverse impacts should there be a decrease in large trees to recruit snags in the long term. Ground dwelling birds (e.g. blue grouse) would experience negligible, local, short- to long-term adverse impacts. Impact intensity would depend on size of higher severity burned areas. Birds needing high tree density would have minor to moderate, local adverse impacts, both short to long term. All bird species could be directly adversely affected by suppression fire due to mortality and displacement. This would be more pronounced if suppression fires occur during nesting season.

Birds that occupy non-fire treatment or fire suppression activity areas could be adversely affected both directly (mortality, displacement) and indirectly (modifying habitat). Impacts would be negligible, local, and short term. Treatments and fire suppression activities during nesting season would have more noticeable but still negligible adverse effects.

Direct and Indirect Effects — Alternative 1 — Wildlife
Bats

Depending on habitat needs, impacts could be beneficial or adverse to bat species. Direct and indirect adverse impacts to bats from Alternative 1 would likely be negligible to minor due to the low intensity fire constraint in treatment areas. For forest dwellers, roost sites would likely not be affected and mortality unlikely, though smoke could have short-term adverse negligible effects. Some bat species would likely receive beneficial effects from treatments by retaining moderate canopy cover after treatment. These beneficial impacts would be long term minor to moderate. Bats that forage on insects that have increased in population and composition one to three years after treatment would receive local minor to moderate beneficial impacts.

Non-fire treatments are anticipated to have negligible adverse or beneficial impacts to bat species.

Bats that prefer open areas and forest edges could have local, minor to moderate, short- to long-term beneficial impacts from expected results following suppression fires in mixed-conifer and spruce-fir habitat, depending on size and amount of high severity burn patches post-disturbance. Prey species could become more available through opening foraging areas, but there would be a short-term delay in availability. Bats that prefer moderate canopy cover and use forest canopy or tree roost sites would likely be adversely affected by suppression fires in mixed-conifer and spruce-fir habitats. Impacts would depend on burn severity mosaics and would range from minor to moderate, short to long term, and local.

Direct and Indirect Effects — Alternative 1 — Wildlife
Small Mammals

As with many wildlife species, Alternative 1 implementation would have local, negligible to minor, beneficial and adverse effects on small mammals. Species that inhabit areas with slash and down logs (e.g.

deer mice) would likely receive local, short-term, negligible to minor, adverse impacts but with the low intensity fire constraint in treatment areas, amount of ground material removed would likely be patchy with some areas unaffected.

Small mammals that prefer grasses and forbs would initially receive local, short-term, negligible to minor, adverse impacts from fire altering their habitat, but would likely receive negligible to minor, local, short-term, beneficial impacts after treatment due to new growth of grass and forbs.

All proposed treatments in Alternative 1 would start to reduce risk of large, high severity suppression fires. Where suppression fires do occur, especially in mixed-conifer and spruce-fir habitat, direct adverse effects to small mammals would be due to mortality, injury, and stress. Depending on size and extent of high severity burn areas, a decrease in populations would likely be short term since most small mammals have multiple breeding seasons with high reproductive potential. Some small mammal species would also experience some long-term beneficial effects from creation of edges and openings which they prefer. It is expected there will be short-term reductions in population numbers (reduced recruitment from habitat alteration and increased predator vulnerability); and a possible shift in species diversity. Impacts are expected to be local short to long term negligible to minor beneficial, and local short term negligible to minor adverse.

Direct and Indirect Effects Alternative 1 Wildlife Carnivores

Large carnivores are expected to have local, long-term, negligible, beneficial impacts from this Alternative due to increased foraging habitat available to prey species. An initial, direct, short-term, negligible, adverse impact from fire, fire suppression activities, and non-fire treatments is displacement. Adverse effects would be negligible, short term, local.

Carnivores with large home ranges (mountain lions) would likely take advantage of increased prey occurring soon, and several years, after fire treatments. With a healthy prey population (mule deer, elk), mountain lions would also likely thrive, having short- to long-term, local, negligible, beneficial impacts.

Badgers may be initially adversely affected by an immediate prey decline (small rodents), but would also benefit from increased small mammal populations soon after and one to three years later. Beneficial impacts to badgers, due to increased prey, would likely be minor to moderate, local and long term. There would be negligible, local, long-term adverse effects to habitat.

Long-tailed weasels prefer open brushy or grassy areas. Fire treatments would likely encourage grass growth but would have minimal effect on tree density due to low intensity fires. Beneficial effects to long-tailed weasel habitat may be local, short term, and negligible. Their prey (small rodents) would likely increase from this alternative, having indirect negligible, local, long-term beneficial effects to weasels.

High burn severity patches would likely reduce prey populations for many carnivore species initially, especially those found in mixed-conifer and spruce-fir vegetation types. Adverse impacts would be local, negligible, short term.

Direct and Indirect Effects Alternative 1 Wildlife Ungulates

Ungulates, such as mule deer and elk that use forest habitat types could be directly, adversely affected by fire, fire suppression activities, and non-fire treatments due to disturbance and displacement. Due to the low intensity fire constraint in treatment areas, adverse effects to species and habitat would be negligible, local short term.

The majority of ponderosa pine habitat (70-100%) would receive treatment. Approximately 82% of mixed-conifer and 19% of spruce-fir habitat would be treated with fire (assuming fires could stay within low intensity constraints in these two habitat types). Since these fires would not produce large openings (maintaining cover) and would produce new forage, impacts to these species would be beneficial, minor to major long term.

Suppression fires in mixed-conifer (18%) and spruce-fir (36%) vegetation types could have short-term negligible and local adverse impacts due to habitat alteration. Depending on high severity burn patch size and extent, long-term impacts may be negligible to minor, local and beneficial due to increased forage habitat. Burn severity patches may favor elk over deer habitat.

Mitigation of Effects Alternative 1 Wildlife

Alternative 1 includes the following mitigation measures that will affect wildlife species.

- Prescribed fires will be managed as low intensity fires
- Wildland fire-use fires will be managed as low intensity fires. The objective will be to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- While natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), occasionally up to 10% mortality may occur in large trees

There is potential fires would cease in mixed-conifer vegetation should it be determined fire treatments cannot stay low intensity. If this occurs, there would be a greater risk for large, high severity suppression fires in these two habitat types. Overall this would have short- to long-term, adverse effects to wildlife.

Cumulative Effects Alternative 1 Wildlife

Past, present, and reasonably foreseeable future actions taken by GRCA inside the park and by other agencies and persons on adjacent lands have potential to contribute to cumulative impacts to wildlife (See Appendix G). During the past decade of fire management, efforts have focused on fuel reduction around values at risk, restoration of fire as an ecological process in ponderosa pine, and the start of restoring fire as a process in mixed-conifer stands. Fire management practices to reduce fuel loads and stand densities have benefited treated areas, but areas not yet treated continue at risk to adverse effects of unwanted, high severity fire managed by suppression tactics to prevent fire spread.

Other planned actions include facility construction or improvement in rim developed areas and maintenance or rehabilitation of existing facilities in the canyon. Each of these projects is designed to minimize adverse impacts to natural resources, and each project receives environmental review under NEPA prior to implementation. Because these actions would occur in developed sites and would affect small areas, these projects, taken together, would result in a negligible loss of or alteration to existing wildlife habitats. These actions could result in increased wildlife disturbance during construction activities, but effects would be local short term.

Past, present, and reasonably foreseeable future projects on the Kaibab National Forest with potential to impact wildlife habitats or species of interest addressed by this plan include implementation of a fire management plan, timber sales, noxious weed control, grazing, vegetation management for improved wildlife and rare plant habitat, and fire management activities including thinning and prescribed fire. These planned projects also fall under NEPA purview and contain measures to avoid or minimize adverse impacts to wildlife and habitats. Effects should be minimal and local.

Wildfires pose the greatest potential for added cumulative effects on wildlife and habitats at both local and regional scales. In areas with high severity fires, habitat recovery time can extend from one or two years for grassland habitats, to decades to regrow forested habitats.

Cumulative effects to wildlife from past, present, and reasonably foreseeable future actions (noted above) would vary in intensity from negligible to minor depending on habitat types and species affected. Most impacts to wildlife species would be local and short term. Proposed fire management activities would slightly reduce risk of large, high severity fires adversely impacting wildlife species through habitat alteration; therefore, providing a negligible to minor beneficial long-term cumulative impact.

Conclusion Alternative 1 Wildlife

Overall there would be a beneficial impact of Alternative 1 to general wildlife. Fire and non-fire treatments would slightly lower high severity fires risk which would have negligible short-term beneficial local impacts to most wildlife species. Due to the low intensity fire constraint in mixed-conifer and spruce-fir vegetation types, there would most likely still be high risk of increased high severity patch size from fire in these habitat types.

Beneficial impacts from treatments generally would be minor beneficial and short term due to the low intensity fire constraint in treatment areas for all forest vegetation types. Ponderosa pine habitat would gain the most benefit since frequent, low intensity fire is part of the natural fire regime.

Direct and indirect impacts of Alternative 1 on wildlife species that prefer late seral stage forested habitat or complex forest structure with multi-storied canopy and abundant woody debris would see local, adverse, negligible to minor short-term impacts as well as local, long-term negligible beneficial impacts after initial habitat disturbances. Wildlife species that use early seral stage habitats with open understory would experience negligible, local, long-term beneficial effects.

Impacts would occur through suppression fires and, depending on size and configuration of high severity patches, impacts could be beneficial or adverse and most likely long term. Wildlife that use woody debris, a high percentage of tree canopy cover, and complex understory vegetation would be adversely affected by predicted suppression fire both short to long term. Impacts would likely be minor to moderate and local. Wildlife that prefer open tree canopy cover, forest openings, and forest edges would likely benefit from predicted suppression fire, depending on size and extent of high severity patch size and distribution on the landscape. These benefits would be minor to moderate, local, and in most cases short to long term. For areas where stand replacement or high severity fire is extensive, adverse impacts to most wildlife species would be short to long term, minor to moderate, and local.

Direct and indirect impacts from manual treatment would be beneficial, local and negligible.

Impairment Alternative 1 Wildlife

Since are no major adverse impacts in Alternative 1 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair wildlife during Alternative 1 implementation.

Unacceptable Impacts Alternative 1 Wildlife

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wildlife as a result of Alterative 1 implementation.

4.2.4.11 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Wildlife

Alternative 2 proposes the same areas for fire treatment as Alternative 1, but removes the low intensity fire constraint in MSO critical habitat (portion of South Rim and all of North Rim). This change would mainly affect fire treatments proposed in mixed-conifer and spruce-fir vegetation types. As noted in Alternative 1, more than 57% of the mixed-conifer vegetation type is proposed for treatment through prescribed fire. In addition, without the low intensity fire constraint in treatment areas, an additional 30% of the mixed-conifer habitat type is anticipated to burn under wildland fire use; it is assumed approximately 18% would burn as suppression fires. Prescribed fire treatment is planned in 19% of the spruce-fir vegetation type; 36% is assumed to burn from suppression fire.

In addition, there would be a total of 2,490 acres of manual/mechanical treatment in the WUI. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 2 Wildlife
Invertebrates

Impacts to invertebrates in ponderosa pine would be the same as Alternative 1, negligible to minor, local, short term, adverse from mortality and habitat modification, but after one to three years, there would be minor to moderate, local, long-term beneficial impacts to invertebrates where populations would likely return to pre-treatment levels, and resulting treated areas would have greater composition and diversity.

Fire treatments in mixed-conifer (approximately 87%) and spruce-fir (19%) would burn with higher fire intensity than Alternative 1. This alternative is predicted to more closely simulate the historic mixed severity fire regime. Stressed trees in burned stands would be vulnerable to insect attack, but surviving trees would, in the long term, be more resilient to environmental disturbances due to lower tree densities. In the spruce-fir vegetation type, tree density reduction from fire could also reduce risk of future insect outbreaks. Increased species richness, composition, and diversity is expected in the long term depending on post-disturbance vegetation response. Impacts to invertebrates from Alternative 2 would be local, short term, negligible, adverse, and local, long term, minor to moderate, beneficial.

Where suppression fires occur, particularly in mixed-conifer (assumed 18%) and spruce-fir (assumed 36%) habitat types, fires would exhibit higher severity, increasing burned patch size and likely increasing stress in vegetation adjacent to high severity burned patches. Recently killed trees would provide prime habitat and encourage population growth of certain insect species. Invertebrates that use crowns would also receive adverse effects to populations due to tree mortality. Negligible short-term local adverse effects are expected from fire suppression activities due to increased potential for habitat loss through high severity fire.

Where non-fire treatment is proposed, there could be short-term adverse effects to invertebrates but impacts would be local, short term, and negligible due to proposed small treatment acreages. Non-fire treatment would have negligible local short- to long-term beneficial impacts in making forested stands more resilient to environmental stressors.

Direct and Indirect Effects Alternative 2 Wildlife
Herpetofauna Vertebrates

Alternative 2 removes the low intensity fire constraint for fire treatments in all vegetation types, allowing historic fire intensities to burn. For ponderosa pine habitat, effects to herpetofauna would be the same as Alternative 1 since the same amount of this habitat type would be treated in both alternatives, and it is believed fire would burn the same (mainly surface with patches of unburned, low, and low/moderate fire severity). Maintaining ecosystem processes in ponderosa pine stands is expected to provide long-term, local, minor to moderate beneficial impacts.

For herpetofauna using mesic habitats (Arizona tiger salamander, Rocky Mountain toad, canyon tree frog, Great Basin spadefoot toad, turtles), fire treatments impacts would likely be indirect, minor to moderate, short- to long-term adverse effects related to habitat modification. There would be minor, local, direct, adverse impact of mortality due to fire and/or non-fire treatment for mesic habitat herpetofauna.

For herpetofauna that prefer open, early successional habitats (northern sagebrush lizard, northern plateau lizard), fire treatment would likely have indirect, local, minor to moderate, beneficial effects. Because higher severity burns would create patches of openings in mixed-conifer and spruce-fir, there would likely be more open understory. There could be a negligible short-term local adverse effect by making herpetofauna more available to predation. There would be a negligible, local, direct, adverse impact of mortality due to fire and/or non-fire treatment since these species can enter burrows and hide beneath soil under rocks.

Where suppression fire is assumed in both mixed-conifer and spruce-fir, adverse impacts would occur due to expected higher burn severity. Patch size and distribution will determine impacts to different species where greater openings of early successional plant species will benefit some species while adversely affecting species dependent on later seral vegetation stages/species. Alternative 2's proposed treatments are expected to have local, long-term minor to moderate beneficial impacts to early seral vegetation dependent herpetofauna; and local, long-term, minor to moderate adverse impacts to late seral vegetation dependent herpetofauna.

Non-fire treatments in forest habitats would likely have local, short-term negligible, direct adverse effects of mortality on all herpetofauna because species would likely have time to avoid physical disturbance.

Direct and Indirect Effects Alternative 2 Wildlife Birds

Impacts to all bird species that use ponderosa pine would have the same effects as described in Alternative 1 since areas treated in ponderosa pine habitat would be the same. Impacts (both beneficial and adverse) would be local, short term, and negligible.

Proposed fire treatments would better simulate natural fire regimes for these vegetation types. Impacts to most raptor species would be similar to those in 4.2.5.13 and 4.2.5.16 for American peregrine falcons, bald eagles, and Swainson's hawks. These species use openings for foraging; therefore, local, indirect, short- to long-term impacts would be beneficial with minor to moderate intensity. In suppression fire areas (18% assumed in mixed-conifer; 36% in spruce-fir) where moderate/high to high burn severity occurs, impacts to species would be local, beneficial, long term, minor to moderate from forest opening creation.

Alternative 2 would initially reduce existing snags, but increase snag numbers the first few years after fire activity in both mixed-conifer and spruce-fir habitats, when compared to Alternative 1. This would have initial adverse effects to both cavity and secondary cavity nesters due to habitat modification (snags), but over time, habitat would increase with new snags. The effect would be local, minor to moderate, long term and beneficial. Depending on size of high burn severity patches, snag recruitment could decrease in these areas over the long term. Long-term effects would be local, minor and adverse.

Birds that inhabit understory vegetation and ground cover (hermit thrush, mountain chickadee, dark-eyed junco, blue grouse) would be adversely affected in mixed-conifer and spruce-fir habitats. Amount of ground cover removed with fire would be equal to or greater than Alternative 1. Adverse effects could be local, minor, and short term since woody debris from burned patches would start to accumulate immediately. The proposed mitigation measure of reassessing fire treatment in mixed-conifer could reduce amount of ground cover removed by fire if reassessment ceases or decreases fire treatment in this vegetation type; therefore, decreasing adverse effects on these bird species in that habitat.

Impacts to birds that prefer high tree density and multiple layered stands (pygmy owl) would be affected the same as addressed for MSO (4.2.5.13 and 4.2.5.16). Impacts would be local, indirect, adverse, and moderate. The mitigation measure proposed to reassess fire treatment in mixed-conifer habitat could decrease adverse effect in that habitat type if reassessment ceases or decreases fire treatment in the vegetation type.

All birds would be directly and indirectly affected by suppression fires in mixed-conifer and spruce-fir habitat types. Those that prefer open forest stands (most raptors) would receive minor beneficial impacts short to long term, and local due to the relatively high amount of moderate/high to high severity areas (40-70%) as long as prey return. Cavity nesters would likely have negligible, short-term beneficial impacts (by having a larger insect prey source in dead and dying trees), and secondary cavity nesters would likely have negligible, local, short-term adverse impacts immediately after the fire (with snag removal); negligible to minor, local, long-term beneficial impacts with snag build-up for several years after the fire; and negligible local adverse impacts should there be a decrease in large trees to recruit snags in the long term. Ground-dwelling birds (e.g. blue grouse) would experience negligible, local, short- to long-term adverse impacts. Impact intensity would be dependent on size of higher severity burned areas. Birds needing high tree density would have minor to moderated local adverse impacts, short to long term. All bird species could be directly adversely affected by suppression fire due to mortality and displacement. This would be more pronounced if suppression fires occur during nesting season.

Non-fire treatments would have direct, local, short-term, negligible adverse impact to species, depending on treatment season. Adverse effects would be greatest if treatment occurs during breeding season in occupied habitat and negligible if treatments occur in unoccupied habitat. Long-term, local, negligible impacts would likely be beneficial to all species by decreasing potential for large, high severity suppression fires in these areas.

Direct and Indirect Effects　　Alternative 2　　Wildlife
Bats

Treatment in ponderosa pine habitat would be the same as Alternative 1. Bats that prefer ponderosa pine habitat would benefit from this alternative. Ponderosa pine habitat roosting areas would not likely be affected and mortality would be a negligible, short-term, local adverse impact. Bats that prefer openings to forage would receive local, long-term negligible, beneficial impacts from treatment.

Bats that inhabit mixed-conifer and spruce-fir vegetation types and prefer openings to forage would benefit from Alternative 2. This beneficial impact would be local, indirect, minor to moderate long term. Bats that roost in trees and prefer moderate canopy cover would be adversely impacted by treatments. Adverse impacts would be local, minor to moderate, short to long term.

Long-term local beneficial impacts would occur to all species by maintaining ecosystem processes that produce complex habitats over time, and that protect habitats over time from large scale stand-replacement fires. Suppression fire impacts would be the same as Alternative 1. Bats that prefer open areas and forest edges could have local, minor to moderate, short- to long-term beneficial impacts from expected results following suppression fires in mixed-conifer and spruce-fir habitat, depending on size and amount of high severity patches post-disturbance. Prey species could become more available by opening foraging areas, but there would be a short-term delay in species availability. Bats that prefer moderate canopy cover and use forest canopy or tree roost sites would likely be adversely affected by suppression fires in mixed-conifer and spruce-fir habitats. Impacts would depend on burn severity mosaics and would range from minor to moderate, short to long term and be local.

Direct and Indirect Effects **Alternative 2** **Wildlife**
Small Mammals

Small mammals that inhabit ponderosa pine vegetation type would have similar impacts as Alternative 1. Adverse impacts to species would be negligible to minor, local and short term by removing some forest floor woody debris habitat. Small mammals that forage on grasses and forbs would receive local, short-term, negligible, adverse impacts but would receive negligible to minor, local, long-term, beneficial effects soon after with new grass and forb components covering a larger area. Small mammals that prefer open areas and forest edges would likely have negligible to minor, local, short- to long-term, beneficial impacts from treatment in ponderosa pine habitat.

Small mammals that inhabit mixed-conifer and spruce-fir vegetation types would experience more open tree canopies, forest openings, and greater forest edge extent due to larger percentage of burned patches created by mixed severity burning proposed with this alternative. Small mammal species that forage in grasses and forbs, and those that prefer openings and forest edges would have beneficial, negligible to minor, local, long-term effects from fires. Small mammal species that prefer complex understory habitats with sufficient quantities of woody debris creating habitat niches will have local, negligible to minor adverse impacts short term. Woody debris will accumulate quickly in burned patches.

Suppression fires in mixed-conifer and spruce-fir result in short-term population reductions in burned patches due to habitat loss. Depending on size and extent of high severity burned areas, a decrease in populations would likely be short-term, local, negligible to minor adverse impact since most small mammals have multiple breeding seasons with high reproductive potential.

Direct and Indirect Effects **Alternative 2** **Wildlife**
Carnivores

Impacts to carnivores would be the same as Alternative 1 for ponderosa pine habitat. Direct, adverse impacts would be negligible, local and short term due to habitat disturbance. A slight increase in prey species is expected (e.g. voles, chipmunks), and would reflect a negligible to minor, local, beneficial impact to carnivore populations.

In mixed-conifer and spruce-fir habitat types, carnivores would be at slightly higher risk for direct adverse impacts from displacement due to expected habitat modifications from proposed treatments. Adverse impacts would likely be negligible and local, and would have the most noticeable effect during mating and birthing seasons in occupied habitat. More open stands and forest openings after fire treatments would also make prey more vulnerable (visible), which would have beneficial short- to long-term impacts to carnivore species that forage in these habitat types. Impacts would likely be local and minor to moderate.

Long-tailed weasels prefer open brushy or grassy areas. Fire treatments in mixed-conifer and spruce-fir vegetation types would provide more open stands and openings, benefiting weasel habitat. Beneficial effects to long-tailed weasels would be local, long term, minor to moderate.

Impacts from suppression fires would be the same as Alternative 1. High severity burn patches would initially reduce prey populations in mixed-conifer and spruce-fir vegetation types. Adverse impacts would be local, minor to moderate, short term.

Direct and Indirect Effects **Alternative 2** **Wildlife**
Ungulates

Impacts to ungulates (e.g. deer, elk) in ponderosa pine habitat would be the same as Alternative 1. Direct adverse impacts due to displacement would be local, short term and negligible from proposed treatments in this habitat type. Due to habitat maintenance and restoration, beneficial impacts to ungulates would be local, moderate and long term.

Non-fire treatments would occur in ponderosa pine and piñon-juniper vegetation types. Direct, local, short-term negligible adverse impacts would be due to displacement during treatment activities. Short- to long-term, local, negligible beneficial impacts would occur from habitat modifications that provide long-term stand resilience.

Depending on burned patch size and location, fire treatments in mixed-conifer and spruce-fir vegetation that create small and medium-sized patches could have beneficial effects to ungulates. Fire treatments would open stands and provide more forest edge. If this were to occur, beneficial impacts would be local, long term minor to moderate.

Suppression fires in mixed-conifer and spruce-fir vegetation types could have short-term negligible local adverse impacts due to initial habitat alteration. Depending on high severity patch size and extent, long-term impacts may be negligible to minor, local beneficial due to increased foraging habitat. Moderate/high to high burn severity patches may favor elk habitat over deer habitat.

Mitigation of Effects — Alternative 2 — Wildlife

Mitigation measures incorporated into alternative descriptions will decrease adverse impacts related to wildlife. None of the adverse impacts in Alternative 2 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased.

Cumulative Effects — Alternative 2 — Wildlife

Cumulative impacts would be similar to Alternative 1 except higher burn severities in mixed-conifer and spruce-fir habitat would have greater potential for habitat disturbance and alteration. These impacts would vary in duration and intensity in different habitat types and for different affected species, but would be mainly local in effect. Cumulative impacts to wildlife would be negligible to moderate, depending on disturbance timing. Compared to Alternative 1, Alternative 2 would reduce hazardous fuel levels and restore more desired vegetation conditions and historic fire regimes to a larger area over the life of the plan. Thus Alternative 2 would have a greater long-term, beneficial cumulative effect on wildlife species than Alternative 1 by further decreasing risk of large, high severity suppression fires that could adversely impact wildlife species through long-term habitat alteration.

Conclusion — Alternative 2 — Wildlife

Alternative 2 has similar treatment acres and type as Alternative 1, but a greater latitude to mimic historic fire regimes in mixed-conifer and spruce-fir vegetation types, and a larger amount of proposed non-fire treatment. Of these differences, potential for higher burn severities in mixed-conifer and spruce-fir produces the greatest change in effects between the two alternatives. Impacts increase in intensity (both beneficial and adverse) in mixed-conifer and spruce-fir habitat types. Impacts from Alternative 2 include both short- to long-term effects. As noted in cumulative effect, because there is more mixed severity allowed in mixed-conifer and spruce-fir; risk of large, high severity suppression fires is further reduced with this alternative (when compared with Alternative 1). Stands would be more open, would have less fuel continuity and accumulation, and would be more resilient to environmental stressors. This alternative would be more in line with the historic fire regimes for GRCA habitat types.

Impairment — Alternative 2 — Wildlife

Since are no major adverse impacts in Alternative 2 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair wildlife during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Wildlife**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wildlife as a result of Alterative 2 implementation.

4.2.4.12 Alternative 3 Non-Fire Treatment Emphasis Wildlife

Alternative 3 would change the existing direction of GRCA's fire management program toward inclusion of a larger mechanical/manual treatment component along with prescribed fire (mainly on South Rim) and suppression programs. There would be approximately 4,000 acres of non-fire treatment; 25,400 acres of prescribed fire treatment; 8,800 acres of wildland fire use; and an estimated 26,070 acres of suppression. There is an expected increase of suppression activities of approximately 6,000 acres above Alternatives 1 and 2. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 3** **Wildlife**
Invertebrates

After proposed treatments occur in the ponderosa pine vegetation type, effects to invertebrates in treated stands would have negligible to minor, local, short-term adverse impacts from direct mortality and habitat modification. After one to three years, there would be negligible to minor, local beneficial impacts to invertebrates where populations would likely return to pre-treatment levels with greater diversity and composition. The majority of this habitat type would not receive treatment, and proposed treatments are located on South Rim. The majority of this vegetation type is within the natural range of variability for the fire regime, and proposed treatments are designed to reduce expected fire behavior; therefore, impacts to invertebrates inhabiting this vegetation type would be negligible.

12% of mixed-conifer and 15% of spruce-fir vegetation types would receive prescribed fire; it is assumed little to no treatment would occur from wildland fire use in this alternative. For areas treated, impacts would be local short term negligible adverse, and local long term minor beneficial. Insect diversity and abundance would likely increase immediately after fire. Long-term stand densities would be reduced in treated sites; however, proposed treated areas are small.

Of all the alternatives, Alternative 3 has the highest risk of large, high severity fires occurring in mixed-conifer (24%) and spruce-fir (46%) vegetation types. It is expected that larger burned patches will occur in all vegetation types over time under this alternative. In the long term, depending on burn severity, stands would be thinned and more resilient to environmental stressors. Recently killed trees would provide habitat and encourage population growth of certain insect species. Invertebrates that use tree canopy habitats would receive adverse population effects due to habitat alteration.

Direct and Indirect Effects **Alternative 3** **Wildlife**
Herpetofauna **Vertebrates**

Focused treatment areas are in and around South Rim WUI. Approximately one third of ponderosa pine would be treated (fire and non-fire treatments). Impacts to herpetofauna in ponderosa pine habitat would be the same as Alternatives 1 and 2, but at a much smaller scale, and would only affect South Rim species.

12% of mixed-conifer and 15% of spruce-fir are proposed for fire treatment. Herpetofauna using mesic habitats in mixed-conifer and spruce-fir would not be affected by proposed treatments.

For herpetofauna that prefer open, early successional habitats (northern sagebrush lizard, northern plateau lizard, Great Basin gopher snake) treatment would likely have indirect, local, minor to moderate, beneficial effects. There could be a local, negligible, short-term adverse effect by making them more available to predation. There would be a negligible, direct, adverse impact of mortality due to fire and/or non-fire treatment since these species can enter burrows and hide beneath soil under rocks.

Suppression tactics and strategies would be primary fire management under this alternative. Herpetofauna that use mesic habitat would be adversely affected; effects would likely be minor to moderate, local, long term through preferred habitat modification. Herpetofauna that prefer early succession habitat, would likely have more habitat area available, but with more open areas they would initially be more vulnerable to predation. Impacts would be short term local negligible adverse, and long term local minor to moderate beneficial.

Non-fire treatments in ponderosa pine, piñon-juniper, and mixed-conifer habitats would likely have negligible direct mortality effects on all herpetofauna because species would likely have time to avoid physical disturbance. GRCA proposes a mix of fuel treatment (removing larger pieces to leaving masticated slash onsite). Openings created through non-fire treatments would be small but more controlled than with fire. Depending on species type, there would be beneficial and adverse effects, but likely both would have local, short-term, negligible effects on species.

Direct and Indirect Effects Alternative 3 Wildlife
Birds

The majority of treatment in this alternative would be located on South Rim in ponderosa pine habitat. On North Rim, 12% of mixed-conifer and 15% of spruce-fir are proposed for fire treatment. Impacts to all species would be the same as in Alternative 2, but acres affected by proposed treatments would be considerably less.

Suppression fire acres would be the highest among all alternatives. Effects to spruce-fir bird habitats would have the greatest effect since 46% would burn as suppression fire, and 40-70% of those acres are predicted to burn as moderate/high to high severity. All birds would be directly and indirectly affected by suppression fires in mixed-conifer and spruce-fir habitat types. Those that prefer open forest stands (most raptors) would receive minor beneficial impacts short to long term, local due to the relatively high amount of moderate/high to high severity areas (40-70%) as long as prey return. Cavity nesters would likely have negligible, short-term beneficial impacts (by having a larger insect prey source in dead and dying trees), and secondary cavity nesters would likely have negligible, local, short-term adverse impacts immediately after fire (with snag removal); negligible to minor, local, long-term beneficial impacts with snag build-up for several years after fire; and, negligible local adverse impacts should there be a decrease in large trees to recruit snags long term. Ground-dwelling birds (e.g. blue grouse) would experience negligible, local short- to long-term adverse impacts. Impact intensity would depend on size of higher severity burned areas. Birds needing high tree density would have minor to moderately local adverse impacts, short to long term. All bird species could be directly adversely affected by suppression fire due to mortality and displacement. This would be more pronounced if suppression fires occur during nesting.

This alternative affects the largest acreage with non-fire treatment. As was noted in Alternative 2, non-fire treatments would have direct, short-term, negligible adverse impact to species. Long term, impacts would likely be local, negligible beneficial to all species by slightly decreasing potential for large, high severity suppression fires in treated areas.

Direct and Indirect Effects Alternative 3 Wildlife
Bats

Impacts to bat habitats from proposed treatments in Alternative 3 would affect considerably fewer acres. Because of low treatment acres, risk for large, high severity suppression fires is high. This would be especially true in mixed-conifer and spruce-fir habitat types.

Adverse impacts from proposed treatments would be indirect, negligible local due to disturbance during treatment activities. Long-term beneficial impacts from reduced fire risk would be local and negligible.

Bats that prefer open areas and forest edges could have local, minor to moderate, short- to long-term beneficial impacts from expected results following suppression fires in mixed-conifer and spruce-fir habitats, depending on size and amount of high burn severity patches post-disturbance. Prey species could become more available by opening foraging areas, but there would be a short-term delay in species availability. Bats that prefer moderate canopy cover and use forest canopy or tree roost sites would likely be adversely affected by suppression fires in mixed-conifer and spruce-fir habitats. Impacts would depend on burn severity mosaics and would range from minor to moderate, short to long term and local.

Direct and Indirect Effects **Alternative 3** **Wildlife**
Small Mammals

Impacts to small mammals from Alternative 3 would be similar to Alternative 2, but affect fewer acres.

Those areas treated with fire in ponderosa pine would likely have negligible, local, long-term, adverse effects to small mammals that inhabit forest-floor woody debris (deer mice); negligible, local, short-term adverse effects to small mammals that forage on grasses and forbs (Botta pocket gopher); and long-term, negligible, local, beneficial effects to small mammals that forage on grasses and forbs (Botta pocket gopher) and species that prefer openings and forest edges (Uinta chipmunk). Impacts would occur on South Rim. Negligible effects would occur on North Rim in ponderosa pine habitat.

Species that inhabit mixed-conifer and/or spruce-fir would receive local, short-term, minor to moderate beneficial effects if they forage on grasses and forbs (Botta pocket gopher); local, long-term, minor to moderate, beneficial effects if they prefer openings and forest edges (Uinta chipmunk); and local, long-term, minor to moderate, adverse effects if their habitat is woody debris (deer mice).

Suppression fires, especially in mixed-conifer (24% assumed would burn as suppression fire) and spruce-fir (46% assumed would burn as suppression fire), could have direct adverse effects to small mammals due to mortality (fast-moving fire) and stress. Depending on size and extent of high severity patches, population decrease would likely be local short term since most small mammals have multiple breeding seasons with high reproductive potential. Impacts from suppression fires are likely to result in local short-term negligible adverse impacts from direct mortality and habitat modification, and local long-term negligible to minor beneficial impacts from habitat modification.

Direct and Indirect Effects **Alternative 3** **Wildlife**
Carnivores

Impacts to carnivore species from proposed treatments would be similar to Alternative 2, except affected acreage would be less. In ponderosa pine habitat, direct local short-term adverse impacts (mortality) would be negligible. Due to slight increases in prey populations resulting from proposed treatments, there would be local negligible to minor beneficial impacts. Beneficial impacts to badgers, due to an increase in prey, would likely be negligible to minor on South Rim. There would be negligible beneficial or adverse impacts to badger habitat. Since little to no treatment is proposed in ponderosa pine on North Rim, effects to wildlife would be negligible.

Because of the little amount of proposed fire treatment in mixed-conifer (12%) and spruce-fir (15%), direct adverse impacts would be very local and negligible. More open forest stands after fire treatments would make prey more vulnerable (visible), which would have beneficial short- to long-term local and minor to moderate impacts to carnivore species that forage in these habitat types.

Long-tailed weasels prefer open brushy or grassy areas. Fire treatments in mixed-conifer and spruce-fir vegetation types would provide more open stands and openings, benefiting weasel habitat. Beneficial effect would be local long term negligible to minor.

The greatest affect to carnivores would be from suppression fires in mixed-conifer (24%) and spruce-fir (46%) habitats. As noted earlier 40-70% of these habitat types would burn at moderate/high to high severity. High severity patches would initially reduce prey populations in mixed-conifer and spruce-fir vegetation types. Adverse impacts would be local minor to moderate short term. Long-term beneficial impacts from habitat modifications would be local minor to moderate.

Direct and Indirect Effects — Alternative 3 — Wildlife
Ungulates

Impact to ungulates in ponderosa pine habitat would be the same as Alternative 1 but to a far lesser degree. At most, only 35% of this habitat would be treated, with most treatment occurring on South Rim. Because of treatment amount, direct adverse impacts due to mortality and displacement would be less than Alternatives 1 and 2, and negligible. Ungulates would receive local minor beneficial effects on South Rim and negligible effects on North Rim in this habitat type.

Direct adverse impacts from non-fire treatment would be due to displacement during treatment activities. Indirect adverse impacts would occur where slash remains onsite covering forage areas. Areas where grass and forbs are allowed to quickly return would have beneficial effects. All effects (beneficial and adverse) due to non-fire treatments would be local short term negligible.

Depending on burned patch size, fire treatments in mixed-conifer and spruce-fir vegetation types could have beneficial effects to ungulates. Fire treatments would open stands and produce more forest edge, but proposed treatments in Alternative 3 are limited in size and extent. Beneficial impacts would be local negligible to minor.

Suppression fires in mixed-conifer (24%) and spruce-fir (46%) could have adverse impacts to ungulates due to amount of high severity expected. These species could be directly adversely affected due to displacement. Impact from direct effects would be greatest with this alternative, but would likely be local negligible to minor. Depending on burned patch size in mixed-conifer and spruce-fir habitats, impacts to foraging habitats could be local short to long term minor to moderate beneficial.

Mitigation of Effects — Alternative 3 — Wildlife

Mitigation measures will decrease adverse impacts related to wildlife. None of the adverse impacts in Alternative 3 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased.

Cumulative Effects — Alternative 3 — Wildlife

Cumulative impacts would be similar to those described under Alternative 2, except addition of mechanical fuels reduction treatments may slightly increase potential for disturbance and alteration of habitats used by wildlife species in WUI areas. These impacts would vary in duration and intensity in different habitat types and for different affected species, but would mainly be local in effect. Compared to Alternative 2, addition of mechanical fuels reduction treatments in WUI areas reduce hazardous fuel levels; however, reduced acreages of prescribed and wildland fire-use projects would result in reduction of approximately 50% in beneficial long-term effects. Thus, Alternative 3 would have a reduced long-term beneficial cumulative effect on wildlife species through risk reduction for large, high severity suppression fires when compared with other alternatives.

Conclusion **Alternative 3** **Wildlife**

Alternative 3 focuses treatment on South Rim with minimal North Rim treatments. Impacts to treated areas would be similar to Alternative 2 but amount would be dramatically reduced (except for non-fire treatment). North Rim would be at higher risk, when compared with other alternatives, for large high severity fires. This alternative has the least beneficial effects to wildlife both short to long term, and due to heightened risk for large, high severity fires, Alternative 3 has the greatest potential for indirect adverse effects, both short to long term. Should large, high severity fires occur, adverse impact would likely be short to long term local minor to moderate.

Impairment **Alternative 3** **Wildlife**

Since are no major adverse impacts in Alternative 3 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair wildlife during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Wildlife**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wildlife as a result of Alterative 3 implementation.

4.2.4.13 Alternative 4 Prescribed Fire Emphasis Wildlife

Alternative 4 would change the existing direction of GRCA's fire management program by notably expanding prescribed fire amount. There would be approximately 800 acres of non-fire treatment; 90,000 acres of prescribed fire; 5,500 acres of wildlife fire use; and 24,070 acres of suppression over the planning period. This is a substantial increase in number of prescribed fire treatment acres from historical averages. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 4** **Wildlife**
Invertebrates

Effects to invertebrates in ponderosa pine vegetation from proposed treatments would be the same as other alternatives: negligible local adverse impacts from direct mortality and initial habitat modification but, after one to three years. There would be minor to moderate local beneficial impacts to invertebrates where populations would likely return to pre-treatment levels with greater diversity and complexity. Very little impact is expected to ponderosa pine tree crowns; therefore, negligible effects would occur to invertebrates that use ponderosa pine tree canopy as habitat.

This alternative proposes 62% of mixed-conifer and 27% of spruce-fir treated through prescribed fire. This alternative is predicted to more closely simulate historic mixed severity fire regime. Stressed trees in burned stands would be vulnerable to insect attack, but surviving trees in the stand would, long term, be more resilient to environmental disturbances due to lower tree densities. In spruce-fir vegetation, tree density reduction from fire could also reduce risk of future insect outbreaks. It is expected there will be increased invertebrate species richness, composition, and diversity in the long term, depending on post-disturbance vegetation response. Impacts to invertebrates from Alternative 4 would be local short term negligible adverse, and local long term minor to moderate beneficial.

Even with the amount of prescribed fire proposed, Alternative 4 has the second highest level of assumed suppression fire. It is expected that larger burned patches will occur in all vegetation types over time under this alternative. In the long term, depending on burn severity, stands would be thinned and more resilient to environmental stressors, including insect outbreaks. Recently killed trees would provide insect habitat and would encourage population growth of certain species. Invertebrates that use tree canopy habitats would receive adverse population effects due to habitat alteration. Overall, impacts to invertebrates would reflect short-term local minor adverse impacts due to direct mortality and habitat alteration; and long-term minor to moderate local beneficial impacts due to habitat alteration.

Direct and Indirect Effects **Alternative 4** **Wildlife**
Herpetofauna **Vertebrates**

Effects to herpetofauna in ponderosa pine would be the same for all alternatives because it is assumed all fires burned would result in patches of unburned, low, and low/moderate severity; small acres in ponderosa pine may reflect moderate/high to high severity, but these patches would be limited.

Alternative 4 proposes the second lowest treatment amount in this vegetation type when compared with all alternatives. Mixed-conifer habitat would receive about the same treatment amount as Alternative 2 (over 60%), and spruce-fir habitat would receive most treatment (27%) compared with other alternatives.

Herpetofauna that use mesic habitat (Arizona tiger salamander, Rocky Mountain toad, canyon tree frog, Great Basin spadefoot toad, turtles) would be adversely affected by fire and non-fire treatments that decrease forest floor woody debris and open stands to sunlight. Impacts would be similar to Alternative 2. Proposed fire treatments would likely cause local negligible to minor adverse effects to habitat. Herpetofauna that prefer open, early successional habitats (northern sagebrush lizard, northern plateau lizard, Great Basin gopher snake), would likely have indirect local minor to moderate beneficial effects to habitat; and local short-term negligible adverse effects by making them more available to predation.

Alternative 4 proposes the second lowest amount of non-fire treatment when compared with other alternatives. As with all the alternatives, where treatment occurs there would likely be negligible direct mortality effects on all herpetofauna because species would likely have time to avoid physical disturbance. A mix of fuel treatment (removing larger pieces to leaving masticated slash on site) is proposed. Vegetation opening size and distribution could be more controlled than with fire. Depending on the species, there would be local short and long-term beneficial and adverse effects, but both would likely have negligible effect on the species.

Direct and Indirect Effects **Alternative 4** **Wildlife**
Birds

Treatment (mainly through prescribed fire) would be located throughout North and South Rims in all forest habitat types. As noted earlier, 62% of mixed-conifer and 27% of spruce-fir are proposed for prescribed fire treatment. Impacts to all bird species would be the same noted in Alternative 2, but acres affected may vary. Alternative 4 proposes the second lowest treatment amount in ponderosa pine (63%); similar amount as Alternative 2 in mixed-conifer habitat (62%); and, the most treatment proposed in spruce-fir (27%) and piñon-pine (9%).

This alternative treats the second least acreage from non-fire treatment. Long term, impacts would likely be beneficial to all bird species by slightly decreasing potential for large, high severity suppression fires in these areas. Impacts would be local short term negligible beneficial.

Suppression fire would be the second highest among all alternatives. All birds would be directly and indirectly affected by suppression fires in mixed-conifer and spruce-fir habitat types. Those that prefer open forest stands (most raptors) would receive minor beneficial impacts short to long term local due to the relatively high amount of moderate/high to high severity areas (40-70%) as long as prey return. Cavity nesters would likely have negligible short-term beneficial impacts (by having a larger insect prey source in dead and dying trees), and secondary cavity nesters would likely have negligible local short-term adverse impacts immediately after fire (with snag removal); negligible to minor local long-term beneficial impacts with snag build-up for several years after fire; and negligible local adverse impacts should there be a decrease in large trees to recruit snags long term. Ground-dwelling birds (e.g. blue grouse) would experience negligible local short- to long-term adverse impacts. Impact intensity would depend on high severity area size. Birds needing high tree density would have minor to moderate local adverse impacts, short to long term. All bird species could be directly adversely affected by suppression fire due to mortality and displacement; more pronounced if suppression fires occur during nesting season.

Direct and Indirect Effects Alternative 4 Wildlife
Bats

Treatment in ponderosa pine habitat would be the same as Alternatives 1 and 2 but would affect fewer acres. Ponderosa pine habitat roosting areas would not likely be affected; and mortality would be negligible. Impacts would be local short to long term negligible beneficial. Bats that prefer forest openings would receive local negligible short-term beneficial effects from treatments in this habitat type.

Bats that inhabit mixed-conifer and spruce-fir vegetation and prefer openings to forage would benefit from proposed treatments and have the same effects as Alternative 2 with a higher acreage affected in spruce-fir habitat. This beneficial impact would be local indirect minor to moderate long term. Bats that prefer moderate canopy cover would be adversely affected in treatment areas in these two habitat types. They may also initially loose roosting sites. Local adverse direct impacts due to mortality could occur for forest dwelling bats in these two habitat types. Impacts would be local short to long term negligible to minor adverse. The mitigation measure to reassess fire treatments in mixed-conifer vegetation type could reduce these effects should reassessment cease or decrease fire treatment amount in this vegetation type.

Bats that prefer open areas and forest edges could have local minor to moderate short- to long-term beneficial impacts from expected results following suppression fires in mixed-conifer and spruce-fir habitats, depending on size and amount of high severity patches post-disturbance. Prey species could become more available by opening foraging areas, but there would be a short-term delay in species availability. Bats that prefer moderate canopy cover and use forest canopy or tree roost sites would likely be adversely affected by suppression fires in mixed-conifer and spruce-fir habitats. Impacts would depend on burn severity mosaics and would range from minor to moderate, short to long term, local.

Direct and Indirect Effects Alternative 4 Wildlife
Small Mammals

Impacts to small mammals from implementation of Alternative 4 would be similar to Alternative 2, but would affect fewer acres in ponderosa pine, similar acres as mixed-conifer, and more acres in spruce-fir. Those areas treated in ponderosa pine would likely have negligible local long-term adverse effects to small mammals that inhabit woody debris (deer mice); negligible local initial adverse effects to small mammals that forage on grasses and forbs (Botta pocket gopher); long-term negligible local beneficial effects to small mammals that forage on grasses and forbs (Botta pocket gopher) and those species that prefer openings and forest edges (Uinta chipmunk).

Species that inhabit mixed-conifer and/or spruce-fir would receive local short-term minor to moderate beneficial effects if they forage on grasses and forbs (Botta pocket gopher); local long-term minor to moderate beneficial effects if they prefer openings and forest edges (Uinta chipmunk); and, local short-term negligible to minor adverse effects if their habitat is forest floor woody debris (deer mice).

As with all alternatives, suppression fires, especially in mixed-conifer (22% assumed would burn as suppression fire) and spruce-fir (43% assumed would burn as suppression fire) could have direct adverse effects to these small mammals due to mortality (fast-moving fire) and stress. Depending on size and extent of high severity burned patches, a population decrease would likely be short term, since most small mammals have multiple breeding seasons with high reproductive potential. Impacts from suppression fires are likely to result in local short-term negligible adverse impacts from direct mortality and habitat modification and local long-term negligible to minor beneficial impacts from habitat modification.

Direct and Indirect Effects Alternative 4 Wildlife
Carnivores

In Alternative 4, fire treatment in ponderosa pine would be the same as Alternative 1 and 2, but to a lesser extent (63%); direct local short-term adverse impacts would be negligible. Due to increased prey populations (deer, voles, chipmunks), there would be local long-term minor to moderate beneficial effects. Beneficial impacts to badgers, due to an increase in prey populations, would likely be local long term minor to moderate. There would be local short-term negligible adverse affect to badger habitat.

Impacts to carnivores in mixed-conifer and spruce-fir would be comparable to Alternative 2. In mixed-conifer and spruce-fir habitat types, carnivores would receive local short-term negligible direct adverse effect from mortality and displacement, and would have the most noticeable effect during breeding season in occupied habitat. More open stands and openings after fire treatments would also make prey more vulnerable (visible), which would have beneficial short- to long-term impacts to carnivore species that forage in these habitat types. Beneficial impacts would likely be local minor to moderate. Long-tailed weasels prefer open brushy or grassy areas. Fire treatments in mixed-conifer and spruce-fir vegetation types would provide more open stands and openings, benefiting weasel habitat. Beneficial effects to long-tailed weasels would be local long term minor to moderate.

Impacts from suppression fires would be the same as all alternatives. High severity burn patches would initially reduce prey populations in mixed-conifer and spruce-fir vegetation types. Adverse impacts would be short term local minor to moderate.

Direct and Indirect Effects Alternative 4 Wildlife
Ungulates

Impact to ungulates (mule deer, elk) in ponderosa pine habitat would be the same as Alternatives 1 and 2, but to a lesser degree (63% would be treated). Direct initial adverse impacts due to displacement would be local short term negligible from proposed treatment impacts to habitat. Due to habitat maintenance and restoration, beneficial impacts to ungulates would be local moderate long term.

Depending on burned-patch size and location, fire treatments in mixed-conifer and spruce-fir vegetation types could have beneficial effects to ungulates. Fire treatments would open stands and provide more forest edge. If this were to occur, beneficial impacts would be local long term minor.

Suppression fires in mixed-conifer and spruce-fir could have adverse impacts to ungulates due to amount of high severity burn expected. These species could be directly adversely affected due to displacement. Impacts would be local, short term, and negligible to minor. Depending on burn-patch size in mixed-conifer and spruce-fir habitats, impacts to foraging habitats could be local, short to long term, minor to moderate beneficial. Burn severity patches may favor elk over deer habitat.

Mitigation of Effects Alternative 4 Wildlife

Mitigation measures incorporated will decrease adverse impacts related to wildlife. None of the adverse impacts in Alternative 4 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased.

Cumulative Effects **Alternative 4** **Wildlife**

Overall, cumulative effects would not differ from Alternative 1. Mixed-conifer and spruce-fir vegetation types would likely result in higher burn severity, but if proposed mitigation measures are implemented, adverse impacts would be lessened.

Conclusion **Alternative 4** **Wildlife**

Alternative 4 focuses on prescribed fire. Effects to wildlife would be minimal; however, non-treated portions of vegetation types would trend away from historic fire regimes and desired conditions, and more vulnerable to future high severity fires.

Mixed-conifer and spruce-fir habitat types receive the greatest amount of fire treatment when compared with other alternatives. Should treatments occur, the trend would be closer to historic mixed severity fire regimes and would likely produce beneficial effects to wildlife as a whole.

This alternative assumes the second highest amount of suppression fire. Impacts to wildlife that use mixed-conifer and spruce-fir habitat types would most likely be adversely affected. Impacts would be short to long term.

Impairment **Alternative 4** **Wildlife**

Since are no major adverse impacts in Alternative 4 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair wildlife during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Wildlife**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wildlife as a result of Alterative 4 implementation.

4.2.4.14 Alternative 5 Fire Use Emphasis Wildlife

Alternative 5 shifts the fire management program to restore and maintain forest types with wildland fire use (88,000 acres). With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. Prescribed fire treatments for this alternative are estimated at 29,900 acres. Mechanical/manual treatments would total approximately 2,675 acres and occur in WUI and along Highway 67 on North Rim. A description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Invertebrates

In Alternative 5, fire treatment amount in the ponderosa pine vegetation type would be the same as Alternatives 1 and 2 (approximately 70-100%). Effects to invertebrates that inhabit ponderosa pine vegetation type would be the same: negligible to minor, local, adverse impacts from direct mortality and habitat modification, but, after one to three years, there would be minor to moderate, local, long-term beneficial impacts to invertebrates where populations would likely return to pre-treatment levels with greater diversity and composition.

It is assumed approximately 71% of mixed-conifer and 16% of spruce-fir would receive some form of fire treatment. Effects to invertebrates in these treated areas would be the same as Alternatives 2-4; this alternative is predicted to produce complex forest structures reflecting mixed severity fire regimes. Stressed trees in burned stands would be vulnerable to insect attack, but surviving stand trees would, in the long term, be more resilient to environmental disturbances due to lower tree densities. In the spruce-fir vegetation type, reduction in tree density from fire could also reduce risk of future insect outbreaks. It is expected there will be increased species richness, composition, and diversity long term depending on post-disturbance vegetation response. Impacts to invertebrates from this alternative would be local short term negligible adverse, and local long term minor to moderate beneficial.

In Alternative 5, it is assumed the amount of suppression fires would be least. Similar to other alternatives, fire severity would be much higher than fire treatments in mixed-conifer (where 17% is assumed would burn) and spruce-fir (where 32% is assumed would burn). Higher burn severity would increase burned patch size and likely increase vegetation stress adjacent to high severity burned patches. Recently killed trees would provide prime habitat and encourage population growth of certain insect species.

Invertebrates that use tree canopy habitats would receive adverse population effects due to tree mortality. Negligible short-term local adverse effects are expected from fire suppression activities due to increased potential for habitat loss through high severity fire. Impacts to invertebrates from suppression fire are expected to be local short term negligible adverse, and local long term negligible to minor beneficial.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Herpetofauna **Vertebrates**

As noted earlier, effects to herpetofauna in ponderosa pine habitat would be the same for all alternatives because it is assumed these stands are within the range of variability for stand structure and resulting fire behavior which is predominantly low to mixed severity burn with only small percentage of acres of moderate/high to high severity burn. Impacts to herpetofauna in ponderosa pine habitat would be the same as Alternatives 1 and 2, since Alternative 5 would treat the majority of this habitat type (70-100%).

Mixed-conifer would receive the third lowest amount of fire treatment (less than 71%) and spruce-fir habitat would receive the second lowest amount of treatment (approximately 16% in spruce-fir).

As noted earlier, herpetofauna that use mesic habitat (Arizona tiger salamander, Rocky Mountain toad, canyon tree frog, Great Basin spadefoot toad, turtles) would be adversely affected by fire and non-fire treatments that decrease woody debris, and open stands to sunlight. Impacts would be similar to Alternative 2; impacts from fire treatments would likely be indirect, minor to moderate, short- and long term-adverse effects related to habitat modification. For herpetofauna that prefer open, early successional habitats (northern sagebrush lizard, northern plateau lizard, Great Basin gopher snake), fire treatment would likely have indirect, local, minor to moderate, beneficial effects. Higher burn severity patches would create openings in mixed-conifer and spruce-fir. There would likely be more open understory. There could be a negligible short-term local adverse impact by making them more available to predation. There would be a negligible, local, direct, adverse mortality impact due to fire since these species can enter burrows and hide beneath soil under rocks.

Alternative 5 proposes about the same non-fire treatment amount as Alternative 2 but includes treatment in the mixed-conifer vegetation type. As with all the alternatives, where treatment occurs there would likely be local, short-term, negligible direct mortality effects on all herpetofauna because the species would likely have time to avoid physical disturbance.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Birds

It is assumed for Alternative 5, a large amount of WFU would occur in ponderosa pine habitat. Impacts to all bird species that use ponderosa pine would be local short term negligible adverse beneficial.

This alternative would reflect natural fire regimes for these vegetation types. Impacts to most raptor species would be similar to that described in 4.2.5.13 and 4.2.5.19 for American peregrine falcons, bald eagles, and Swainson's hawks. These species use openings for foraging; therefore, local, indirect, short- to long-term impacts would be beneficial with minor to moderate intensity. This beneficial impact could be reduced in mixed-conifer habitat if mitigation measures to reassess fire treatments are approved, and reassessment ceases or decreases fire treatment amount in this vegetation type.

This alternative would initially reduce existing snags but increase snag numbers the first few years after fire activity in both mixed-conifer and spruce-fir habitats, having initial adverse effects to both cavity and secondary cavity nesters due to habitat modification (snags); but over time, habitat would increase with new snags. The effect would be local, minor to moderate, long term beneficial. Depending on high severity burn patch size, snag recruitment could decrease in these areas long term. Long-term effects would be local, minor, adverse. If the mitigation measure is approved to reassess fire treatment in mixed-conifer habitat, and reassessment ceases or decreases fire treatment in this vegetation type, all impacts (beneficial and adverse) would decrease in this habitat type.

Birds that inhabit understory vegetation and ground cover (hermit thrush, mountain chickadee, dark-eyed junco, blue grouse) would be adversely affected in mixed-conifer and spruce-fir habitats. Adverse effects could be local, negligible to minor, and short term since woody debris from burned patches would start to accumulate immediately. The proposed mitigation measure of reassessing fire treatment in mixed-conifer could reduce ground cover amount removed by fire if reassessment ceases or decreases fire treatment in this vegetation; therefore, decreasing adverse effects on these bird species in that habitat.

Impacts to birds that prefer high tree density and multiple layered stands (pygmy owl) would be affected the same as addressed for MSO (4.2.5.13 and 4.2.5.19). Impacts would be local, indirect, adverse, and minor to moderate. However, over time this alternative would provide complex habitats resilient to environmental stressors, ensuring long-term, local, minor to moderate beneficial impacts.
All birds would be directly and indirectly affected by suppression fires in mixed-conifer and spruce-fir habitat types. Those that prefer open forest stands (most raptors) would receive minor beneficial impacts short to long term local due to the relatively high amount of moderate/high to high severity areas, as long as prey return. Cavity nesters would likely have negligible short-term beneficial impacts (by having a larger insect prey source in dead and dying trees) and secondary cavity nesters would likely have negligible local short-term adverse impacts immediately after fire (with snag removal); negligible to minor local long-term beneficial impacts with snag build-up for several years after fire; negligible local adverse impacts should there be a decrease in large trees to recruit snags long term. Ground-dwelling birds (blue grouse) would experience negligible local short- to long-term adverse impacts. Impact intensity would be dependent on higher severity burned area size. Birds needing high tree density would have minor to moderate local adverse impacts short to long term. All bird species could be directly adversely affected by suppression fire due to mortality and displacement; more pronounced if during nesting.

Non-fire treatments would have direct local short-term negligible adverse impact to species depending on treatment season. Adverse effects would be greatest if treatment occurs during breeding in occupied habitat, and negligible if treatments occur in unoccupied habitat. Long-term local negligible impacts would likely be beneficial to all species by slightly decreasing potential for large, high severity fires.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Bats

Treatment in ponderosa pine habitat would be the same as Alternatives 1 and 2; therefore, effects in this habitat type would be the same. In ponderosa pine habitat, roosting areas would not likely be affected and mortality would be negligible. Bats that prefer openings to forage would receive short- to long-term, local, negligible, beneficial effects in ponderosa pine habitat.

Bats that inhabit mixed-conifer and spruce-fir vegetation types and prefer openings to forage would benefit from Alternative 5. This beneficial impact would be local indirect minor to moderate long term. Bats that prefer moderate canopy cover would be adversely affected in treatment areas in these two habitat types. They may also initially loose roosting sites. Local negligible adverse direct impacts due to mortality could occur for forest dwelling bats in these two habitat types. Alternative 5 proposes the second least amount of fire treatment in the spruce-fir habitat type.

Alternative 5 assumes the least suppression fires of all the alternatives. Impacts to bats would be the same as those noted earlier, but to a lesser extent.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Small Mammals

Impacts to small mammals from Alternative 5 would be similar to Alternative 2, and affect similar acres in ponderosa pine, fewer acres in mixed-conifer, and slightly fewer acres in spruce-fir.

As with Alternatives 1 and 2, Alternative 5 would likely treat the majority of the ponderosa pine habitat (70-100%) and would likely have negligible local short-term adverse effects to small mammals that inhabit woody debris (deer mice); negligible local short-term adverse effects to small mammals that forage on grasses and forbs (Botta pocket gopher); long-term negligible local beneficial effects to small mammals that forage on grasses and forbs (Botta pocket gopher) and those species that prefer openings and forest edges (Uinta chipmunk).

Species that inhabit mixed-conifer (71% proposed for fire treatment) and/or spruce-fir (16%) would receive local short-term minor to moderate beneficial effects if they forage on grasses and forbs (Botta pocket gopher); local long-term minor to moderate beneficial effects if they prefer openings and forest edges (Uinta chipmunk); local short-term minor to moderate adverse effects if their habitat is woody debris (deer mice).

As with all alternatives, suppression fires, especially in mixed-conifer (17% assumed would burn as suppression fire) and spruce-fir (32% assumed would burn as suppression fire) could have direct adverse effects to small mammals due to mortality. Depending on size and extent of high severity burned patches, a decrease in populations would likely be short term since most small mammals have multiple breeding seasons with high reproductive potential.

Direct and Indirect Effects **Alternative 5** **Wildlife**
Carnivores

Impacts to carnivores in ponderosa pine habitat would be the same as Alternatives 1 and 2. Direct, short-term, local adverse impacts from mortality and displacement would be negligible. Due to increased prey populations, there would be local, minor to moderate, beneficial effects. Beneficial impacts to badgers, due to increased prey populations, would likely be local, long term, and minor to moderate. There would be local, short-term, negligible adverse effects to their habitat.

Impacts in mixed-conifer would be similar (in effects) to Alternative 2 with fewer treated acres. Carnivores would have negligible, direct, short-term, adverse effects from mortality and displacement, and would have local, minor to moderate, indirect, short- to long-term beneficial effects due more open forest stands. The same would be true of spruce-fir and would involve slightly fewer acres (16%) than Alternative 2 (19%). As with the other alternatives, long-tailed weasels in mixed-conifer and spruce-fir treatment areas would see more open forest stands, which would benefit weasel habitat. Beneficial effects to weasels would be local, long term, and minor to moderate.

As with all alternatives, suppression fires would have local, short-term, negligible, direct adverse impacts due to mortality and displacement. High severity burn patches would initially reduce prey populations in mixed-conifer and spruce-fir habitats. Adverse impacts would be local, minor to moderate, and short term. Long-term beneficial impacts from habitat modifications would be local, minor to moderate.

Direct and Indirect Effects — Alternative 5 — Wildlife
Ungulates

Impacts to ungulates (mule deer, elk) in ponderosa pine habitat would be the same as Alternatives 1 and 2 both in acres and effects. Direct, short-term, adverse impacts due to mortality and displacement would be local and negligible.

Depending on burned area patch size and extent, fire treatments in mixed-conifer and spruce-fir vegetation types could have beneficial effects to ungulates. Fire treatments would open stands and provide more forest edge. Beneficial impacts would be local, long term, and minor to moderate.

Impacts from suppression fires would be the similar to Alternatives 1 and 2 but to a lesser degree. Suppression fire in mixed-conifer and spruce-fir habitats could have adverse impacts to ungulates due to habitat alteration. Depending on high severity burn patch size and extent, long-term impacts may be negligible to minor, local and beneficial due to increased foraging habitat. Burn severity patches may favor elk over deer habitat.

Mitigation of Effects — Alternative 5 — Wildlife

Mitigation measures incorporated will decrease adverse impacts related to wildlife. None of the adverse impacts in Alternative 5 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased.

Cumulative Effects — Alternative 5 — Wildlife

Overall, cumulative effects would not differ from Alternative 1. Mixed-conifer and spruce-fir vegetation types would likely burn at higher severity fire but treatment amount in these two vegetation types is decreased. Because fire-use and prescribed fires are minimized in both vegetation types, there would be higher risk of large, high severity suppression fires when compared to other alternatives; therefore, cumulative effects in these two habitat types could be magnified.

Conclusion — Alternative 5 — Wildlife

Alternative 5 focuses wildland fire-use treatment in ponderosa pine habitat. Those species that use this vegetation type would receive short- to long-term beneficial effects because the range of treatments would continue the trend toward the natural fire regime of frequent, low severity fires.

This alternative proposes the second least treatment amount in spruce-fir vegetation type when compared with the other alternatives, making it higher risk for large, high severity fires. Should these fire types occur, impact to wildlife, in general, would likely be adverse minor to moderate short to long term.

Impairment **Alternative 5** **Wildlife**

Since are no major adverse impacts in Alternative 5 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair wildlife during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Wildlife**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wildlife as a result of Alterative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Wildlife**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether by implementing mitigation measures or changing the nature of a proposed action. Thus, unavoidable adverse impacts would persist throughout the action's duration.

Alternatives 2, 4, and 5 would have adverse, minor to moderate, local, short- to long-term, indirect impacts to herpetofauna that use mesic habitat due to vegetation modifications that would make these habitats more open and potentially more xeric.

Alternative 3 would have adverse, negligible to moderate impacts to herpetofauna that use mesic habitat due to vegetation modifications that would make these habitats more open and potentially more xeric.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Wildlife**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

There would be no irreversible or irretrievable commitments of resources.

4.2.5 Special Status Wildlife Species

4.2.5.1 Guiding Regulations And Policies — Special Status Wildlife Species

Guiding regulations and policies for special-status species and their habitats are the same as those noted in 4.2.4.1for wildlife and include

- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Clean Air Act of 1955
- Wilderness Act of 1964
- Wild and Scenic Rivers Act 1968

- Noise Control Act of 1972, as amended
- Noxious Weed Act of 1974, as amended
- Aircraft Overflight in National Parks Act of 1987
- Federal Cave Resources Protection Act of 1988
- Executive Orders 13112 (Invasive Species)
- Migratory Bird Species Action of 2001
- Health Forest Restoration Act of 2004
- Director's Orders 12, 18, 41, 46, 47, 60, and 77
- Species management guides or conservation strategies

In addition, NPS Management Policies 2006 direct park managers to understand, maintain, restore, and protect the park's inherent integrity of natural resources, processes, systems, and values. To the extent possible, the NPS will allow natural processes, including species evolution, to control landscape and population level dynamics, assuming all components of natural systems remain intact. Preservation of fundamental physical and biological processes, as well as individual species, plant communities, and other components of naturally evolving ecosystems, is inherent in management direction. Management Policies 2006 state the park service will successfully maintain animals by

- Preserving and restoring natural abundance, diversities, dynamics, distributions, genetic and ecological integrity, and behaviors of animal populations and the communities and ecosystems in which they occur
- Restoring animal populations in parks when they have been extirpated by past human-caused actions
- Minimizing human impacts on animal, communities, and ecosystems, and processes that sustain them

In addition, the following existing management direction for special status animals (which include threatened, endangered, proposed, and candidate animal species and their habitats) in GRCA

- Endangered Species Act of 1973 (as amended)
- Species-specific recovery plans

The USFWS may designate critical habitat for threatened or endangered species. Critical habitat, as defined in Federal Register, Volume 41, Number 187, September 24, 1976, could be the entire habitat of the species, or any portion thereof, if any primary constituent element is necessary to the normal needs or survival of that species. MSO critical habitat has been designated and is addressed in this assessment.

NPS direction for Federally listed and proposed species is to manage NPS habitats to sustain populations and meet recovery objectives so that special protection measures provided under ESA are no longer needed (DO 77-8). Each national park is responsible for managing threatened or endangered species consistent with the applicable species recovery plan, if one exists, and to meet the NPS share of threatened and endangered species recovery goals.

NPS Management Policies 2006 states that the agency would consider potential effects of actions on state and locally listed species. The NPS is required to perpetuate the natural distribution and abundance of these species and the ecosystems on which they depend. Former species of concern to USFWS (former C2 species noted in the Federal Register, Volume 61, Number 40, February, 28, 1996) for which there is no legal status and are not listed by the AGFD as Arizona Wildlife of Special Concern, are considered GRCA Species of Concern by NPS biologists. These species are listed in Chapter 3.

Arizona does not have a threatened or endangered fish and wildlife statute, but the state does list wildlife Species of Special Concern at http://www.azgfd.gov/w_c/edits/species_concern.shtml. State Species of Special Concern in GRCA boundaries were determined from this database.

The Recovery Plan for the Mexican Spotted Owl (USFWS 1995) has goals, objectives, direction, and guidelines related to fire treatment and managing habitat to minimize risk of stand-replacing wildland fires which includes

- Fire management should be given highest priority
- Implement a program consisting of appropriate treatments to abate fire risk
- The primary objective is to protect the best available MSO habitat, while maintaining sufficient flexibility for land managers to abate high fire risks and improve habitat conditions for MSO and its prey
- In many cases, patchy fires will result in habitat heterogeneity and may benefit MSO and its prey
- If the spatial extent of crown loss is limited, a mosaic is created that could provide a diversity of prey for the owl and actually be beneficial
- Greater acreage should be treated through thinning and fire, if threats of catastrophic fire are to be decreased on steep slopes

4.2.5.2 Management Objectives — Special Status Wildlife Species

Special status animal species management objectives are the same as those noted for wildlife and include

Goal 2 Restore and maintain park ecosystems in a natural, resilient condition
- Ecosystems within the range of natural variability or desired conditions should be maintained through natural processes within policy constraints
- Ecosystems not within the range of natural variability should be restored to desired conditions and subsequently maintained through natural processes, within policy constraints
- Set priorities for treatment activities based on site specific information on departure from natural fire return interval, desired conditions, and other relevant factors

Goal 3 Protect the park's natural, cultural, and social values
- Maintain critical habitat elements for listed threatened, endangered, and sensitive species
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and limit spread of invasive plant species
- Minimize smoke impact on air-quality related values including visibility

Goal 4 Promote a science-based program that relies on current and best-available information
- Conduct research to understand natural fire regimes, refine prescriptions, provide data for fire-behavior models, and effectively implement the fire management program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, and fuel reduction treatments), to assess their effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions, prescriptions, and fire treatment priorities as relevant data becomes available

4.2.5.3 Methodology For Analyzing Impacts — Special Status Wildlife Species

Tools and Methodology Used to Analyze Effects

Assessing impacts to special status wildlife species is essentially the same as described for wildlife, except it is focused on Federally listed threatened, endangered, proposed, and candidate species, and Arizona wildlife species of special concern listed in Chapter 3.

Analysis of an impact to particular species and its habitat, which may include designated critical habitats (when they exist), involves a complex examination of the interaction of context, duration, timing, and intensity of each identified impact.

4.2.5.4 Impact Thresholds — Special Status Wildlife Species

Type of Impact

Adverse	Adverse impacts are those actions that impede normal breeding, foraging, and resting behavior or lead to a significant loss of nesting, foraging, or dispersal habitat
Beneficial	Impacts are classified as beneficial if they would positively affect size, continuity, or integrity of individual species habitat in reaching desired condition. Beneficial impacts are normally considered long term

Intensity

	Intensity and magnitude of impacts on habitat and special status animal species are described as negligible, minor, moderate, or major
Negligible	Impacts to special status animal species and/or their habitats (including USFWS designated habitats) would not be perceptible or measurable. Impacts would not be of any measurable or perceptible consequence to special-status animal species population or the ecosystem supporting them A negligible effect would equate to a “no effect” determination under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species
Minor	Impacts to special status animal species would be perceptible or measurable, but severity and timing of changes to parameter measurements are not expected outside natural variability and are not expected to have effects on special status animal species populations. Impacts would be outside critical periods such as breeding season A minor effect would equate to a determination of “not likely to adversely affect” or “likely to adversely affect” under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species
Moderate	Impacts to special status animal species would be perceptible and measurable. No species would be at risk of being extirpated. Some impacts might occur during critical time periods such as breeding season For adverse impacts, severity and timing of changes to parameter measurements expected to sometimes be outside natural variability; changes with natural variability might be long term; and special status animal species populations might have small to moderate declines, but are expected to rebound to pre-impact numbers A moderate effect would in most cases equate to a determination of “likely to adversely affect” under Section 7 of ESA regulations for Federally listed threatened, endangered, or proposed species
Major	Impacts to special status animal species would be measurable. Impacts would be long term or permanent For adverse impacts, severity and timing of changes to parameter measurements expected outside natural variability for long periods or even permanent; changes within natural variability might be long term or permanent; special status animal species populations might have large declines with population numbers significantly depressed; in extreme cases, a species might be at risk of being extirpated, key ecosystem processes like nutrient

cycling might be disrupted, or habitat for any species might be rendered non-functional; and substantive impacts would occur during critical periods

A major effect would equate to an "adverse affect with/without a jeopardy opinion" under Section 7 of ESA regulations.

Context

Local Impacts affect a small part of a habitat or range such as a single spring, canyon, or plateau

Regional Impacts affect widespread suitable habitats or the GRCA population or species range

Duration

Short term Impacts to an individual or habitat area would last from one day up to one year. Short-term impacts to a population would last up to one year

Long term Impacts to habitat area would be greater than one year. Long-term impacts to a population would be longer than one year

Timing Impacts could occur year-round, but generally resources are most sensitive during spring and summer when mating (spawning), birthing, and hatching occur

4.2.5.5 Mitigation of Effects Special Status Wildlife Species

Measures Common to All

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description, address impacts to special status animal species, and are addressed in other sections of this Chapter.

- Manage fire incidents using natural barriers to fire spread when safe and feasible
- Employ MIST in fire management techniques
- Protect aquatic habitat, riparian, and wetland areas, meadows, and other sensitive resource areas during suppression fires by defining and avoiding these areas
- Restrict fire retardant use during fire management operations where possible
- Retain snags, particularly large snags (over 24 inches dbh), to provide wildlife habitat. Generally, snags will not be cut during fire management activities unless they present a threat to human life, safety, property, or a valued resource
- Lop and scatter debris from cut vegetation (slash) to a depth of no more than 12 inches and burn during a subsequent prescribed fire, or pile and burn
- During prescribed burning, drip torch fuel will not be applied directly to large, down, woody debris greater than ten inches diameter
- Establish trigger points (geographic locations that, if reached by fire, trigger action to mitigate) if sensitive biological areas are located in MMA that require some mitigation during wildland fire-use fires. Implement mitigation plans when fire reaches trigger points
- Rehabilitate disturbed sites (control lines, staging areas, and helispots) where and when safe to do so by pulling soil, duff, litter, woody debris, and rocks back onto the line to bring it up to grade and blend with the surrounding area
- Implement best management practices for smoke mitigation and emission reduction techniques to reduce health risks and visibility impacts to Class I airshed
- Implement best management practices for exotic species spread reduction and control during fire management operations
- Use resource advisors on fire management projects and incidents

- Use resource advisors in preparation of contract fire management activities (scope of work, mitigation measures) as well as implementation of contract work on the ground
- Implement management response strategies to affect the least disturbance possible in known occupied territories during breeding season

4.2.5.6 Mitigation of Effects Special Status Wildlife Species Measures for Animal Species Listed under ESA
MSO and MSO Critical Habitat Mitigation Measures

GRCA is currently asking for relief from the USFWS on MSO survey requirements. If relief is granted, then survey requirements listed in the following mitigation measures would not occur.

- To the maximum extent possible, aircraft will remain at least 1,200 feet (400 meters) from the boundary of any designated PAC
- Locate areas associated with fire related activities, such as dip sites or drop points, at least 437 yards (400 meters) from the boundary of any designated PAC
- Notify a GRCA Wildlife Biologist or Resource Advisor if MSO are discovered during any projects
- Survey known PACs that can be surveyed from the Rim, and adjacent to prescribed fire or active fire-use areas
- Survey all MSO habitats within 0.5 miles of project perimeters prior to project implementation in accordance with formal MSO Survey Protocol
- Inform all field personnel who implement any portion of the proposed action about MSO regulations and protective measures. A wildlife biologist will present a program regarding fire management in Threatened and Endangered Species habitat to all personnel involved in the fire use program
- Advise the Resource Advisor immediately if a MSO is encountered during any project. The Resource Advisor will maintain a record of MSO encountered during suppression activity and will include location, date, time of observation, and general condition of each owl
- Consult GRCA Wildlife Biologists early in the decision-making process for prescribed, wildland fire-use and suppression fires
- Adhere to recommendations in September 2, 1997, USFWS memorandum, Clarification of Recommendations in the Recovery Plan for Mexican Spotted Owl in Regard to Prescribed Natural Fire
- Ensure all pertinent information from the reasonable and prudent measures from the Biological Opinion issued by the USFWS for the proposed FMP is included in Wildland Fire Implementation Plan for all wildland fire-use actions
- Document all actions, report incidental take, and monitor effects of proposed action on habitat. Report findings to USFWS
- Integrate data from reports to USFWS on fire activity into adaptive management processes
- Ensure, to the extent funding allows, sufficient monitoring of fire effects on key MSO habitat components are conducted after each wildland fire-use event. Monitoring may require additional plots beyond those previously established for the existing fire effects program. Intent is to adequately determine event effects on key habitat components
- GRCA will minimize cutting of trees and snags larger than 18 inches dbh, and no trees or snags larger than 24 inches dbh will be cut unless absolutely necessary for safety reasons

Mitigation of Effects Special Status Wildlife Species
California Condor and Habitat Mitigation Measures Measures for ESA Wildlife

- Cover all water dip tanks when not in use
- Keep camp areas free of trash
- Provide all fire personnel literature or instruction regarding condor concerns
- Record and report immediately any condor presence in the project area to the Resource Advisor or a GRCA wildlife biologist

- Avoid any condors that arrive at any area of human activity associated with fire management activities. Notify the assigned Resource Advisor or a GRCA wildlife biologist, and only permitted personnel will haze the birds from the area
- Survey any fire-retardant chemical application areas to the extent possible and remove contaminated carcasses before they become condor food sources
- Minimize aircraft use along the rim to the greatest extent possible
- Keep aircraft at least 437 yards (400 meters) from condors in the air or on the ground unless safety concerns override this restriction. This restriction does not apply to North Rim Helispot
- Aircraft will give up airspace to the extent possible, if airborne condors approach aircraft, as long as this action does not jeopardize safety
- Prescribed fire projects will not occur within 0.5 miles of active condor nesting sites
- Crews will stop activity on thinning projects if condors arrive on site

Mitigation of Effects — Special Status Wildlife Species
Bald Eagle Habitat Mitigation Measures — Measures for ESA Wildlife

- A 1,200-foot (400 meter) no-flight perimeter will be established around all active roost locations November 1 to April 1

4.2.5.7 Mitigation of Effects — Special Status Wildlife Species
Measures for Other Special Status Animal Species
Northern Goshawk Species and Habitat Mitigation Measures

The northern goshawk is not listed under the Endangered Species Act, but is a state species of concern. Mitigation measures for this species include

- Unless previously agreed by Fire and Wildlife Staffs, no more than 60% of the entire home range of a northern goshawk pair may be burned by prescribed fire during a single year
- Surveys must be completed in potential goshawk habitat one season prior to burning
- In general, burn unit preparations, such as thinning and removal of dead-and-down fuels, using chainsaws and vehicles within 0.25 miles of northern goshawk nest trees will be prohibited in active nesting areas. These activities will be allowed in known goshawk territories and potential goshawk habitat after surveys have determined the areas are inactive or unoccupied. Such operations may be allowed in active territories if agreed to by Fire and Wildlife Staffs
- Measures to mitigate disturbance to nesting goshawks will be undertaken at the direction of the GRCA Wildlife Biologist and Fire Management Staff. Allowing fire within active 40-acre nesting areas may be considered if fire can be implemented at low intensity

4.2.5.8 Cumulative Impacts — Special Status Wildlife Species

The cumulative effects boundary includes all of Grand Canyon National Park, Kaibab National Forest, Arizona Strip and Kingman BLM Districts, the Hualapai and Havasupai Indian Reservations, and any Arizona state lands which may intermingle.

Many species identified in this document are not isolated to GRCA. Most species have a much broader range and distribution than the Congressionally designated GRCA boundary. Many vegetation types such as piñon-juniper, mixed-conifer, spruce-fir, ponderosa pine, shrub, grasslands, and riparian are widespread and occur over much of the Kaibab and Coconino Plateaus. Fire played a significant role in crafting and maintaining the vegetation mosaic across the landscape and did not recognize administrative boundaries. Likewise, wildlife species associated with these vegetation types can range far beyond GRCA.

4.2.5.9 Assumptions — Special Status Wildlife Species

All proposed fire and non-fire projects are planned above the rim. No fire management projects are planned below the rim. Assumptions that specifically relate to alternatives and their effects on special status wildlife are

- Wildlife species are mobile, have evolved with habitat disturbances, and can avoid most direct negative impacts from fire disturbance
- Wildlife species have evolved with fire as a disturbance factor that maintains habitats over time
- Fire is a critical disturbance process to renew and maintain wildlife habitat
- General impacts of each treatment type (prescribed and wildland fire-use fire, mechanized/manual treatment) are the same throughout all alternatives
- The primary differences of anticipated impacts of each alternative to special status wildlife relate to acreage treated, potential burning severity expected, action timing, and treatment locations relative to essential wildlife habitat areas
- Present vegetative or habitat conditions may be outside the range of historical conditions and vary in degree by major habitat type (Covington and Sackett 1984, 1986, Fulé et al. 2003, 2004, Lang and Stewart 1910, Vankat et al. 2005, White and Vankat 1993)
- Ecosystem conditions have changed primarily due to human-caused influences with wildland fire suppression being most prevalent (Fradkin 1981)
- Based on fire history, prescribed and wildland fire-use fires have potential to modify habitats
- Based on fire history, prescribed and wildland fire-use fires will have long-term beneficial effects on most wildlife species and habitats
- Suppression fires hold greatest potential for adverse impacts to wildlife and wildlife habitats due to greater extent of high severity burning, and potential for more ground disturbance and other potentially adverse activities resulting from suppression activities such as fire lines; retardant use; potential for greater chainsaw, mechanized equipment, and aircraft use; and greater disturbance from fire fighting resources, support staff, and equipment during fire incidents
- Because it is impossible to predict when, where, or to what extent suppression fires will occur, this assessment does not attempt to make predictions on site-specific impacts. This analysis does assume that suppression fires burn during more extreme fire behavior periods resulting in larger burned patches from stand-replacement type fire. Based on the past 25 years of fire history, this analysis assumes that for all alternatives, the percentage of suppression impacted acres per vegetation type are
    - Mixed-conifer 34%
    - Spruce-fir 31%
    - Ponderosa Pine 13%
    - Piñon-Juniper 9% (Rasmussen 2007)
- Depending on vegetation type, elevation, and lightning occurrence, there is a history of fire occurring on the plateaus March through October
- There is a relationship between the Composite Burn Index and conifer canopy cover
- Mitigating measures will minimize adverse effects to special status species

4.2.5.10 Incomplete and/or Unavailable Information — Special Status Wildlife Species

There is little information specific to GRCA regarding fire effects on special status animal species or their habitat. Research data from outlying areas surrounding GRCA, areas in the Southwest U.S., and areas with similar vegetation types in the species range served as surrogate information where site specific data was lacking, and was extrapolated to GRCA.

There is significant data on distributions, relative population size, etc., for MSO, condors, and Southwestern willow flycatcher, but little survey data on range, distribution, and relative populations are available on other special status animal species. Historical range, distribution, and relative population size is lacking for these species making it difficult to determine the historic range of variability.

4.2.5.11 Impact Analysis **Special Status Wildlife Species**
Effects Common To All Alternatives
Noise And Visual Disturbance

Effects common to all alternatives related to noise and visual disturbance is addressed in wildlife (4.2.4.8). Potential impacts to special status animal species would be similar, if not the same. In summary

- Although general disturbance from noise and human activity (e.g. fire fighting handcrews) is possible, it is also likely that some special status species may be attracted to areas with high activity levels associated with fire operations. Some species, such as condors, are naturally curious and it is not uncommon to observe them in busy areas
- Reported animal responses vary greatly among species. Species ability to adapt to overflights also varies. In general, long-term aircraft overflights effects are unclear. Potential consequences from noise are thought to be greatest on breeding animals (NPS 1995a). The majority of studies on wildlife responses to overflights suggest that responses appear to be temporary and do not result in long-term effects to animal population numbers or habitat use.
- Raptor responses to noise and disturbance in studies vary. Most studies report relatively minor impacts, and many found temporary effects (Lamp 1987). In the few cases where reproductive success was evaluated, reproductive parameters were sometimes affected, but not to a large degree. Frazer et al. (1985) and Grubb and King (1991) reported nesting raptors more sensitive to ground-based activities compared to aircraft, and animals show a greater response to helicopters than to fixed-wing aircraft

Impact Analysis **Special Status Wildlife Species**
Collisions with Aircraft **Effects Common To All Alternatives**

Effects common to all alternatives related to collisions with aircraft are addressed in wildlife (4.2.4.8). Potential impacts to special status animal species would be similar, if not the same. In summary

- No data are available documenting number of collisions between birds and aircraft over GRCA or at Grand Canyon Airport

Impact Analysis **Special Status Wildlife Species**
Smoke **Effects Common To All Alternatives**

Smoke-related effects common to all alternatives are addressed in wildlife (4.2.4.8). Potential impacts to special status animal species would be similar, if not the same. In summary

- There is a lack of scientific literature detailing what effects smoke may have on wildlife species in general, and certainly little on special status species evaluated below. Given that many species have evolved with Southwest fire-adapted ecosystems, they are no doubt tolerant of a certain amount of smoke, but no data are available to determine what this tolerance level might be. As with other fire effects, young and less mobile individuals would be more likely negatively affected than adults, which could more easily move away from smoke. Fire management activity timing would have varied adverse effects on special status wildlife species. Late summer fires would minimize possible adverse effects from smoke on special status species

4.2.5.12 Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Not Likely Effected **Effects Common To All Alternatives**

Special status wildlife species listed in Table 4-27 would not be directly or indirectly affected by implementation of any alternative in this analysis. These special status animal species occur in the Colorado River basin or other GRCA locations outside areas proposed for treatment or anticipated impacted by the proposed FMP. Since there would be no effect, these species are not discussed further; these species are not carried forward in the following impacts analysis section(s) of this FEIS/AEF.

Table 4-27 Special Status Wildlife Species Not Likely Affected

Common Name	Reason Not Likely Affected
Relict Leopard Frog	No known GRCA populations. Sedimentation is projected as negligible in habitats they might normally occupy
Northern Leopard Frog	No known GRCA populations. Sedimentation is projected as negligible in habitats they might normally occupy
Western Yellow-billed Cuckoo	Potential habitat limited to canyon bottom. Only one bird seen; no evidence of GRCA nesting. No affect from any alternative implementation
Southwestern Willow Flycatcher	A single nesting pair was located in lower Grand Canyon far removed from proposed project area. River corridor wildfire is limited, and no fire activities are proposed in the canyon
California Brown Pelican	Uncommon park visitor. However, have been observed using river corridor (far removed from proposed projects). River corridor wildfire is limited; no fire activities are proposed near the river corridor
Western Red Bat	Inhabits riparian areas not targeted for treatment in the proposed plan. Some light underburning may back into habitat, but no anticipated impacts
Desert Tortoise	Habitats outside areas where fire management activities would occur. Tortoise habitats are sparsely vegetated and unlikely to carry fire
Kanab Ambersnail	Two populations known in the river corridor. River corridor wildfire is limited; no fire activities proposed near the river corridor. Sedimentation is projected as negligible in the river corridor due to distance from proposed activities
Humpback Chub	Sedimentation resulting from any alternative is projected as negligible
Razorback Sucker	Sedimentation resulting from any alternative is projected as negligible

4.2.5.13 Impact Analysis — Special Status Wildlife Species
Special Status Wildlife Species Likely Effected — Effects Common To All Alternatives

Following are predicted species-specific effects common to all alternatives. These effects may be part of, or in addition to, general effects discussed in 4.2.4.8 (noise and visual disturbance, collisions with aircraft, smoke). Relative amounts of impacts among various alternatives are tied to acreage treated, treatment type, implementation locations and timing, and fire severity.

Impact Analysis — Special Status Wildlife Species
Special Status Wildlife Species Likely Affected — Effects Common To All Alternatives
Northern Goshawk

Northern goshawks occupy stands of mixed-conifer and ponderosa pine forest on North and South Rims, and several nesting sites have been documented for both rims. Fire and fire activities including flames, smoke, chainsaw use, aircraft, and increased human activity in areas surrounding active nests could have an adverse impact on reproductive success by causing stress to adults, mortality of young in the nest, or abandonment of the nest or breeding attempts. Use of low-flying aircraft for fire management activities could result in loss of individuals if collision occurs; however, this would be an extremely unlikely event.

Wildland fire use and prescribed fire could have a beneficial indirect impact on northern goshawks by improving nesting and foraging habitat. Goshawks use a wide variety of forest ages and types, including closed canopy stands for nesting, and closed canopy, open mid-story stands for foraging. Northern goshawks prefer conifer stands with high canopy cover, little midstory, and relatively open understory. Fires with low/moderate fire intensity that remove understory without crown fire would have a beneficial effect to the species. Fires resulting in loss of canopy and high severity (stand-replacing) fire would make areas unsuitable for goshawk use, and have adverse effect. While adult birds are rarely killed by fire (Landers 1987), fires in early spring before fledging may result in direct adverse effect through mortality of chicks and juveniles from direct burning or from effects of smoke inhalation by sedentary birds.

Large, high severity fires could reduce northern goshawk recruitment by altering nesting and foraging areas (Landers 1987). Historic land uses as well as past management actions have altered GRCA vegetation structure. Current fuel accumulations in ponderosa pine habitats are considered within the range of historic variability for the area, and are expected to reflect historic fire regimes resulting in relatively open forested stands of mixed age classes. Current fuel accumulations in mixed-conifer are considered on the high end of the range of historic variability in some stands. Expected fire behavior from these fuel loads is within the range of historic variability and on the high end to outside the range of variability. Expected fire behavior will reflect a mixed severity fire regime with stands having large burned patch sizes of greater extent than might have occurred in the past. Spruce-fir stands are considered within the historic range of variability for fuel accumulations. Expected fire regime indicates a high burn severity with large burned patch size and extent. Fires in northern goshawk territories will predominantly provide benefits in long-term protection of resulting complex habitat conditions. Initial impacts to northern goshawks from fires occurring in-season will be adverse, displacing birds from occupied territories with a possible reduction in recruitment short term. Initial effects would be minor to moderate adverse local.

Fire management (prescribed and wildland fire-use fire) could be beneficial to the northern goshawk by perpetuating preferred forest types and structural composition and which also provide prey habitat. Reynolds et al. (1992) recommended prescribed fire in ponderosa pine and mixed-conifer forests to perpetuate northern goshawk habitat and reduce fuel loading.

Impact Analysis
Special Status Wildlife Species Likely Affected
Mexican Spotted Owl

Special Status Wildlife Species
Effects Common To All Alternatives

GRCA MSO occupy side canyons and forested areas below the rim. All known MSO nests occur below the rim where no prescribed fire is proposed and where potential effects would be limited to incidental burning in event of fire-fall from above. In past years there have been six fire treatment projects with incidental fire-fall into canyons below the rim; each fire averaged approximately nine acres below the rim (Ward 2007). The limited nature and extent of these incidental events would not normally result in any measurable adverse effects on MSO as these sites are typically not nest locations.

MSO have very rarely been found to forage and temporarily roost on the plateau on both rims. Probability of direct mortality from fire activities remains low as these owls would typically escape any fire events as no nest sites or young would tend to hold them in place.

Direct, adverse impacts from fire activities in occupied MSO habitat may include noise and visual disturbance from aircraft overflights and human presence on the ground (rare due to PAC locations). Studies report no measurable difference to MSO reproductive success and behavior in response to overflights (Delaney et al. 1999, Johnson and Reynolds 2002). Aircraft collisions would be unlikely because owls are not soaring birds and are generally inactive during daylight hours when overflights occur. A mitigation measure incorporated in all alternatives requires aircraft to remain at least 1,200 feet (400 meters) from PAC boundaries, to the maximum extent possible, further reducing potential adverse impact. Human presence in owl territories may cause owls to flush from nests or perches (Swarthout and Steidl 2001). In cases of extreme or continuous disturbance, nest abandonment could occur; however, there is no known MSO nesting on plateaus where the majority of FMP implementation would occur. Only incidental activity from the proposed FMP would be likely below the rim. Thus, MSO would unlikely be directly affected by fire or manual/mechanical treatments in occupied habitats. A mitigation measure requiring new fire-related activity centers (e.g. dip sites, drop points) be located at least 1,200 feet (400 meters) from PAC boundaries would further decrease any potential direct adverse impact.

MSO critical habitat encompasses a portion of the mixed-conifer vegetation type on North Rim and would be affected by fire management activities. However, MSO prefer dense, multi-layered habitat with greater tree basal area and large down woody material. Because of this, not all mapped habitat qualifies [as critical habitat], as a significant portion of the North Rim falls under the definition of Other Forest and Woodland Habitat as found in the MSO Recovery Plan. Only habitat that meets the criteria of protected or restricted habitat within the mapped boundaries of critical habitat in CP-10 is included in the critical habitat designation. Main adverse fire impacts relate to amount of canopy removal and other understory vegetation (USFWS 2004). Ganey (2004) showed that owls select cooler, moister habitats apparently to reduce diurnal evaporative water loss. Importance of this appears to vary by elevation, being more important in lower elevations with higher potential for hotter temperatures. Areas with higher canopy cover (greater than 75%) are selected for nesting sites than expected in random selection. Jenness et al. (2004) studied 33 nest sites which had previously burned at various fire severities and found no biologically interpretable influence on occupancy rates. They concluded that fires with low/moderate intensity burning with limited canopy cover loss, tend to have negligible effects on MSO. Similar results were found by Willey (1998) and Bond et al. (2002). Ganey and Balda (1994) found MSO roosted primarily in virgin mixed-conifer forests with high canopy closures averaging 79%. They found roosting sites also had more big logs and greater densities of live trees and snags than did foraging sites. Some constituent elements, such as large tree density, could decrease in moderate/high and high severity fire areas causing an adverse habitat affect. Removal of down debris through fire could adversely affect habitat short term but because this vegetation type has a relatively high productivity level, within ten years fuels would increase to near pre-burn levels. All GRCA mixed-conifer has been repeatedly surveyed, and no nesting or roosting owls were located. Studies mentioned above took place in areas south of GRCA where nesting occurs in mixed-conifer.

Scientific literature has shown potential beneficial effects from fire treatment of identified MSO habitat. Mixed severity fire can treat timber stands to produce a more diverse structural composition in treated areas and also provide healthier, more fire-resistant habitat. Fire that produces small areas of high severity crown fire can also help open even-aged, overstocked timber stands that are less productive for MSO prey species. Block et al. (2005) found fire that helps produce more shrub and herbaceous vegetation by creating openings in otherwise closed stands will favor key MSO prey species including deer mice, Mexican woodrats, and voles. Jenness et al. (2004) recommend proactive fuels-management treatments in areas not currently occupied by owls to reduce future risk of loss of these areas when they would otherwise be available for occupancy.

Impact Analysis
Special Status Wildlife Species Likely Affected
California Condor

Special Status Wildlife Species
Effects Common To All Alternatives

Fire suppression activities could cause adverse impacts, such as temporary nest abandonment (leaving eggs or chicks more susceptible to predation), egg breakage by a disturbed adult, increased disturbance from fire line construction, and presence of fire personnel, aircraft and equipment (USFSW 1984). In addition, concentrations of human fire-suppression activities may either disturb or attract condors. Mitigation measures such as requiring trash removal, covering helicopter dip tanks when not in use, and locating fire management activities (firelines, helipads) to minimize damage to biological resources would lower adverse effects.

Fire from all fire types (prescribed, wildland fire-use, suppression) may provide beneficial impacts to California condor habitat by creating snags for future roost sites, improving foraging habitat through creating openings in otherwise dense forest stands, and, to a lesser extent, more foraging opportunities from food animals killed by fire. However, large, high severity fires may adversely impact habitat by destroying existing roost trees (Bernard and Brown 1977). An increase in carcasses from fire in existing open areas or new openings created by high severity fires immediately post-burn could have beneficial impacts to condors. Researchers have observed condors in Arizona using snags as perches and roosts in timbered areas that experience stand-replacing fires due to increase in prey availability in these newly created feeding sites (Parish 2007). Prescribed and wildland fire-use fires may be used to improve condor foraging habitat and reduce the chance of large, high severity suppression fires (Smith and Murphy 1973).

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Kaibab Squirrel

The Kaibab squirrel, a subspecies of Abert's squirrel, is dependent on ponderosa pine forests (Keith 1965). They occur at highest densities in forests with more than 120 trees per acre greater than 12 inches dbh with interlocking crowns (Patton 1977). These relatively dense stands also appear important for juvenile recruitment (Dodd et al. 1998). Dodd et al. (1998) and Chambers and Germaine (2003) also showed that the squirrels use more open forest habitat as well, particularly in summer in areas with high ponderosa pinecone production. In winter, squirrels moved back to areas of adjacent dense habitat. These findings emphasize the need for stand structure diversity across the larger landscape to provide desired Kaibab squirrel habitat.

These squirrels can typically escape low intensity fires due to their ability to move about rapidly both on the ground and in tree canopy. There is no research literature on Abert's squirrel mortality due to fire. Squirrels would be more susceptible to habitat loss and disturbance from human activities associated with manual/mechanical treatments and fire suppression.

Ponderosa pine is dependent on frequent, low severity fire for health stand maintenance and reproduction. The immediate adverse low severity fire effect in ponderosa pine on squirrel habitat is negligible (USDA 2007).

Patches of higher severity fire can result in production of openings important to squirrels especially during summer months (Chambers and Germaine 2003). Therefore, fire use can provide a more diverse structural component mix critical to the Kaibab squirrel survival.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
American Peregrine Falcon

American peregrine falcons nest in cliff habitats that do not sustain fire, and as such, would not be directly affected by fire itself. Nichols and Menke (1984) reported that fires near nesting cliffs could disturb peregrine young or nesting pairs; however, disturbances would be short term.

Peregrine falcons require open areas for hunting; fires that create these open areas would have a beneficial effect, provided burning leads to prey species increase.

Taylor and Barmore (1980) reported that following fire in Yellowstone and Grand Teton National Parks, soaring bird species were present by the second year and firmly established by the fifth year. However, as the canopy closed (after 40 years), these species began to drop out and were replaced by other, but fewer, species. Total bird biomass was at least 70% greater 5 to 29 years following fire than it was after 40 years. These results indicate both short- to long-term beneficial effects for peregrines following fire treatments that create open forested or shrubland canopies.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Bald Eagle

Since bald eagles are not known to nest in GRCA, but occur in the park as migrants and winter residents fall until early spring, there should be minimal adverse effects from proposed fire management activities. Wintering bald eagles are found primarily along the river corridor, on South Rim, and have been sighted in forests and meadows near North Rim's entrance.

Forested winter roost areas are generally open with roost trees taller than surrounding canopy. Wildland fire-use and prescribed fires could have a beneficial indirect impact on bald eagles by creating or maintaining open habitat, reducing stand density, and promoting growth of large trees.

Proposed fire management activities would decrease potential for large, high severity fires that could reduce currently available roost habitat and create even-aged forest conditions which may hinder or stop continuous snag recruitment (Quinby 1991).

Fires create snags which are important bald eagle perching and nesting sites. These snags could possibly increase potential for lightning-caused fire when standing, and when fallen, could increase fuel loading (Lyon 1977). There have been no studies to determine if snag hazards outweigh benefits to eagles.

Fire treatments could be used to reduce litter buildup, control disease, remove less vigorous species, and allow more vigorous trees to reach maturity, thus indirectly providing healthy forest stands that contribute to habitat for bald eagles (Harrington and Sackett 1992).

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Allen's Big-eared Bat

Allen's big-eared bats inhabit ponderosa pine, piñon-juniper, and riparian areas. Fire would have direct impacts on Allen's big-eared bats through mortality and displacement. Bats could be disturbed or displaced by human activities associated with fire such as implementation of prescribed fire, manual/mechanical treatment, or fire suppression activities. Favored roost trees could be eliminated by fire or fire related activities.

Fire can also produce indirect impacts on Allen's big-eared bats by modifying habitat. Fire, as a GRCA disturbance process typically improves forest stand diversity, and burned patches provide open understory. Decreased canopy closure and new vegetation growth in burned areas can improve foraging opportunities, and fire can promote growth of large trees that provide roost sites. Patches of high burn severity could remove existing roost sites and alter prey populations (generally with a short-term reduction and a longer-term increase in species richness, diversity, and composition).

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Pale Townsend's Big-eared Bat

Pale Townsend's big-eared bats use desert-scrub, oak woodland, oak-pine forests, piñon-juniper, and coniferous forests indicating the species uses a wide range of habitats. Pale Townsend's big-eared bats forage along forest edges. Fires that maintain open areas and forest edges would have a beneficial effect to this species by maintaining foraging habitat. Fires also affect prey species populations, generally with a short-term reduction and longer-term increase in species richness, diversity and composition.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Spotted Bat and Greater Western Mastiff Bat

Spotted bats and greater western mastiff bats typically roost in cliffs, rock crevices, and occasionally hollow trees; they forage in coniferous forest and open meadow habitats.

Prescribed and wildland fire-use fires that provide forest openings would have local, beneficial impacts on foraging habitat. Fires would also have a local, beneficial impact by playing a role in limiting forest encroachment, maintaining grassy meadows, and thus maintaining bat foraging habitat. These bats are wide-ranging, traveling substantial distances from roost to foraging sites, and should be able to avoid local areas of reduced insect prey.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Long-legged Myotis

Long-legged Myotis use a wide range of forested habitats from piñon-juniper, ponderosa pine, and montane to subalpine forests, usually foraging over open areas like campgrounds, forest clearings, vegetated riparian areas, and in forest canopy. During summer, long-legged Myotis roost in tree cavities, buildings, rock crevices, caves, abandoned mines, and under loose bark. During winter, the bats hibernate primarily in caves and abandoned mines. Wildland fire can provide disturbance factors that contribute to important foraging, roosting, and prey habitat. Adverse impacts would be elimination of existing roost trees through burning and direct bat mortality. Beneficial impacts would include habitat restoration and maintenance, roost tree and forest opening creation, and increased prey diversity and composition.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Golden Eagle and Ferruginous Hawk

The main golden eagle and ferruginous hawk habitat types affected by proposed FMP actions are piñon-juniper and open grassland. Raptors could be impacted through territory displacement during fire or fire management activities. Nests are typically located on cliff tops or in large trees. Human disturbances could cause nesting disruption or abandonment.

These raptors tend to forage over open grasslands. Fire would maintain grasslands and could open forested habitats to grasslands in some habitat types. Burned areas would temporarily increase prey availability. The amount of piñon-juniper vegetation type proposed for treatment from any alternative is minor; therefore, all alternatives would likely have negligible beneficial or adverse effects to these species.

Impact Analysis **Special Status Wildlife Species**
Special Status Wildlife Species Likely Affected **Effects Common To All Alternatives**
Swainson’s Hawk

Swainson’s hawks are known to nest and forage on North Rim, particularly in large meadows near the entrance. Fire directly reduces Swainson's hawk reproductive success if it crowns in occupied nest trees (Landers 1987). Fires that reduce vegetation height and create open areas would probably increase Swainson's hawk hunting efficiency. Swainson's hawks use scattered woody vegetation patches near open foraging areas for nesting and perching.

Regular burning helps maintain habitat for many prey species (Landers 1987; Dodd 1988). Several studies indicate that many prey populations increase rapidly subsequent to burning in response to increased food availability (Landers 1987). Fire suppression in grasslands was detrimental to small bird and mammal populations due to organic matter accumulation and reduced plant vigor (Wagle 1981). Swainson's hawk has been observed hunting on recently burned areas in Colorado County, Texas (Baker 1940). On the Bridger-Teton National Forest, Swainson's hawks were more commonly observed using a high severity fall burn than a low severity spring burn in the same area (McGee 1976).

Fire treatments can be beneficial to Swainson's hawk populations by enhancing habitat and increasing prey base (Landers 1987; Dodd 1988). Burning in grasslands where scattered trees are retained benefits Swainson's hawk populations, particularly in areas with limited nesting sites. If fire treatments create maximum interspersion of openings and edge, with high vegetative diversity, treatments would have a beneficial effect on the hawk.

4.2.5.14 Effects Common to Alternatives 2 through 5 Special Status Wildlife Species
Direct and Indirect Effects

Mitigation measures requiring low intensity fires in all MSO critical habitat were not included in Alternatives 2 through 5. Instead mitigation measures were developed through this analysis to minimize adverse effects to MSO and other special status animal species. Effects with and without these mitigation measures are addressed in analysis of each alternative.

Effects Common to Alternatives 2 through 5 Special Status Wildlife Species
Direct and Indirect Effects Mitigation of Effects
MSO Habitat Mitigation Measures Measures for ESA Wildlife

- Assess the amount of moderate/high and high severity fire through composite burn index monitoring after each managed fire in the mixed-conifer vegetation type above the rim. Use the adaptive management process to adjust burn prescription, ignition pattern, burn seasonality, and/or pre-treatment to ensure no more than 30% of the mixed-conifer vegetation type and MSO mixed-conifer restricted habitat burns with moderate/high and high severity. This includes high and moderate/high fire severity from past fires (2000 to present) (Table 4-15a), and all fires that will occur within the scope of this planning document.

4.2.5.15 Alternative 1 No Action Special Status Wildlife Species
Existing Program

Alternative 1, Existing Program maintains the present fire management strategy by managing the landscape under three existing FMUs (Chapter 2) with approximately 20,050 suppression acres; 55,000 wildland fire use acres; 58,500 prescribed fire acres; and 400 non-fire manual treatment acres over the planning period. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species
Northern Goshawk

The majority of ponderosa pine and mixed-conifer are expected to receive some form of fire treatment. The majority of ponderosa pine (76%) is at the natural range of variability for its fire regime.

Under Alternative 1, mixed-conifer fire treatments have a constraint of low intensity fires. This constraint would minimize wildland fire-use amount (5% of wildland fire-use acres, 7% of mixed-conifer vegetation type), and the scheduled prescribed-fire acreage in this vegetation type may not be realized.

In treated acres, impacts would be local to regional, moderate, beneficial, long-term to northern goshawk foraging areas and nesting habitat; local, short-term, adverse impacts to nesting sites during fire activities. Impacts would be most noticeable during breeding and nesting, late April through mid-August.

Only 4% of this vegetation type is assumed to burn from suppression fires. In these locations, fire could burn with higher fire behavior, approximately 13% burning at moderate/high to high severity fire (Table 4-5). These areas would likely have local, negligible, long-term, adverse effects to goshawk habitat.

It is assumed approximately 18% of mixed-conifer would burn from suppression fire. Fire is expected to have varied burn severities in mixed-conifer forests ranging from unburned to high burn severity patches. Short-term, local, minor to moderate, adverse impacts will occur from initial habitat modification, depending on size and extent of high burn severity patch size and extent. Long-term, local, minor to moderate beneficial impacts will occur from increased prey availability and quantity, habitat restoration and maintenance, and reduced risk of large high burn severity fire occurrence.

If fire treatments would not stay in low fire intensity criteria in mixed-conifer and spruce-fir vegetation types, fewer acres could be treated, increasing risk of high severity suppression fires over time. Should this occur, impacts would be minor to moderate long-term adverse.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Mexican Spotted Owl

All vegetation types in MSO critical habitat (portion of South Rim and all of North Rim) have a low intensity fire constraint during fire treatments. For this analysis, low intensity is defined as 15% or less of crown fire or 15% moderate/high to high severity burn. As noted in Chapter 3, PACs (located below the rim) and mixed-conifer (slopes greater than 40% slope) are designated as critical habitat. Mixed-conifer and riparian areas are restricted habitat. Alternative 1 proposes more than 57% of mixed-conifer be treated through prescribed fire and possibly an additional 7% from wildland fire use. Some of this vegetation type is classified in a moderate/high level of departure from historic fire regimes. The low intensity fire constraint is intended to protect MSO habitat, but if fire treatment cannot stay in this constraint, it would likely cease. This would increase risk of high severity suppression fires in this important habitat type. In areas where treatment is successful, impacts would be local, long term, beneficial with negligible impact intensity. Where high severity suppression fires occur in the mixed-conifer vegetation type (it is assumed 18%, but risk could increase over time with this alternative), impacts would be local, long term, adverse with minor to moderate impact intensity. In those suppression fire areas, over 11% is expected to be stand-replacing, and 31% would likely produce single tree and small-scale group torching (Table 4-7) opening existing dense canopy.

If fire occurs in occupied PACs, impacts would be local short term negligible adverse due to fire suppression activities; local, short to possibly long-term, minor to moderate, adverse to habitat. Direct adverse impacts from displacement would be most noticeable during breeding (March through August).

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species California Condor

California condors use forest lands for roosting, and open lands for foraging. Fires would likely maintain or create foraging habitats and possibly reduce roost trees temporarily. Fire would have local, short- to long-term, negligible to minor adverse or beneficial effects to this species. Maintaining fire as an ecosystem process would be important for long-term habitat restoration, maintenance, and protection for this species.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Kaibab Squirrel

It is anticipated 70 to100% of ponderosa pine would receive some form of fire treatment. These areas would include Kaibab squirrel habitat located entirely in the ponderosa pine vegetation type. Overall, impacts are anticipated to be local, long term, minor, beneficial as long as large habitat portions retain moderate canopy cover where tree crowns interlace. Additionally, fire treatments would decrease potential for large, high intensity fires that would eliminate squirrel habitat until vegetation recovery.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species American Peregrine Falcon

American peregrine falcons prefer foraging above riparian areas, will forage in all forest types, but require open areas for hunting. Proposed fire treatments would burn at low intensity providing opportunities for creating high severity burn patches. Proposed fire treatment areas would have local, long-term, negligible, beneficial effects. Fire suppression areas in mixed-conifer (18% assumed) and spruce-fir (36% assumed) would have beneficial effects because it is anticipated 40 to 70% of suppression areas in these vegetation types would burn as moderate/high (31 to 38%) to high (11 to 31%) severity, and would likely create open patches for forage. This beneficial impact would be long term, local, minor to moderate.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Bald Eagle

Bald eagles forage in the river corridor, on South Rim, and have been seen near the North Rim Entrance. No fire treatment is proposed in these areas during the time bald eagles inhabit GRCA. There would be no direct impacts to bald eagles from proposed treatments.

Treatments that produce open areas while retaining large trees would have beneficial effects to eagle roosting habitat. Fires that have high severity burn patches would likely benefit this species. Due to low intensity fire constraints, these areas would likely be minimal. Fire treatments would lower risk of large, high severity fires. Minimizing risk for suppression fires would have local, negligible, long-term, beneficial impacts. This would be especially true in ponderosa pine where the majority of the area (76%) is at low to low/moderate departure from historic fire regime and treatments would continue this existing trend.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Allen's Big-eared Bat

The majority of ponderosa pine vegetation type (70-100%) will receive some form of fire treatment in Alternative 1. This would produce moderate canopy cover with an open understory in most of this forest type, a key habitat for this species. This would have regional, beneficial, long-term minor to moderate effects. It is anticipated the majority of fire treatments would be surface fire with low to low/moderate fire severity. Impacts to roosting trees in ponderosa pine would be unlikely. In addition, fire treatments would also have indirect, beneficial effects to this species by reducing risk of higher severity fires.

Very little treatment is proposed in piñon-juniper, another habitat type for this species (less than 4%, including assumed fire suppression acres). Any beneficial or adverse effects from this treatment would be local and negligible.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Pale Townsend's Big-eared Bat

Fires that maintain open areas and forest edges would have beneficial effects to this species by maintaining forage habitat. Because fire treatments require low intensity fires, the amount of open areas created from these treatments would likely be minimal (a maximum of 15% over the treated areas) but all fire types would likely maintain forest edges. Beneficial impacts would be local, long term, and negligible.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Spotted Bat and Greater Western Mastiff Bat

Spotted bat and greater western mastiff bat normally forage forest openings and in meadows. Based on forage habitat, this alternative would have very similar effects to pale Townsend's big-eared bat. Beneficial impacts would be local, long term, and negligible.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Long-legged Myotis

Proposed fire treatments and management strategies will provide disturbance factors that contribute to important foraging, roosting, and prey habitat maintenance and enhancement. Beneficial impacts from fire would include habitat restoration and maintenance, creation of roost trees and forested openings, and increases in prey species diversity and composition. Impacts would be local, long term, minor beneficial.

Adverse impacts would be elimination of existing roost trees through burning and direct bat mortality. Impacts would be local, short term, negligible and adverse.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Golden Eagle and Ferruginous

Very little treatment (less than 4%, including assumed suppression fire acreage) is proposed in the piñon-juniper vegetation type, a key habitat for these two species. Adverse and beneficial impacts noted in Effects Common to All Alternatives to these two species would be local and negligible.

Direct and Indirect Effects Alternative 1 Special Status Wildlife Species Swainson's Hawk

According to Chapter 3, Swainson's hawks are known to nest and forage on North Rim, particularly in large meadows near North Rim's entrance. Low severity fires probably have little direct effect on Swainson's hawk; therefore, proposed fire treatments would have no to negligible, direct, beneficial, or adverse effects to this species.

Fires that reduce vegetation height and create open areas probably increase hunting efficiency by Swainson's hawks. Open-habitat raptors, such as Swainson's hawk, use scattered patches of woody vegetation near open foraging areas for nesting and perching. Suppression fires in mixed-conifer and spruce-fir vegetation types would likely have beneficial effects to this species because of the amount of moderate/high to high severity fire that would likely occur (40 to 70% of total acres burned). These higher severity burned areas would cause openings in these dense vegetation types. Beneficial impacts would be local and minor to moderate.

Mitigation of Effects Alternative 1 Special Status Wildlife Species

Alternative 1 includes the following mitigation measures that will affect special status wildlife species.
- Prescribed fires will be managed as low intensity fires
- Wildland fire-use fires will be managed as low intensity fires. The objective will be to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- While natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), occasionally up to 10% mortality may occur in large trees

Cumulative Effects Alternative 1 Special Status Wildlife Species

Special status animal species inhabiting GRCA forested and wooded areas could be impacted by fire suppression activities. Special status animal species in adjacent areas could potentially be impacted by GRCA fire management activities, and fire management activities in adjacent areas could potentially impact GRCA special status animal species. Therefore, these areas mainly define the geographic scope of this cumulative impact analysis.

Cumulative impacts can result from individually minor but collective actions taking place over time. Cumulative effects to special status animal species will be measured against a baseline of the early-to-mid 1990s when GRCA's current FMP and GMP were developed and adopted.

Past, present, and reasonably foreseeable future actions taken by GRCA, other agencies, and persons on adjacent lands have potential to contribute to cumulative impacts to special status animal species (Appendix G). Past GRCA fire management practices focused on fire suppression contributed to increased fuel loads and high stand densities that lead to increased risk of high severity fire that could adversely affect special status animal species through habitat loss or alteration. Recent fire management practices have included treatments to reduce fuel loads and stand densities which show benefits to habitats in reduced high severity burn risk. Habitats not yet treated continue at risk to adverse effects from high severity burning.

Other planned actions in GRCA include facility construction or improvement in North and South Rim developed areas, and maintenance or rehabilitation of existing facilities in the canyon. Each of these projects is designed to minimize adverse impacts to natural resources, and each receives environmental review prior to implementation. Because these actions would occur in developed areas and affect small areas, these projects, taken together, would result in a negligible loss or alteration of existing special status animal habitats. These actions could result in increased disturbance to special status animals during construction activities, but these adverse effects would be local and short term.

Past, present, and reasonably foreseeable future projects in Kaibab National Forest include timber sales, fire management plan implementation, noxious weed control, grazing, and vegetation management for improved wildlife and rare plant habitat. Fire management activities include thinning and prescribed fire.

Adverse cumulative effects to special status wildlife species from past, present, and reasonably foreseeable future actions would vary in intensity from negligible to moderate depending on habitat type and species affected. Most adverse cumulative impacts to special status wildlife species would be local short term. Fire management activities would reduce risk of large, uncontrolled, high severity fires that could impact special status wildlife species adversely through habitat loss or alteration. Management activities that reduce fuel loads would provide a moderate beneficial cumulative indirect impact to all special status wildlife species.

Conclusion Alternative 1 Special Status Wildlife Species

Alternative 1 proposes a mix of fire treatments with mitigation measures included in the project description that require low intensity fires in MSO critical habitat (portions of South Rim and all of North Rim). For this analysis, low intensity is defined as no greater than 15% moderate/high to high severity fire and no greater than 15% crown fire. Special status wildlife species that prefer medium to high canopy cover with open understory would gain the greatest beneficial effects from this alternative (MSO, northern goshawk, Kaibab squirrel, long-legged Myotis, bald eagle, Swainson's hawk, California condor [perching habitat], Allen's big-eared bat, pale Townsend's big eared bat). But because low intensity fire is outside the natural range of variability for both mixed-conifer and spruce-fir, these forests would still be at risk for high severity suppression fires after the planning period. There would also be very little to no wildland fire-use treatments in these two vegetation types which would increase risk of high severity suppression fires in these vegetation types. Areas where high severity suppression fires occur would have beneficial effects to California condor (foraging areas), American peregrine falcon, greater western mastiff bat, and spotted bat. Because very little piñon-juniper vegetation type or broadleaf riparian habitat will be treated by this alternative, there would be no to negligible adverse or beneficial impacts to golden eagle or ferruginous hawk.

Impairment Alternative 1 Special Status Wildlife Species

Since are no major adverse impacts in Alternative 1 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status wildlife during Alternative 1 implementation.

Unacceptable Impacts Alternative 1 Special Status Wildlife Species

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on special status wildlife as a result of Alterative 1 implementation.

4.2.5.16 Alternative 2 Preferred Alternative Special Status Wildlife Species Mixed Fire Treatment Program

Alternative 2 proposes the same areas for fire treatment as Alternative 1, but removes the low intensity fire requirement in MSO critical habitat (portion of South Rim and all of North Rim). This change would mainly effect fire treatments proposed in mixed-conifer and spruce-fir vegetation types. As noted in Alternative 1, more than 57% of mixed-conifer vegetation type is proposed for treatment through prescribed fire. In addition, without the low intensity fire constraint, an additional 20% of wildland fire use acres, and 30% of mixed-conifer vegetation type are anticipated to burn under wildland fire use, and it is assumed approximately 18% would burn as suppression fires. Prescribed fire treatment is planned in 19% of the spruce-fir vegetation type, 36% is assumed to burn from suppression fire.

In addition, there would be a total of 2,490 acres of mechanical/manual treatments in the WUI. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species Northern Goshawk

Effects in the ponderosa pine vegetation type would be the same as Alternative 1. Anticipated fire treatments in ponderosa pine would mainly produce low/moderate burn severity and very little crown fire. The majority of treated areas would retain tree canopy cover with open understory producing local, indirect, moderate, beneficial, long-term impacts to northern goshawk foraging areas and nesting habitat.

The majority of mixed-conifer vegetation type would receive some form of fire (prescribed, wildland fire use, suppression). Since 42% of this vegetation type is presently in a high level of departure from historic fire regime, this vegetation type is anticipated to reflect mixed severity burn from low to high burned patches. Under mild fire weather (50th percentile), approximately 28% of prescribed fire could generate crown fire (Table 4-13), and approximately 29 to 42% of wildland fire-use and suppression fires would burn as moderate/high to high severity fire (Table 4-7). This could possibly produce larger burned patches than occurred historically. This would cause local, short- to long-term, minor to moderate, adverse impacts to northern goshawk habitat. A mitigation measure has been developed where future treatments in mixed-conifer would be reassessed if the cumulative extent of high and moderate/high severity fire of all fire in mixed-conifer exceeds 30% of the vegetation type. This mitigation measure could reduce this adverse effect; but should fire treatments cease (because of this measure) prior to treating much of this vegetation type, there would be a higher risk level for future large, high severity fires.

Any fire and fire suppression activities could have local, direct, short-term, negligible adverse impacts to nesting sites and individuals through displacement, disturbance, or habitat modification. Impacts would be most noticeable during breeding and nesting seasons late April through mid-August.

If all acres proposed for treatment are accomplished, potential for large, high severity fire risk would be decreased. This would have local, long-term, minor to moderate, beneficial effects to this habitat.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species Mexican Spotted Owl

Fire treatment in the mixed-conifer vegetation type would have greatest potential effect to MSO. As noted under impacts to northern goshawk, a portion of mixed-conifer vegetation is anticipated to receive some form of fire treatment that could produce larger burned patch size than occurred historically. This would have local, long-term, minor adverse impacts to MSO protected and restricted habitat. However, no MSO pairs/nests have been detected in this designated habitat in over ten years of survey. Existing monitoring and survey work have detected no population decreases from a decade of fire management activities on both GRCA rims. A mitigation measure has been developed where future mixed-conifer treatments would be reassessed if cumulative extent of high and moderate/high severity fire (of all fire in mixed-conifer) exceeds 30% of the vegetation type. This mitigation measure could reduce proposed adverse effects, but should fire treatments cease (because of this measure) prior to treating much of this vegetation type, there would be a higher risk for future large, high severity fires.

Approximately 18% of mixed-conifer habitat is assumed would burn as suppression fire. With current fuel loading, fire is expected to produce a mix of burn severity patches from unburned to high severity. Impacts would depend on size and extent of high severity patches. Expectations are this would have local, long-term, minor adverse impacts to mixed-conifer habitat.

Should fire occur in occupied PACs, there would be local, short-term, negligible to minor adverse impacts due to fire suppression activities; local, short- to possibly long-term minor to moderate adverse habitat impacts.

Non-fire treatments would not affect MSO because treatments are proposed on South Rim in ponderosa pine and piñon-juniper vegetation types in the WUI.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
California Condor

Alternative 2 would have beneficial and adverse impacts to California condor. Openings in mixed-conifer and spruce-fir vegetation types due to moderate/high to high severity fire areas (from all fire types) would produce local, indirect, negligible to minor, beneficial impacts. Opening these dense stands would provide better foraging habitat. Although some perch or roost trees could burn, other trees will become perch trees as fire works as a disturbance process. This adverse impact would be local, negligible to minor.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Kaibab Squirrel

Alternative 2 would have the same effects as Alternative 1. Impacts to Kaibab squirrel habitat for both alternatives are the same. Impacts are anticipated to be long term, regional, minor, beneficial as long as large habitat portions retain moderate canopy cover where tree crowns interlace. Fire treatments would also decrease potential for large, high intensity fires that could destroy individuals and habitat.
As noted in Effects Common to All Alternatives, fire suppression activities could cause local, short-term negligible adverse effects to individuals.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
American Peregrine Falcon

Fire treatments in mixed-conifer and spruce-fir vegetation types are anticipated to have local, beneficial, indirect, minor to moderate, long-term impacts to American peregrine falcon habitat by providing important openings for foraging in mixed-conifer and spruce-fir habitat types. The proposed mitigation measure to reassess fire treatments in mixed-conifer, if those fire acres have greater than 30% high to moderate/high severity fire, could decrease beneficial impacts of creating openings for the species, if the park determines in reassessment to stop fire treatments in this vegetation type.

18% of mixed-conifer and 36% of spruce-fir vegetation types are assumed would burn from suppression acres. Where moderate/high and high severity fire occur, impacts to this species would be beneficial, local, long term, and minor to moderate due to the forest openings.

As noted in Effects Common to All Alternatives, fire suppression activities could cause local, short-term negligible adverse effects to individuals.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Bald Eagle

Fire in spruce-fir and mixed-conifer vegetation types located at or near the North Rim boundary could have local, beneficial, long-term impacts with negligible to minor impact intensity. High severity burn areas would open these dense stands for foraging. Large snags nearby would increase beneficial impact. Fire treatments would reduce risk of future large high severity suppression fires. This would have indirect beneficial effects by decreasing potential for even-aged stand replacement. The proposed mitigation measure to reassess fire treatments in mixed-conifer if those fire acres have greater than 30% high to moderate/high fire severities could reduce beneficial impacts to eagles if reassessment stops or decreases fire treatments.

Treatments in the ponderosa pine vegetation type (both fire and non-fire) would have long-term, local, minor to moderate, beneficial impacts due to enhanced foraging habitat by retaining moderate canopy cover with an open understory.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Allen's Big-eared Bat

Alternative 2 would have the same effects as Alternative 1. This alternative would produce moderate canopy cover with an open understory in most of the ponderosa pine vegetation, a key habitat type for this species. This would have indirect, beneficial, long-term minor to moderate effects. It is anticipated the majority of fire treatments would be surface fire with low to low/moderate fire severity. Negative impacts to roosting trees in ponderosa pine would be unlikely. In addition, fire treatments would also have indirect, beneficial effects to this species by reducing risk of higher severity fires.

If this species uses ponderosa and piñon-juniper habitat in the WUI, non-fire treatments would also have long-term, local, negligible to minor, beneficial impacts to this species. Additional fire that might occur in the piñon-juniper habitat is proposed to be minimal in this alternative. Any beneficial or adverse impacts to this species would be negligible and local.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Pale Townsend's Big-eared Bat

Fire treatments in the mixed-conifer and spruce-fir vegetation types are anticipated to have local, beneficial, minor to moderate, long-term impacts to pale Townsend's big-eared bat foraging habitat by providing important openings and maintaining forest edges. As with the other species, fire and fire activities could cause local, short-term adverse impacts (mortality, displacement) with negligible effects.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Spotted Bat and Greater Western Mastiff Bat

Spotted bat and greater western mastiff bat normally forage along forest openings and in meadows. Based on forage habitat, this alternative would have very similar effects as the pale Townsends big-eared bat. Beneficial impacts would be local, long term and minor to moderate. As with other species, fire and fire activities could cause short-term adverse impacts (mortality and displacement) with negligible effects.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Long-legged Myotis

Proposed fire treatments and management strategies will provide disturbance factors that contribute to important foraging, roosting, and prey habitat maintenance and enhancement. Beneficial impacts from fire would include habitat restoration and maintenance, creation of roost trees and forested openings, and increases in prey species diversity and composition. Impacts would be local, long term, minor to moderate beneficial. Adverse impacts would include elimination of existing roost trees through burning and direct bat mortality. Impacts would be local, short term, negligible adverse.

As with the other species, fire and fire activities could cause local, short-term adverse impacts (mortality, displacement) with negligible effects.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Golden Eagle and Ferruginous Hawk

Very little treatment (less than 4%, including assumed suppression fire acreage) is proposed in piñon-juniper, a key habitat for these two species. Adverse and beneficial impacts noted in Effects Common to All Alternatives from this alternative to these two species would be local, short term negligible.

Direct and Indirect Effects Alternative 2 Special Status Wildlife Species
Swainson's Hawk

Fire treatments and fire suppression adjacent to meadows would help maintain meadow structure. Fire in mixed-conifer and spruce-fir vegetation types would open these stands. These effects would have local, long-term beneficial, minor to moderate impacts to Swainson's hawk habitat. The MSO mitigation to reassess fire treatments in mixed-conifer due to high to moderate/high fire severities could decrease these beneficial impacts if reassessment stops or decreases fire treatment in this vegetation type through the planning period.

Mitigation of Effects Alternative 2 Special Status Wildlife Species

Mitigation measures will decrease adverse impacts related to special status wildlife species. None of the adverse impacts in Alternative 2 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased.

Cumulative Effects Alternative 2 Special Status Wildlife Species

Overall, cumulative effects would not differ from Alternative 1, except that without the low severity only mitigation measure for mixed-conifer vegetation types, cumulative adverse impact to MSO, northern goshawk, and long-legged Myotis could be greater due to higher fire severities expected in prescribed and wildland fire-use fires in mixed-conifer and spruce-fir vegetation types.

Expected higher burn severity in mixed-conifer and spruce-fir vegetation types would have greater potential for special status wildlife species habitat disturbance and alteration. Impacts would vary in duration and intensity in different habitat types and for different affected species, but would be local in effect. Cumulative impacts to wildlife would be negligible to the upper end of moderate, depending on impact timing and extent. Compared to Alternative 1, Alternative 2 would reduce hazardous fuel levels and better restore historic fire regimes and fuel conditions to a larger park area. Thus Alternative 2 would have a greater long-term, beneficial cumulative effect by reducing risk of large scale, high intensity wildfires that could adversely impact special status wildlife species through habitat alteration.

Conclusion Alternative 2 Special Status Wildlife Species

Alternative 2 proposed similar treatment amounts in the same locations as Alternative 1, except for the increase of 30 acres of manual treatment, and introduction of mechanical treatment for 2,435 WUI acres. This alternative allows for all burn severities to occur in all vegetation types with a restriction of 30% overall moderate/high to high burn severity for mixed-conifer stands. If treatment acres are decreased due to the reassessment mitigation measure, mixed-conifer could be at higher risk for large, high burn severity fires. Special status wildlife species that prefer openings, grasslands, and/or meadows would realize long-term habitat benefits.

Special status wildlife that prefer moderate to high canopy cover with open understory in ponderosa pine would receive beneficial impacts (northern goshawk, Kaibab squirrel, California condor [perching habitat], bald eagle, Allen's big-eared bat, pale Townsend's big-eared bat, long-legged Myotis, Swainson's hawk).

Similar to all other alternatives, there would be no to negligible adverse or beneficial impacts to golden eagle or ferruginous hawk since very little piñon-juniper will be treated by this alternative.

Impairment — Alternative 2 — Special Status Wildlife Species

Since are no major adverse impacts in Alternative 2 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status wildlife during Alternative 2 implementation.

Unacceptable Impacts — Alternative 2 — Special Status Wildlife Species

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on special status wildlife as a result of Alterative 2 implementation.

4.2.5.17 Alternative 3 — Non-Fire Treatment Emphasis — Special Status Wildlife Species

Alternative 3 would change the existing direction of GRCA's fire management program toward inclusion of a large mechanical/manual treatment component, some prescribed fire (mainly on South Rim), and suppression programs. There would be approximately 4,000 acres non-fire treatment; 25,400 acres prescribed fire treatment; 8,800 acres wildland fire use; and 26,070 acres suppression over the planning period. There is an expected increase of suppression activities of approximately 6,000 acres above Alternatives 1 and 2. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects — Alternative 3 — Special Status Wildlife Species
Northern Goshawk

Alternative 3 provides the least amount of treatment in ponderosa and mixed-conifer vegetation types, important habitat for goshawks; therefore, this alternative would have the least beneficial effects to this species when compared to other alternatives. Areas treated in ponderosa pine (fire and non-fire) would have long-term, beneficial, minor to moderate, local impacts.

Only 12% of mixed-conifer would receive prescribed fire, very few acres of wildland fire use is assumed would occur with this alternative, and 24% of acres are assumed would burn from suppression fire. For acres that receive fire and areas that are moderate/high to high severity fire there would likely be local, long-term adverse, minor impacts to this species due to new openings and opening of canopy cover. As noted in Alternative 2, mitigation measures are proposed (4.2.5.16 and 4.2.5.14) where future fire treatments in mixed-conifer would be reassessed if the cumulative extent of high and moderate/high fire severity (of all fire in mixed-conifer) exceeds 30% of the vegetation type. This mitigation measure could reduce this adverse effect if reassessment ceases or decreases fire treatment in this vegetation type through the end of the planning period. However, risk for habitat burning with larger patches of high severity is greater over time through implementation of the 30% moderate/high severity mitigation measure. If these types of fires occur, impacts would be local, moderate, long term and adverse.

Fire and fire activities could cause local, short-term adverse impacts (mortality, displacement) with negligible effects.

Direct and Indirect Effects — Alternative 3 — Special Status Wildlife Species
Mexican Spotted Owl

Fire treatment in the mixed-conifer vegetation type would have the greatest potential effect to MSO. As noted under impacts to northern goshawk, a portion of mixed-conifer vegetation is anticipated to receive some form of fire treatment which could produce larger burned patch size than occurred historically. This would have local, long-term, minor adverse impacts to MSO protected and restricted habitat. However, no MSO pairs/nests have been detected in this designated habitat in over ten years of survey. Existing monitoring and survey work have detected no population decreases from a decade of fire management activities on both GRCA rims. A mitigation measure is proposed (4.2.5.14) where future treatments in mixed-conifer would be reassessed if the cumulative extent of high and moderate/high fire severity (of all fire in mixed-conifer) exceeds 30% of the vegetation type. This mitigation measure could reduce proposed adverse effects, but should fire treatments cease (because of this measure) prior to treating much of this vegetation type, there would be higher risk for large, high severity future fires.

Approximately 24% of mixed-conifer habitat is assumed would burn as suppression fire. With current fuel loading, fire is expected to produce a mix of burn severity patches from unburned to high severity. Impacts would depend on size and extent of high severity burn patches. Expectations are this would have local, long-term, minor adverse impacts to mixed-conifer habitat.

Should fire occur in occupied PACs, there would be local, short-term, negligible to minor adverse impacts from fire suppression activities; local, short- and possibly long-term minor to moderate adverse impacts to habitat.

Direct and Indirect Effects — Alternative 3 — Special Status Wildlife Species
California Condor

Very little treatment is proposed in potential condor habitat. Treatment is focused in the South Rim WUI. There would also be a small amount of non-fire treatment on North Rim. Effects from these treatments would have negligible impacts to condor habitat.

This alternative proposes the largest acreage treated by manual/mechanical means. Proposed non-fire treatments could encourage condors to investigate disturbances. This local, short-term, adverse impact is very unlikely since there is already heavy WUI human activity, and condors have not visited these sites. Non-fire treatments on North Rim have a higher risk of condor/human interaction, but overall impacts would be negligible.

As noted in Effects Common to All Alternatives fire suppression activities could cause local, short-term negligible adverse effects to individuals.

Direct and Indirect Effects — Alternative 3 — Special Status Wildlife Species
Kaibab Squirrel

Alternative 3 proposes very little treatment in North Rim Kaibab squirrel habitat, and only 6% of the entire ponderosa pine vegetation type would be impacted by suppression fire. This alternative would have negligible impact to the Kaibab squirrel. Squirrel habitat would become vulnerable to higher severity suppression fires in the future. Should this occur, there would be local, long-term, minor adverse impact to squirrel habitat.

Direct adverse impacts from displacement or disturbance from fire and/or fire management activities would be local, short term, negligible and adverse.

Direct and Indirect Effects Alternative 3 Special Status Wildlife Species
American Peregrine Falcon

Fire treatments and suppression fires in mixed-conifer and spruce-fir vegetation types could have local, beneficial, indirect, minor to moderate, long-term impacts to American peregrine falcon habitat by providing important openings for foraging. The total amount of treatment and suppression fire is the least of all alternatives; therefore, these beneficial impacts would be least compared with the other alternatives.

This alternative provides highest risk for future large, high severity fires. Should these fires occur, they would have local, long-term, minor to moderate, beneficial impacts to this species.

Direct and Indirect Effects Alternative 3 Special Status Wildlife Species
Bald Eagle

Treatments in the ponderosa pine vegetation type (both fire and non-fire) would have long-term, local, negligible to minor, beneficial impacts due to enhanced foraging habitat by retaining existing forest canopy cover with an open understory.

High severity fire areas in spruce-fir and mixed-conifer vegetation types located at or near the North Rim boundary could have local, beneficial, long-term impacts with negligible to minor impact intensity. These high severity areas would open stands for foraging. Large snags nearby would increase beneficial impact. Fire treatments would reduce risk of future large high severity suppression fires. The proposed mitigation measure to reassess fire treatments in mixed-conifer, if cumulative fire acres have greater than 30% high to moderate/high burn severities, could reduce beneficial impacts to eagles if reassessment stops or decreases fire treatment in these vegetation types.

As noted earlier, this alternative provides the least amount of treated acres when compared with other alternatives. Beneficial and adverse impacts noted above would be less due to fewer acres treated. In addition, this alternative provides highest risk for future large, high severity fires. Should these fires occur, they would overall have negligible to minor, local, long-term adverse impacts to this species.

Direct and Indirect Effects Alternative 3 Special Status Wildlife Species
Allen’s Big-eared Bat

In areas that receive treatments in ponderosa pine and piñon-juniper vegetation types, the outcome of producing moderate canopy cover with an open understory would have local, beneficial, long-term, minor impacts to this species. Because the amount of area proposed for treatment is lowest of all alternatives, this beneficial impact would be lowest when compared with other alternatives.

This alternative provides highest risk for future large, high severity suppression fires. Should these fires occur, they would have negligible to moderate, local, long-term adverse impacts to this species. Risk to this species is much lower than other alternatives because ponderosa pine and piñon-juniper are unlikely to produce large, high severity burn patches with current fuel loading.

Direct and Indirect Effects Alternative 3 Special Status Wildlife Species
Pale Townsend’s Big-eared Bat, Spotted Bat, and Greater Western Mastiff Bat

Fire treatments and suppression fires in mixed-conifer and spruce-fir vegetation types are anticipated to have local, beneficial, indirect, minor to moderate, long-term impacts to pale Townsend’s big-eared bat, spotted bat, and greater western mastiff bat foraging habitat by providing important openings and maintaining forest edges. The proposed mitigation measure to reassess fire treatments in mixed-conifer, if cumulative fire acres have greater than 30% high to moderate/high fire severities, could decrease beneficial impacts from creation of openings, should reassessment cease or decrease fire treatment in this vegetation type. As noted earlier, Alternative 3 proposes very little treatment in this vegetation type; therefore, the mitigation measure would likely have negligible overall effect.

Direct adverse impacts from displacement or disturbance from fire and/or fire management activities would be local, short term, negligible and adverse

Direct and Indirect Effects **Alternative 3** **Special Status Wildlife Species**
Long-legged Myotis

Proposed fire treatments and management strategies will provide disturbance factors that contribute to important foraging, roosting, prey habitat maintenance and enhancement. Beneficial impacts from fire would include habitat restoration and maintenance, creation of roost trees and forested openings, and increases in prey species diversity and composition. Impacts would be local, long term, minor and beneficial. Adverse impacts would be elimination of existing roost trees through burning, and direct bat mortality. Impacts would be local, short term, negligible and adverse.

Direct adverse impacts from displacement or disturbance from fire and/or fire management activities would be local, short term, negligible adverse

This alternative provides highest risk for future large, high severity suppression fires. Should these fires occur, they would have minor to moderate local long-term adverse impacts to this species.

Direct and Indirect Effects **Alternative 3** **Special Status Wildlife Species**
Golden Eagle and Ferruginous Hawk

Very little treatment (less than 4% including assumed amount of suppression fire) is proposed in the piñon-juniper, a key habitat for these two species. Adverse and beneficial impacts noted in Effects Common to All Alternatives from this alternative would have to these two species would be local, short term and negligible.

Direct and Indirect Effects **Alternative 3** **Special Status Wildlife Species**
Swainson's Hawk

Very little treatment is proposed on North Rim. Where fire treatment or suppression fires occur in mixed-conifer and spruce-fir vegetation types, and depending on size and extent of burned patches from fire, these areas could have local, beneficial, long-term, minor to moderate impacts to the hawk by opening canopy cover and understory. The MSO mitigation measure to reassess fire treatments in mixed-conifer, due to high to moderate/high fire severities in mixed-conifer, could decrease beneficial impacts should reassessment cease or decrease fire treatment in this vegetation type.

This alternative provides highest risk for future large, high severity suppression fires. Should these fires occur, they would have negligible to moderate, local, long-term adverse impacts to this species.

Mitigation of Effects **Alternative 3** **Special Status Wildlife Species**

Mitigation measures will decrease adverse impacts related to special status wildlife species. None of the adverse impacts in Alternative 3 were considered major (significant), but if mitigation measures are implemented, adverse impacts would be further decreased.

Cumulative Effects **Alternative 3** **Special Status Wildlife Species**

Cumulative impacts would be similar to those described under Alternative 2, except addition of mechanical fuels reduction treatments may slightly increase potential for disturbance and alteration of habitats used by special status wildlife species in WUI areas. These impacts would vary in duration and intensity in different habitat types and for different affected species, but would be mainly local in effect. Compared to Alternative 2, addition of mechanical fuels reduction treatments in WUI areas would reduce hazardous fuel levels and restore more natural conditions and fire regimes to this relatively small park area; however, reduced amounts of prescribed and wildland fire-use projects would result in a reduction of approximately 50% in beneficial long-term effects. Thus Alternative 3 would have a reduced long-term, beneficial cumulative effect on special status wildlife species through reduced risk of large scale, high intensity wildfires than the other alternatives.

Conclusion **Alternative 3** **Special Status Wildlife Species**

Because Alternative 3 minimizes fire treatments, this alternative would continue the trend out of natural range of variability for mixed-conifer, spruce-fir, and to a lesser extent, ponderosa pine vegetation types. MSO, which favors closed canopies with midstory, would receive short-term benefit from this alternative. All other species that prefer habitat with canopy cover and open understory on North Rim would receive indirect adverse effects due to no fire treatments (Kaibab squirrel, northern goshawk, long-legged Myotis, bald eagles, Allen's big-eared bat, pale Townsend's big-eared bats, California condor [perching habitat], Swainson's hawk). This alternative provides greatest risk for large, high severity suppression fires, especially on North Rim, due to increased fuels build-up during the planning period. Should large, high severity suppression fires occur, adverse impact could be moderate to major and regional depending on location, size, and what special status wildlife species might be affected. Special status wildlife species that prefer openings, grasslands and/or meadows, would have local, long-term, minor to moderate beneficial impacts from habitat modifications from fire.

Similar to all other alternatives, there would be no to negligible adverse or beneficial impacts to golden eagle or ferruginous hawk since very little piñon-juniper will be treated by this alternative.

Impairment **Alternative 3** **Special Status Wildlife Species**

Since are no major adverse impacts in Alternative 3 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status wildlife during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Special Status Wildlife Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on special status wildlife as a result of Alterative 3 implementation.

4.2.5.18 Alternative 4 Prescribed Fire Emphasis Special Status Wildlife Species

Alternative 4 would change the existing direction of GRCA's fire management program by expanding prescribed fire. There would be approximately 800 acres non-fire treatment; 90,000 acres prescribed fire; 5,500 acres wildlife fire use; and 24,070 acres suppression over the planning period—a substantial increase in prescribed fire treatment acreage from historical averages. The alternative is described in Chapter 2.

Direct and Indirect Effects **Alternative 4** **Special Status Wildlife Species**
Northern Goshawk

Amount of fire treatment in mixed-conifer and ponderosa pine is less than proposed in Alternative 2 (approximately 65% in ponderosa pine and 62% in mixed-conifer). Indirect and direct impacts to goshawk would be the same as Alternative 2, but to a lesser extent since fewer acres would be treated. Impacts in ponderosa pine habitat would be indirect, moderate, beneficial, and long term to northern goshawk foraging areas and nesting habitat. Impacts to mixed-conifer habitat would be local, long term, adverse, and minor to moderate impact intensity. A proposed mitigation measure (4.2.5.14) where fire treatments would be reassessed if cumulative extent of high and moderate/high fire severity of all fire in mixed-conifer exceeds 30% of the vegetation type could reduce this adverse effect, but should fire treatments cease (because of this measure) prior to treating much of this vegetation type, there would be higher risk of future large, high severity suppression fires. Suppression fires (estimated to cover 22% of this vegetation type) would cause local, long-term, adverse, minor to moderate impact to northern goshawk habitat from expected habitat alterations.

Any fire types and fire suppression activities could have local, short-term, negligible to minor adverse impacts to nesting sites and individuals.

Non-fire treatments would be the same as Alternative 2. If treatments occur near occupied nests, the effect would have local, short-term, negligible adverse impacts.

Direct and Indirect Effects **Alternative 4** **Special Status Wildlife Species**
Mexican Spotted Owl

Impacts to mixed-conifer habitat would be the same as Alternative 2 but to a slightly lesser extent due to fewer acres treated. Fire treatment in the mixed-conifer vegetation type would have greatest potential effect to MSO. Fire treatment could produce larger burned patch size than occurred historically. This would have local, long-term, minor adverse impacts to MSO protected and restricted habitat. However, no MSO pairs/nests have been detected in this designated habitat in over ten years of survey. Existing monitoring and survey work have detected no population decreases from a decade of fire management activities on both GRCA rims. A proposed mitigation measure (4.2.5.14) where future treatments in mixed-conifer would be reassessed if the cumulative extent of high and moderate/high fire severity of all fire in mixed-conifer exceeds 30% of the vegetation type could reduce proposed adverse effects, but should fire treatments cease (because of this measure) prior to treating much of this vegetation type, there would be higher risk for future large, high severity fires.

Approximately 22% of mixed-conifer habitat is assumed would burn as suppression fire. With current fuel loading, fire is expected to produce a mix of burn severity patches from unburned to high burn severity. Impacts would depend on size and extent of high severity patches. Expectations are this would have local, long-term, minor adverse impacts to mixed-conifer habitat.

If fire occurs in occupied PACs, there would be local, short-term, negligible to minor adverse impacts due to fire suppression activities; local, short- and possibly long-term minor to moderate adverse impacts to habitat.

Direct and Indirect Effects **Alternative 4** **Special Status Wildlife Species**
California Condor

Prescribed fire treatment and suppression fires in mixed-conifer and spruce-fir vegetation types would open these dense stands, having local, direct, long-term, minor to moderate beneficial impacts to condor foraging habitat and possible local, long-term, negligible to minor adverse impacts to roosting habitat. The proposed mitigation measure to reassess fire treatments in mixed-conifer if cumulative extent of high and moderate/high severity fire exceeds 30% of the vegetation type could reduce beneficial impacts to foraging habitat and adverse impacts of roost tree loss if reassessment ceases or decreases fire treatment.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Kaibab Squirrel

Approximately half the Kaibab squirrel habitat would be treated with prescribed fire in Alternative 4. In areas treated, impacts are anticipated to be long term, local, and minor to moderate beneficial as long as large portions of habitat retain forest canopy cover where tree crowns interlace.

Where fire treatments occur, there would be decreased risk for large, high severity fires that could produce long-term, local, moderate adverse impacts to squirrel habitat. Areas that do not receive treatment or suppression fires would be more vulnerable to higher severity fires.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
American Peregrine Falcon

Approximately 62% mixed-conifer and 27% spruce-fir vegetation types are proposed for prescribed treatment. In addition, approximately 22% mixed-conifer and 43% spruce-fir are assumed to burn as suppression fire. These fires would have local, beneficial, long-term, minor to moderate impact to peregrines by opening dense forest stands. Should the mitigation measure cease or decrease treatment in mixed-conifer, it would decrease effects, and untreated areas would be at higher risk for large, high severity fires. Should these fires occur, impacts would be local, long term, minor to moderate beneficial.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Bald Eagle

Prescribed fire treatment and suppression fires in spruce-fir and mixed-conifer vegetation types near the North Rim boundary could have both beneficial and adverse impacts to bald eagle habitat. Bald eagles prefer open areas with large trees for roosting habitat. Prescribed fire in spruce-fir would likely produce forest openings and low canopy cover after treatment. Openings would have some beneficial impacts to habitat depending on roost tree retention. Impacts generally would be local, minor to moderate, long term beneficial. If the mitigation measure related to mixed-conifer and MSO is approved, it could decrease effects if reassessment ceases or decreases fire treatment in this vegetation type during life of the plan.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Allen's Big-eared Bat

Approximately 54% of ponderosa pine forest type would receive prescribed fire treatment and 9% would receive wildland fire-use fire from this alternative. In addition, approximately 5% is assumed to burn as suppression fire. Overall, fire would have local to regional, beneficial, long-term minor to moderate effects by retaining current tree canopy cover with an open understory. As with the other alternatives, there could be direct, adverse impacts to this species during fire treatments, suppression fire, and/or suppression activities through disturbance and habitat modification. These adverse effects would be local, short term with negligible effect. Areas not treated would be more vulnerable to higher severity fires. Should this occur, adverse impact would be local, long term, and negligible to minor through alteration of preferred habitats.

This alternative proposes the most treatment to piñon-juniper habitat (approximately 10% including suppression fire acres). Impacts from proposed habitat modification would likely be local, long term, and negligible to minor beneficial.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Pale Townsend's Big-eared Bat, Spotted Bat, and Greater Western Mastiff Bat

Prescribed fire and suppression fires in mixed-conifer and spruce-fir vegetation types would produce openings in dense stands providing foraging habitat to these species. In addition, fires would maintain forest edges. Impacts from these effects would be local, long term, beneficial, negligible. If the mitigation measure proposed to minimize adverse MSO impacts in mixed-conifer is approved, and reassessment ceases or decreases fire treatment in this type, effects could be decreased.

As with other species and alternatives, fire and suppression activities could cause local, short-term, negligible, adverse impacts from disturbance and/or displacement.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Long-legged Myotis

Proposed fire treatments and management strategies will provide disturbance factors that contribute to important foraging, roosting, and prey habitat maintenance and enhancement. Beneficial fire impacts would include habitat restoration and maintenance, creation of roost trees and forested openings, and increases in prey species diversity and composition. Impacts would be local, long term, minor beneficial. Adverse impacts would eliminate existing roost trees through burning and direct bat mortality. Impacts would be local, short term, negligible adverse.

Direct adverse impacts from displacement or disturbance from fire and/or fire management activities would be local, short term, negligible and adverse

The highest risk for Myotis habitat is future large, high severity fires. Should these fires occur, they would have minor to moderate, local, long-term adverse impacts to this species.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Golden Eagle and Ferruginous Hawk

Little treatment (less than 10% including assumed suppression fire) is proposed in the piñon-juniper vegetation type, a key habitat for these two species. Though this alternative proposes the most treatment to this vegetation type, adverse and beneficial impacts noted in Effects Common to All Alternatives from this alternative would be local and negligible to these two species.

Direct and Indirect Effects Alternative 4 Special Status Wildlife Species
Swainson's Hawk

As noted earlier, 62% of mixed-conifer and 27% of spruce-fir vegetation types would receive prescribed fire. These sites, along with suppression fires in mixed-conifer (22%) and spruce-fir (43%) vegetation types, would produce openings and open canopies in dense stands. Depending on size and extent of burned patches, these areas could have local, beneficial, long-term, minor to moderate impacts to the hawk by opening canopy cover and understory. The proposed mitigation measure in mixed-conifer for MSO could reduce beneficial impacts to the hawk if reassessment ceases or decreases fire treatment in mixed-conifer vegetation type during the life of the plan.

Mitigation of Effects Alternative 4 Special Status Wildlife Species

Mitigation measures may decrease adverse impacts related to special status wildlife species. None of the adverse impacts in Alternative 4 were considered major (significant), but if mitigation measures are implemented adverse impacts could be further decreased. The 30% moderate/high burn severity restriction mitigation may increase adverse effects to special status wildlife species long term.

Cumulative Effects **Alternative 4** **Special Status Wildlife Species**

Overall, cumulative effects would not differ from Alternative 1. Mixed-conifer and spruce-fir vegetation types would likely burn at higher fire severity. This alternative would likely maintain fire regimes and desired conditions for most ponderosa pine habitats, but not piñon-juniper, mixed-conifer, or spruce-fir. Impacts to special status wildlife species would be minimal short term. Adverse impacts to special status wildlife species may increase over time under this alternative.

Conclusion **Alternative 4** **Special Status Wildlife Species**

Alternative 4 emphasis is prescribed fire. Prescribed fire treatments are proposed equally on North and South Rims. This alternative proposes the most prescribed fire in mixed-conifer (62%) compared with other alternatives, but it is unlikely any wildland fire use would occur in this vegetation before fire prescription treatments occur. Analysis shows under mild fire weather conditions 26% of mixed-conifer could produce crown fire with prescribed fire (Table 4-20). If these crown fires produce high severity patches larger than five acres, this could have long-term adverse effects to special status wildlife species that prefer closed canopy mixed-conifer and/or spruce-fir habitat types (MSO, northern goshawk, California condor [perching habitat]). Adverse impacts would be moderate, local, long term. Proposed MSO mitigation measures in mixed-conifer could decrease impact for those areas affected, but with the reassessment mitigation measure there is a possibility proposed acres would not be treated and would be vulnerable to future large, high severity fires with greater adverse effects. Without mitigation measures, special status wildlife that prefer open areas would receive local, long-term, moderate beneficial impacts (California condor [foraging], peregrine falcon, spotted bat, greater western mastiff bat).

The majority of prescribed fires would occur in the ponderosa pine vegetation type (55%), but total areas treated are less than other alternatives except Alternative 3 because of the wildland fire use limitation. Those areas that receive fire would likely burn at low to low/moderate fire severity for all fire types. Fire in this vegetation type would benefit special status wildlife species that prefer moderate canopy cover with open understories (Kaibab squirrel, California condor [perching habitat], bald eagle, Allen's big-eared bat, pale Townsend's big-eared bat, long-legged Myotis, Swainson's hawk).

Similar to all other alternatives, there would be no to negligible adverse or beneficial impacts to golden eagle or ferruginous hawk since very little piñon-juniper will be treated by this alternative.

Impairment **Alternative 4** **Special Status Wildlife Species**

Since are no major adverse impacts in Alternative 4 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status wildlife during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Special Status Wildlife Species**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on special status wildlife as a result of Alterative 4 implementation.

4.2.5.19 Alternative 5 **Fire Use Emphasis** **Special Status Wildlife Species**

Alternative 5 shifts the fire management program to restore and maintain forest types with wildland fire use (88,000 acres). With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative aims to deemphasize prescribed fire treatments, treating 29,900 acres. Mechanical and manual treatments would include 2,675 acres, and would occur in the WUI and along Highway 67 on North Rim. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Northern Goshawk

Impacts to ponderosa pine habitat for goshawk would be the same as Alternatives 1 and 2. Anticipated fire treatments in ponderosa pine would mainly produce low to low/moderate fire severity and very little crown fire where the majority of area treated would have moderate canopy cover with open understory. This would produce local, indirect, moderate, beneficial, long-term impacts for northern goshawk foraging areas and nesting habitat. In addition, treatments would reduce risk of higher fire severity, keeping this vegetation type in its fire regime of frequent, low severity fires.

Approximately 24% of mixed-conifer is proposed for prescribed fire, 47% is assumed would burn as wildland fire use, and approximately 17% is assumed would burn as suppression fire. Based on Table 4-7 moderate/high to high severity burn in this vegetation type would be similar for both prescribed and wildland fire-use fires (approximately 30%). Suppression fires are anticipated to burn at higher fire severities (approximately 40%). In these areas, habitat would be adversely impacted depending on size and extent of burned area patches. This impact would be local, long term, adverse minor to moderate. A mitigation measure is proposed (4.2.5.14) where future treatments in mixed-conifer would be reassessed if the cumulative extent of high and moderate/high fire severity of all fire in mixed-conifer exceeds 30% of the vegetation type. This measure could reduce adverse effect if reassessment ceases or decreases fire treatment in this vegetation type during life of the plan. In the long term, large high severity fire risk would increase with possible local, long-term, moderate adverse impacts to habitats.

At most 71% of mixed-conifer would receive fire treatment, and an additional 17% would burn under suppression fires. Areas that received no fire during this planning period would be at higher risk for large, high severity fires. If these fires occurred, adverse impact would be local, long term, minor to moderate.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Mexican Spotted Owl

Approximately 24% of mixed-conifer is proposed for prescribed fire, 47% is assumed to burn as wildland fire use, and approximately 17% is assumed to burn as suppression fire. In areas that have moderate/high to high burn severity, habitat would be adversely impacted depending on size and extent of high severity burned patches. This would have local, adverse, minor to moderate impacts to MSO protected and restricted habitat. A mitigation measure is proposed (4.2.5.14) where future mixed-conifer treatments would be reassessed if cumulative extent of moderate/high and high fire severity of all fire in mixed-conifer exceeds 30% of the type. This mitigation measure could reduce this adverse effect should reassessment cease or decrease fire treatment in this vegetation type, but should fire treatments cease (because of these measures) prior to treating much of this vegetation type, there would be higher future risk for large, high severity suppression fires.

Approximately 12% of this habitat type would receive no treatment (fire, manual/mechanical). There would be higher risk for large, high severity fires. If these fires were to occur, adverse impacts would be local, long term, and minor to moderate.

If fire occurs in occupied PACs, there would be local, short-term, negligible to minor adverse impacts due to fire suppression activities; local, short- and possibly long-term minor to moderate adverse impacts to habitat.

Direct and Indirect Effects **Alternative 5** **Special Status Wildlife Species**
California Condor

Where prescribed and suppression fires occur in mixed-conifer and spruce-fir vegetation types, openings would likely occur. These openings would have local, long-term, minor to moderate beneficial effects to condor foraging habitat. Like other alternatives, this could also have local, long-term, negligible to minor adverse impact by reducing perching trees.

Direct and Indirect Effects **Alternative 5** **Special Status Wildlife Species**
Kaibab Squirrel

It is assumed the majority of ponderosa pine would receive some form of fire (prescribed 21%; wildland fire use 71%; suppression 4%). These areas would include Kaibab squirrel habitat located entirely in ponderosa pine. Impacts would be similar to Alternatives 1 and 2. Overall, impacts are anticipated to be long term, regional, minor to moderate, beneficial as long as large portions of habitat retain current tree canopy cover where tree crowns interlace. Additionally, fire treatments would decrease potential for large, high intensity fires that may adversely impact preferred habitats.

Direct adverse impacts during fires causing displacement or disturbance would be local, negligible, and short term, lasting the duration of the fire activity.

Direct and Indirect Effects **Alternative 5** **Special Status Wildlife Species**
American Peregrine Falcon

As with the other alternatives, fire treatments in mixed-conifer and spruce-fir vegetation types are anticipated to have local, beneficial, indirect, minor to moderate, long-term impacts to American peregrine falcon habitat by providing important openings for foraging in mixed-conifer and spruce-fir. If the proposed mitigation measure to reduce adverse impacts to MSO in mixed-conifer is approved, these beneficial impacts could decrease if reassessment ceases or decreases fire in the mixed-conifer vegetation type; therefore, minimizing opening creation.

17% of mixed-conifer, and 32% of spruce-fir vegetation types are assumed would burn from suppression fires. Where moderate/high and high severity fire occur, impacts to this species would be beneficial, local, long term, minor to moderate due to increased foraging habitats.

As noted in Effects Common to All Alternatives, fire suppression activities could cause local, short-term adverse effects to individuals.

Direct and Indirect Effects **Alternative 5** **Special Status Wildlife Species**
Bald Eagle

Impacts in South and North Rim habitat would be very similar to Alternative 3. Treatments during winter on South Rim could have direct adverse impacts to bald eagles from prescribed fire or non-fire treatment human activity that would be local, short term, negligible. Treatments in ponderosa pine (both fire and non-fire) would have long-term, local, minor to moderate, beneficial impacts due to enhanced foraging habitat retaining moderate canopy cover with open understory.

High severity burn patches in spruce-fir and mixed-conifer vegetation types located at or near the North Rim boundary could have local, beneficial, long-term impacts with negligible to minor impact intensity. These high severity areas would open dense stands for foraging. Large snags nearby would increase beneficial impact. Fire treatments would reduce risk of future large high severity suppression fires. This would have indirect beneficial effects by decreasing potential for even-aged stand replacement. The mitigation measure proposed to reduce adverse impacts to MSO in mixed-conifer could reduce beneficial impacts to eagles if reassessment ceases or decreases fire treatment in this vegetation type.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Allen's Big-eared Bat

Because of the fire amount anticipated in ponderosa pine vegetation for this alternative, impacts would be similar to Alternatives 1 and 2. Fire would likely produce moderate canopy cover with open understory in most of this forest type, a key habitat type for this species. This would have regional, beneficial, long-term minor to moderate effects. It is anticipated the majority of fire treatments (majority wildland fire use) would be surface fire with low to low/moderate fire severity. Impacts to roosting trees in ponderosa pine would be unlikely. In addition, fire treatments would also have indirect, beneficial effects to this species by reducing risk of higher severity fires. There could be direct, local, adverse impacts to this species during fire treatments, suppression fire, and/or suppression activities due to disturbance. These adverse effects would be short term with negligible effect.

Very little treatment is proposed in piñon-juniper, another habitat type for this species (less than 4%, including assumed fire suppression acres). Any beneficial or adverse effects from this treatment would be local short to long term negligible.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Pale Townsend's Big-eared Bat, Spotted Bat and Greater Western Mastiff Bat

Fire treatments and suppression fires in mixed-conifer and spruce-fir vegetation types would have local, beneficial, long-term, minor to moderate impacts to habitat by providing important vegetation openings and maintaining forest edges and meadow structure. If the proposed mitigation measure to reduce adverse impacts to MSO in mixed-conifer is approved, beneficial impacts could decrease if reassessment ceases or decreases fire treatment, minimizing openings.

Because at least 40% of this habitat type would receive no fire or non-fire treatment with this alternative, there would be higher risk for large, high severity fires. If these fires occur, adverse impacts from habitat modifications would be local, long term, minor to moderate.
As with the other species, fire and fire activities could cause local, short-term adverse impacts from disturbance and/or displacement. These impacts would have negligible effects.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Long-legged Myotis

Proposed fire treatments and management strategies will provide disturbance factors that contribute to important foraging and roosting habitat and prey habitat maintenance and enhancement. Beneficial impacts from fire would include habitat restoration and maintenance, creation of roost trees and forested openings, and increases in prey species diversity and composition. Impacts would be local, long term, minor beneficial. Adverse impacts would be elimination of existing roost trees through burning and direct bat mortality. Impacts would be local, short term, negligible adverse.

Direct adverse impacts from displacement or disturbance from fire and/or fire management activities would be local, short term, negligible adverse.

The highest risk for Myotis habitat is future large, high severity fires. Should these fires occur, they would have minor to moderate, local, long-term adverse impacts to this species.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Golden Eagle and Ferruginous Hawk

Very little treatment (less than 4% including assumed amount of suppression fire) is proposed in piñon-juniper, a key habitat for these two species. Adverse and beneficial impacts noted in Effects Common to

All Alternatives to these two species would be local and negligible.

Direct and Indirect Effects Alternative 5 Special Status Wildlife Species
Swainson's Hawk

As with the other alternatives, fire treatments adjacent to meadows would help maintain meadow structure. Fire in mixed-conifer and spruce-fir vegetation types would open these stands. These effects would have local, indirect, beneficial, minor to moderate impacts to Swainson's hawk habitat. The mitigation measure proposed to reduce potential adverse impact to MSO in mixed-conifer could decrease these beneficial effects if reassessment ceases or decreases fire treatment in this vegetation type.

Mitigation of Effects Alternative 5 Special Status Wildlife Species

Mitigation measures will decrease adverse impacts related to special status wildlife species. None of the adverse impacts in Alternative 5 were considered major (significant), but if mitigation measures are implemented adverse impacts would further decrease. If the 30% moderate/high burn severity mitigation restriction is implemented, and fire management options are reduced or ended, beneficial impacts from proposed management strategies to Swainson's haws, condors, bald eagles, Kaibab squirrels, peregrines, and various bats species would be reduced.

Cumulative Effects Alternative 5 Special Status Wildlife Species

Overall, cumulative effects would not differ from Alternative 1. Mixed-conifer and spruce-fir vegetation types would likely burn at higher fire severity, but treatment in these two vegetation types is decreased. Because fire-use and prescribed fire are minimized in both vegetation types, there would be higher risk of high severity suppression fires when compared to other alternatives; therefore, cumulative adverse effects to these vegetation types could be greater.

Conclusion Alternative 5 Special Status Wildlife Species

Alternative 5 would focus on wildland fire-use treatment. Impacts would be similar to Alternative 2. This alternative would directly affect fewer acres in mixed-conifer than Alternative 2, but impacts would be similar to special status wildlife species that have habitat in this vegetation type.

The focus of wildland fire use would be in ponderosa pine. Because 76% of this vegetation type is at low or low/moderate departure from historic fire regime, this alternative would continue the trend toward the natural range of variability. Special status species that prefer moderate to high tree canopy cover with an open understory in ponderosa pine would likely benefit most from this alternative. These species include northern goshawk, Kaibab squirrel, California condor (perching habitat), bald eagle, Allen's big-eared bat, pale Townsend's big-eared bat, long-legged Myotis, and Swainson's hawk.

Similar to the other alternatives, there would be no to negligible adverse or beneficial impacts to golden eagle or ferruginous hawk since very little piñon-juniper will be treated by this alternative.

Impairment Alternative 5 Special Status Wildlife Species

Since are no major adverse impacts in Alternative 5 to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair special status wildlife during Alternative 5 implementation.

Unacceptable Impacts Alternative 5 Special Status Wildlife Species

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on special status wildlife as a result of Alterative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Special Status Wildlife Species**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternative 1 would have negligible impacts to MSO habitat in fire treated areas. Alternative 1 would have adverse minor to moderate local, long-term impacts to MSO habitat where suppression fires occur in the mixed-conifer forest type.

Alternatives 2-5 would have adverse, minor, local, long-term impacts to MSO habitat in fire treated areas, and adverse, minor, local, long-term impacts to MSO habitat where suppression fires occur in the mixed-conifer forest type.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Special Status Wildlife Species**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

There would be no irreversible or irretrievable commitments of resources.

4.3 Cultural Resources

4.3.1 Guiding Regulations and Policies **Cultural Resources**

Federal Statutes
- The Antiquities Act of 1906 (34 Stat. 225)
- The Historic Sites Act of 1935 (49 USC 303)
- The National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)
- The Archaeological and Historic Preservation Act of 1974 (16 USC 469 et seq.)
- The American Indian Religious Freedom Act (AIRFA) of 1978 (42 USC 1996)

Executive Orders
- Executive Order 11593
- Executive Order 13007

National Park Service Policies, Director's Orders
- Director's Order 28A (DO 28A), Archeology
- Director's Order 58 (DO-58), Structural Fire Management, Section V.D., Cultural Resources

See Appendix A for more information.

4.3.2 Management Objectives — Cultural Resources

Management objectives for the proposed FMP are in Chapter 1. Objectives for cultural resources as they relate to fire management in Grand Canyon are

- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and limit spread of invasive plant species
- Conduct research to understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the Fire Management Program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, and fuel reduction treatments) to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions, fire treatment priorities and prescriptions as relevant data become available
- Maintain government-to-government and informal relationships with Native American tribes to exchange knowledge about fire management and traditional cultural practices
- To the greatest degree possible, collaborate with interested tribes in fire projects. An example could include allowing designated tribal representatives to monitor effects to resources, and have pre-project access to ethnobotanical resources

4.3.3 Methodology for Analyzing Effects — Cultural Resources

Cultural resources inventory and monitoring is an ongoing NPS program. 3% of GRCA lands have been systematically surveyed; 14% of the park lands within the FMUs containing planned fire management activities (above the rims) have been surveyed. Pedestrian surveys were primarily conducted in developed and recreational areas, the river corridor, and in prescribed fire project areas. Currently, the principal data source for rim sites is the Grand Canyon Archaeological Database. This database shows 3,646 sites exist in Fire Management Units, and was used in calculating site distribution for this document.

To analyze each alternative's effects on cultural resources, all available information was considered. Impact analysis was based on interaction of fire context, duration, timing, intensity, and fire management actions to cultural resources, and was completed for each category of cultural resources (archeological sites, historic structures, cultural landscapes, and ethnographic resources). Impact intensity, both regional and local, was defined using resource-specific impact thresholds. All cultural resources are assumed eligible for inclusion on the National Register of Historic Places (NRHP) until evaluated otherwise.

Archeological Sites — Methodology — Cultural Resources

Analysis of environmental consequences of fire and fire management actions on archaeological sites was based on expertise of GRCA cultural resource staff and other professional archaeologists, examination of site files maintained by the fire management program and Cultural Resources Branch of the Science and Resource Management Division, and relevant literature. Literature consulted regarding fire effects on cultural resources included, but was not limited to, Bibliography of Fire Effects on Cultural Resources (Rude and Jones 2001) and sources cited therein. Specific references used were: Evaluating Fire Effects on Cultural Resources (Ryan 2001), Ignition and Burning Characteristics of Organic Soils (Hungerford et al. 1995), Fire Effects on Archaeological Resources, Phase 1 (Lentz et al. 1996), and The Dome Fire Archeology Project of 1996–1997 (Elliott et al 1999).

Estimates were calculated on park data to provide approximate site numbers in each FMU and different vegetation types. Appendix J estimates the numbers of archeological sites in different categories of fire severity, vegetation, and fire management actions and responses. All planned fire management actions would apply mitigation measures, reducing or eliminating adverse effects to cultural resources during planned fire management activities. Unplanned fire management actions and responses would be subject to mitigation measures when possible, and may or may not be successful. Total estimated site numbers in Table 4-29 combine planned and unplanned actions.

Table 4-29 Number of Archaeological Sites that may be Present by Proposed FMU

Fire Management Unit	Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper	Approximate Site Density For FMU
Backcountry Uplands	1,774.0	0	0	86,287.7	1 site/14.3 acres
Fire Islands	2,834.3	0	0	7,282.5	1 site/18.5 acres
Inner Canyon	2,385.3	3,594.6	463.7	191,507.4	1 site/18.2 acres
Kaibab Summit	0	490.0	15,515.0	0	1 site/183.7 acres
Peninsulas	37,368.9	6,797.3	16.0	4,131.9	1 site/42 acres
Plateau	4,452.4	26,655.1	1,595.4	166.9	1 site/116.3 acres
Secondary WUI	6,077.2	0	0	8,711.7	
WUI	4,589.8	12.9	0	7,988.4	
Approximate Site Density for Forest Type	1 site/18.1 acres	1 site /111.2 acres	Unknown (limited survey)	1 site/12.3 acres	**Average Site Density** 1 site/25.2 acres

Historic Structures **Methodology** **Cultural Resources**

The majority of GRCA's historic structures are located in developed areas. Some historic structures such as cabins and corrals are located in undeveloped areas. Analysis of environmental consequences of fire and fire management actions on historic structures is based on GRCA staff expertise, examination of the list of classified structures, documentation on GRCA historic districts listed on the National Register of Historic Places, and other park documents.

Ethnographic Resources **Methodology** **Cultural Resources**

Analysis of environmental consequences of fire and fire management actions on ethnographic resources is based on GRCA cultural resources staff and other professional anthropologists' expertise, consultation with affiliated tribes, and examination of relevant literature. Particularly valuable resources include an overview of ethnographic studies at GRCA (Neal and Gilpin 2000) and literature cited therein. Although no comprehensive studies to identify rim traditional cultural properties have been completed (Horn et al. 2004), ongoing communication between GRCA and affiliated tribes has resulted in identification of Traditional Cultural Properties on South Rim (Horn et al 2004).

Ethnographic resources can include archaeological sites, historic structures, cultural landscapes, geologic features, and important vegetation (ethno-botanical resources). Affiliated tribes had opportunities to comment on the Draft EIS, and will be invited as participants and signatories of a Programmatic Agreement for accomplishing Section 106 of the NHPA requirements.

Cultural Landscapes **Methodology** **Cultural Resources**

Analysis of environmental consequences of fire and fire management actions on cultural landscapes is based on expertise of GRCA cultural resource staff. Cultural Landscapes are based on existing historic districts listed on the National Register of Historic Places. Seven Cultural Landscapes are identified in GRCA. On South Rim: Grand Canyon Village, West Rim Drive, Desert View. On North Rim: Grand Canyon Lodge National Historic Landmark (NHL), Bright Angel Peninsula Historic District, North Rim Entrance Road Corridor. In the Inner Canyon: Indian Gardens Cultural Landscape. These Cultural Landscapes are in various states of documentation; ultimately, documentation for each landscape will include a cultural landscape inventory, report, and National Register nomination(s).

4.3.4 Impact Thresholds — Cultural Resources

Effects specific to cultural resources are characterized for each alternative based on impact thresholds presented below. Additionally, each alternative was evaluated to determine whether effects are direct or indirect. The following intensity descriptions reflect evaluations consistent with those described by the Advisory Council on Historic Preservation (36 CFR 800) relative to applying criteria of effect.

Intensity

Negligible — Impacts at the lowest detection levels with neither adverse nor beneficial consequences; historic properties receive no change to diagnostic artifacts, defining features, or characteristics that contribute to NRHP eligibility. Negligible impacts are barely perceptible and alter neither resource condition, such as traditional access and site preservation nor relationship between resource and affiliated group's body of practices and beliefs. Determination of effect for Section 106 would be "no historic properties affected"

Minor

Adverse — For archaeological sites and historic structures, impacts result in little, if any, loss of resource integrity. Minor impacts are measurable, but localized and do not result in changes to archaeological site or historic structure defining elements. Artifact depletion or displacement (based on baseline documentation) would not affect research potential or NRHP eligibility. The determination of effects for Section 106 would be "no adverse effect" to archaeological sites and historic structures

For ethnographic resources, impacts would be slight and noticeable, but would not appreciably alter resource conditions, such as traditional access and site preservation or relationship between resource and affiliated group's body of practices and beliefs. Determination of effect for Section 106 would be "no adverse effect" to ethnographic resources

For cultural landscapes, impacts would be detectable but would not affect a character-defining pattern or feature of a landscape district listed in or eligible for inclusion in the National Register. Determination of effect for Section 106 would be "no adverse effect" to cultural landscapes

Beneficial — Effects measurable and localized resulting in setting restoration and more natural ecological conditions resulting from fire frequency and timing, decrease in susceptibility to fire, and increased site landscape stability

Moderate

Adverse — For archaeological sites and historic structures impacts result in loss of integrity and detection of measurable changes to character-defining elements, artifact depletion, or displacement (based on baseline information), effects to elements having research potential, and increased site landscape instability. Moderate effects would jeopardize a site or structure's National Register eligibility. Determination of effect for Section 106 would be "adverse effect" to archaeological sites and historic structures

For ethnographic resources, impacts would be apparent and would alter resource conditions or interfere with traditional access, site preservation, or relationship between resource and affiliated group's practices and beliefs, even though the group's practices and beliefs would survive. Determination of effect on traditional cultural properties for Section 106 would be "adverse effect" to ethnographic resources

For cultural landscapes, impacts would alter a character-defining pattern or feature of the cultural landscape, but would not diminish district integrity to the extent that its National Register eligibility is jeopardized. Determination of effect on cultural landscapes for Section 106 would be "adverse effect" to cultural landscapes

In the event of an adverse effect determination, a Memorandum of Agreement would be executed between the NPS and the applicable state or tribal historic preservation officer and, if necessary, the Advisory Council on Historic Preservation in accordance with 36 CFR 800.6(b). Measures identified in the MOU to minimize or mitigate adverse impacts would reduce impact intensity under NEPA

Beneficial

For archaeological sites, effects measurable, and contribute to overall site landscape stability (e.g., reduction of onsite fuels)

For historic structures, beneficial effects would include decreasing susceptibility to fire and maintaining historic structure setting

For ethnographic resources, beneficial effects include maintaining natural ecosystem processes

For cultural landscapes, beneficial effects include maintaining native or culturally significant vegetation, viewsheds, or other features

Major

Adverse

For archaeological sites and historic structures, major adverse impacts result in loss of overall integrity and significant changes to character-defining, cultural, or structural elements to the extent that the property would no longer be eligible for inclusion in the National Register. Impacts include destabilization of structures or cultural contexts, depletion or displacement of artifact assemblages (based on baseline information) to an extent that research potential was compromised, increased exposure or vulnerability to natural elements, incineration of wooden structures and features, and severe effects to, or loss of, elements having research potential and integrity. Determination of effect for Section 106 would be "adverse effect" to archaeological sites and historic structures

For ethnographic resources, impacts alter resource conditions or block or greatly affect traditional access, site preservation, or relationship between resource and affiliated group's body of practices and beliefs to the extent that the survival of a group's practices and/or beliefs would be jeopardized. Impacts result in significant changes or destabilization to defining elements and resource condition and an increase in exposure or vulnerability to natural elements. Determination of effect on traditional cultural properties for Section 106 would be "adverse effect" to ethnographic resources

For cultural landscapes, impacts alter a character-defining cultural landscape pattern or feature including proliferation of nonnative plant species that may threaten setting integrity and traditional vegetative resources. A major effect would render a property ineligible for inclusion on the National Register. Determination of effect on cultural landscapes for Section 106 would be "adverse effect" to cultural landscapes.

In event of adverse effect determination, a MOU would be executed between the NPS and applicable state or tribal historic preservation officer and, if necessary, the ACHP in

	accordance with 36 CFR 800.6(b). Identified MOU measures to minimize or mitigate adverse impacts would reduce impact intensity under NEPA
Beneficial	For archaeological sites, effects would be measurable and contribute to overall site landscape stability (e.g., reduction of onsite fuels)
	For historic structures, beneficial effects include reducing fire susceptibility and maintaining historic structure setting
	For ethnographic resources, beneficial effects include maintaining and/or restoring natural ecosystem processes
	For cultural landscapes, beneficial effects include maintaining and/or restoring native or culturally significant vegetation
Context	
Regional	Impacts occur to several specific resource sites. This might also include impacts to a regionally significance site
Local	Impacts restricted to specific site or localized site areas
Duration	
Short term	An effect that, within five years, would no longer be detectable (e.g., trash and other items that could be removed or vegetation trampled but not denuded). Short-term adverse impacts to archaeological sites, ethnographic resources, and historic sites include: artifact sooting, vegetation removal, and exposure to visitor impacts and erosion. These impacts could be the result of fire itself or fire management activities such as handline construction, installation of structural fire material (historic structures), or fire-retardant application. Short-term beneficial impacts include: fuel-load reduction and return to historic landscape
Long term	A change in a resource or its condition that lasts five or more years and for all practical purposes would be considered permanent (e.g., element damage or artifact removal). Long-term adverse impacts include: handline construction through sites or features, destruction of fire-sensitive elements (wood, rock art), impacts to data potential (introduction of modern charcoal), artifact theft, vandalism, decrease in site stability (e.g., vegetative cover removal and subsequent erosion), non-Native American discovery or disclosure of sacred site locations, graffiti, and invasive plant species proliferation
	Long-term beneficial impacts include: setting restoration and more natural ecological conditions resulting from fire frequency and timing, decrease in fire susceptibility, and landscape stabilization
Timing	Post-fire erosion on archeological sites is potentially more during summer when monsoon thunderstorms typically occur. Since archaeological sites are sometimes ethnographic resources, the above effects would be considered effects to ethnographic resources as well. Fire-related closures could also restrict access to traditional use areas during times when traditionally gathered resources are available. Burning outside natural fire season may also impact ethnographic resources (i.e., trees and other plants)
	When introduced outside the natural range of variability, fires can affect ethnographic resource availability, impede access to ethnographic resources, and disrupt traditional practices. Fire-related closures could also restrict access to traditional use areas during

times when traditionally gathered resources are available. American Indian consultation is required to identify ethnographic resources and traditional practices potentially affected by timing

4.3.5 Mitigation of Effects — Cultural Resources

Previous mitigation efforts indicate specific measures can be effective in deterring increased site damage due to fire management actions.

Mitigations Common to All Alternatives — Cultural Resources

- During any planned fire management activity, project area cultural resource locations will be determined and adverse impacts avoided. Cultural resources will be identified through database and paper-record searches and field inventories or verifications. As needed, project and site-specific mitigation measures will be developed, implemented, and designed to minimize adverse impacts
- Prior to project work, fire staff will be trained (yearly or as needed) in cultural resource identification and laws and policy regarding management and protection
- Control lines, helispots, fire camps, staging areas, and other ground-disturbing activities will not occur in identified cultural resources
- Fire will be excluded from National Register eligible fire-sensitive archeological sites or features. Exclusion measures may include line construction, site or feature fuel reduction, and application of fire shelter material, foam, or water
- During aerial ignition operations, National Register eligible fire-sensitive sites will be marked to be seen from the air and avoided. Marking will be removed after implementation
- Post-fire assessments will be completed for all National Register eligible fire-sensitive sites. Post-fire assessments at additional sites will be completed as needed to assess effects of high intensity fire or specific management actions
- As needed, emergency stabilization and restoration will be implemented following BAER standards
- During prescribed fire projects and wildland fire-use and suppression incidents, a cultural resource specialist may be assigned as a resource advisor to prevent adverse cultural resources impacts
- During manual/mechanical thinning projects, no slash will be dragged through or piled in an archeological site, and to the greatest degree possible, no trees will be felled on archeological features or sensitive cultural sites
- Manual/mechanical thinning in view of National Historic Landmark and Individually Listed Historic Buildings will be consistent with the Secretary of the Interior's Standards for Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes (NPS 1996a).Work in these areas will be coordinated with the Historical Architect or appropriate cultural resource specialist
- Manual/mechanical thinning in identified cultural landscapes will be consistent with treatment recommendations in relevant cultural landscape reports and the Secretary of the Interior's Standards for Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes (NPS 1996b). Work in these areas will be coordinated with a Historical Landscape Architect or appropriate cultural resource specialist
- Any road and helispot maintenance activities will avoid adverse cultural resources impacts
- A Programmatic Agreement will be developed with the SHPO in consultation with affiliated tribes and interested parties to address potential cultural resources impacts and how they can be mitigated. All planned fire management activities will comply with NHPA Section 106 and implementing regulations
- A fuel assessment and reduction program will be developed and implemented for National Register eligible cultural resources
- Fire modeling data will be included with prescribed fire plans to allow cultural resource specialists to better assess proposed project affects

- Tribal consultation will be conducted yearly with affiliated tribes to determine potential effects from fire management activities on resources of concern to the tribes. Efforts will be made to ensure tribal concerns are incorporated into prescribed burn plans, and tribes are afforded ample opportunities to comment. The Branch of Fire and Aviation will initiate and coordinate consultation through the park's tribal liaison
- To the greatest degree possible, collaborate with interested tribes in fire projects. An example could include allowing designated tribal representatives to monitor resource effects, and pre-project access to ethnobotanical resources

4.3.6 Cumulative Impacts Cultural Resources

Cumulative impacts on cultural resources were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions (Appendix G).

As part of a larger ecosystem, cultural resources will continue to be affected by fire and fire management actions. Common effects to cultural resources from fire and fire management actions can be found below.

4.3.7 Impacts and NHPA Section 106 Cultural Resources Common to All Alternatives

In accordance with NHPA Section 106 and it's implementing legislation (36 CFR Part 800), the NPS conducted an assessment of effects for GRCA FMP implementation. Advisory Council on Historic Preservation regulations (36 CFR Part 800.8(c)) allow agencies to use the NEPA process to comply with Section 106 "in lieu of the procedures set forth in §800.3 through 800.6." When the proposed FMP was initiated, the park indicated the NEPA process would serve as adequate substitute for the Section 106 process. Additionally the park identified and consulted with the public, as well as appropriate agencies, stakeholders, and American Indian tribes in a manner consistent with 36 CFR 800.3(f) (see Chapter 5). Development and analysis of alternatives was based largely on these consultations. In accordance with 36 CFR 800.4 through 800.5, thresholds for determining impacts to cultural resources were crafted based on predicted changes to elements of integrity and how those changes may affect NRHP eligibility.

Grand Canyon holds a wealth of cultural resources, including historic and prehistoric archaeological sites, historic structures, traditional cultural places, and cultural landscapes. A review of Grand Canyon's cultural resource files yielded data on prior studies and recorded cultural resources in the area of potential effect (see Chapter 3); these data provided background information for this FEIS. The environmental impact analysis process for the proposed FMP used existing inventory and monitoring information for cultural resources evaluations. If, during the fire management planning process, there is an adverse determination of effect under Section 106, the NPS will coordinate with the Arizona SHPO to determine level of effect on the property and needed mitigation measures.

Impacts to cultural resources (archeological sites, historic structures, cultural landscapes, ethnographic resources) are described in terms of type, context, duration, and intensity consistent with CEQ regulations for implementing NEPA. The following impact analyses are intended to also comply with requirements of Section 106. In accordance with ACHP regulations implementing 36 CFR Part 800, impacts to cultural resources were identified and evaluated by 1) determining area of potential effect, 2) identifying cultural resources present in the area of potential effect either listed on or eligible for the NRHP, 3) applying criteria of adverse effect to affected cultural resources either listed on or eligible for the NRHP, and 4) considering ways to avoid, minimize, or mitigate adverse effects.

Under ACHP regulations a determination of either adverse effect or no adverse effect must also be made for affected NRHP-eligible cultural resources. An adverse effect occurs whenever an impact alters, directly or indirectly, any characteristic of a cultural resource that qualifies it for inclusion (e.g., diminishing integrity of resource location, design, setting, materials, workmanship, feeling, or association). Adverse effects also include reasonably foreseeable effects caused by the alternative but that would occur later in time, farther removed in distance, or be cumulative (36 CFR 800.5). A determination of no adverse effect means there is an effect, but the effect would not diminish in any way cultural resource characteristics that qualify it for the NRHP.

CEQ regulations and DO-12 call for discussion of mitigation appropriateness, as well as analysis of mitigation effectiveness in reducing potential impact intensity (reducing intensity from major to moderate or minor). Resultant reduction in impact intensity due to mitigation, however, is an estimate of mitigation effectiveness under NEPA only. It does not suggest level of effect as defined by Section 106 is similarly reduced. Even though adverse effects under Section 106 may be mitigated, effect remains adverse.

Degree of cultural resource impact depends on fire severity and duration, mapped as fire severity, which, in turn, depends on vegetation type and fuel loading. Fire severity is a complex issue; any fire can exhibit high, moderate, and low severity, and unburned areas. Some above the rim vegetation is in the natural range of variability; therefore, cultural resources located in those areas will not be exposed to more, or more severe, fire resulting from excessive fuels. Table 4-30 shows percentages are based on severity mapping conducted on historic GRCA fires. This analysis combines moderate/low and moderate/high fire severity used in the vegetation analysis into a moderate category, since range of effects is similar.

Artifact scatters and artifact scatters with undated features (Paleoindian, Archaic, Basketmaker, and Formative) are generally unaffected by low severity fire. Low severity fires have burned through these sites before, and whatever potential low severity fire damage likely to occur has already occurred. Moderate and high severity fires can also be expected during any fire activity (Table 4-30). Table 4-31 summarizes potential beneficial and adverse impacts to cultural resources from planned and unplanned fire actions and responses.

Table 4-30 Historic Fire Severity by Forest and Fire Types

Fire Severity		Ponderosa Pine (%)	Mixed-Conifer (%)	Spruce-Fir (%)	Piñon-Juniper (%)
Prescribed Fire	High	4	10	20	3
	Moderate	31	50	40	14
	Low	50	20	10	47
	Unburned	16	20	30	36
Wildland Fire Use	High	1	9	20	No Data
	Moderate	31	50	40	No Data
	Low	60	39	10	No Data
	Unburned	8	3	30	No Data
Suppression Fire	High	3	11	31	2
	Moderate	32	55	54	80
	Low	51	22	10	15
	Unburned	14	12	4	4

Note Prescribed fire severity percentages for all vegetation types were based on historic fire severity mapping in and near GRCA. In spruce-fir forest types, fire severity percentages from prescribed fire were used for WFU fire as there is insufficient historic data to calculate averages. Analysis of WFU fire in piñon-juniper must be qualitative due to lack of sufficient data and widely varying fire behavior in this forest type. For fire suppression, severity percentages were taken from the Outlet Fire's severities for mixed-conifer, spruce-fir, and piñon-juniper forest types as these are thought to be more representative of typical fire behavior.

Table 4-31 Beneficial and Adverse Affects of Fire Management Activities on Cultural Resources

Management Type	Benefit to Cultural Resources	Detriment to Cultural Resources
Thinning (Hand and Mechanical)	• Ability to inventory prior to action • Ability to treat and/or avoid fire-vulnerable sites • No exposure to fire	• Some exposure to theft/vandalism • Ground disturbance and compaction (increases with mechanical)
Prescribed Fire	• Ability to inventory prior to action • Ability to treat and/or avoid fire sensitive sites • Relative control over fire severity • Ability to reduce fuels on a bigger scale than individual sites	• Some exposure to theft/vandalism • Fire exposure
Wildland Use Fire	• Some opportunity to inventory sites • Some opportunity to treat and/or avoid fire-sensitive sites • Ability to reduce fuels on a bigger scale than individual sites	• Fire exposure • Less control over fire severity • Fire retardant exposure
Suppression	• Limited opportunity to treat/avoid sites • Wildland fire will result in reduced fuels	• Fire exposure • Fire retardant exposure • Least control over fire severity • Increased ground disturbance and compaction from suppression and rehabilitation work

Certain types of archaeological sites, features, and artifacts are considered fire sensitive and can be adversely affected by fire of any severity. These effects can be long term and variable in intensity. Historic Native American sites often contain fire-sensitive, partially preserved wooden dwellings and structures such as wickiups, forked-stick hogans, lean-tos, windbreaks, cabins, conical structures, wooden structures, brush structures, corrals, and sweat lodges. Historic Euro-American sites often contain fire-sensitive, partially preserved wooden dwellings, corrals, fences, fence posts, tree towers, enclosures, wood-cutting areas, woodpiles, hitching posts, wooden gates, benches, and signposts. Combustion of fire-sensitive features would be a long-term to permanent impact. Structural habitation sites that date to Protohistoric and Historic periods may include flammable materials such as wood. Historic artifact scatters and artifact scatters with extramural features may include flammable artifacts such as wood, leather, and other fire-sensitive features, and materials that can melt, such as glass and solder. Historic Native American structures are typically found on South Rim in piñon-juniper woodland or near the piñon-juniper to ponderosa pine transition. Historic Euro-American dendroglyphs and ranching features are most commonly found on North Rim along historic roads and trails and near water sources in ponderosa pine, mixed-conifer, and spruce-fire vegetation types. Other fire-sensitive sites such as Euro-American camp features and prehistoric structures occur in all vegetation types and FMU. Fire-sensitive sites comprise approximately 12% of all recorded GRCA sites.

Rock shelters and cliff structures (classified as protected habitations) of all periods are susceptible to wall and ceiling exfoliation and sooting, thermal feature contamination (with modern charcoal), and perishable material ignition, including wooden architectural elements. Rock shelters contain perishable materials often on or near the surface. Fire timing and severity and amount of vegetation growing at rock shelter mouths affect extent of fire impact.

Rock art of all periods except Paleoindian is reported at GRCA. Fire can soot and exfoliate rock art; effects ranging from temporarily obscuring rock art (light sooting in open areas where natural precipitation can remove it) to destroying rock art (entire element or panel exfoliation). Adverse impacts on rock art sites and rock shelters can range from short- to long-term sooting, oxidation, and exfoliation.

Most direct fire impacts to archaeological materials are to surface remains; most buried archaeological materials receive few direct impacts, particularly if below depths of ten cm (Hanes 2001). Wood, bone, plant remains, and pollen may be destroyed (Cartledge 1996:211). Flaked stone may exhibit sooting, discoloration, changes in luster, cracking, shattering, and exfoliation (Eininger 1990, Romme et al. 1993:28). Obsidian may melt at very high temperatures, and obsidian hydration and thermoluminescence dating potential may be adversely affected (Eininger 1990). Low severity fire can cause sooting, discoloration, and changes in luster, diminishing flaked stone utility for microwear analysis, but Romme et al. (1993:28) do not consider this information loss significant, since these types of studies are not usually conducted on surface artifacts. Spalling, cracking, and shattering occur at temperatures greater than 700°F (350°C) (Romme et al. 1993:28). At sites burned by the Henry Fire in the Jemez Mountains of New Mexico, only 34% of surface flaked stone (and only 40% of surface flaked stone even at heavily burned sites) exhibited any of these effects (Lentz et al. 1996).

In their study of the 1976 Grand Canyon Dutton Point Fire which burned mostly with low severity, Jones and Euler (1986) found pottery sooting the highest impact, that it occurred commonly, was not immediately completely reversible, and sometimes impeded sherd classification, thus reducing usefulness for site dating. At sites burned by the Henry Fire in the Jemez Mountains, 40.5% of surface potsherds exhibited fire effects, including sooting (23.2% of surface sherds), spalling (9.5%), discoloration (5.2%), pigment alteration (1.8%), and other (11.9%). Percentage of sherds exhibiting these effects increased with fire severity, from approximately 20–35% of sherds exposed to low severity fires to 55–65% of sherds exposed to high severity fires (Lentz et al. 1996).

Architectural stone is subject to discoloration, cracking, and exfoliation (Cartledge 1996:211, Eininger 1990). Rock faces (including rock art panels) may be scorched and exfoliated (Cartledge 1996:211).

Common to All Alternatives

Soil compaction and/or disturbance are possible impacts to cultural resources from manual and mechanical fuel reduction projects under analyzed alternatives. Soil compaction/disturbance could result in inadvertent artifact displacement, broken artifacts, and damaged features and/or structural remains.

Post-fire erosion (water) and deflation (wind) are primary indirect adverse fire impacts to cultural resource sites. Natural impacts such as erosion and deflation may result from burning or fire management activities such as line construction. Intensity of impacts from post-fire erosion and deflation are linked to fire severity. Studies following the Dome Fire (Elliott et al. 1999) document that where fire consumed groundcover, sites are vulnerable to soil loss until vegetation returns. Soil loss contributes to proliferation of rill and gully formation; tree, rock, and forb/grass pedestaling; and sheetwashing. Wall undermining and falling, rock alignment disruption, artifact scattering, and cultural material burial have been recorded in post-burn site monitoring. All these processes result in information and cultural context loss.

Fire management projects can result in inadvertent displacement or intentional theft or vandalism of artifacts, features, structures, and ethnobotanical resources. Examples include artifacts theft and carving on historic aspen dendroglyphs, rocks, cliff faces, and overhangs with prehistoric and historic rock art.

Planned Fire Management projects will satisfy NHPA Section 106 via a signed PA between the park, the Arizona SHPO, and participating affiliated tribes. Mitigation measures will be employed, will be likely to be successful, and adverse impacts to cultural resources would be reduced or eliminated. During any unplanned wildland fire activities, a resource advisor (archeologist or archaeologist technical specialist) will be assigned to all extended attacks on wildland fire. The resource advisor will brief fire personnel on the identification, distribution, and sensitivity of cultural resource sites. A resource advisor will accompany crews in the field, flag sensitive features to be avoided, help to mitigate potential impacts from logistics and operations. Mitigation measures will be implemented when possible, and may or may not be successful. In the event that eligible properties cannot be protected through avoidance or by established treatment methods, the NPS shall consult with SHPO on adverse effects and site specific mitigation procedures. Additionally, the NPS shall consult with tribes on mitigation procedures for eligible Traditional Cultural Properties.

4.3.8 Alternative 1 — No Action Existing Program — Cultural Resources

This alternative continues the existing program use of suppression, wildland fire use and prescribed fire, and limited manual fuel reduction treatments (Table 4-32). This alternative uses ponderosa pine, mixed-conifer, and grass-shrub-piñon-juniper FMU identified in Chapter 2. Approximately 13,395 acres would be affected annually. No fire treatments are proposed for the grass-shrub-piñon-juniper ecosystem.

Table 4-32 Treated Acres by Alternative, Annually

Acres	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Prescribed Fire	5,850	5,850	2,540	9,000	2,990
Wildland Fire Use	5,500	5,500	880	550	8,800
Suppression	2,005	2,005	2,607	2,407	1,805
Thinning	40	249	395	80	268
Manual Thinning	*40*	*38*	*59*	*12*	*40*
Mechanical Thinning	*0*	*212*	*336*	*68*	*228*
Estimated Total Acres	**13,395**	**13,604**	**6,422**	**12,037**	**13,863**

Impact Analysis — Alternative 1 — Cultural Resources
Planned Fire Management Actions — Archeological Sites

Planned fire management actions include planned projects designed to contribute to desired future conditions. In Alternative 1, these actions include manual fuel reduction and prescribed burn projects.

Planned fire management actions may have beneficial effects on cultural resources. Reduced fuels and ecosystem restoration/maintenance could be beneficial to archeological sites, historic structures, ethnographic resources, and cultural landscapes.

Impact Analysis — Alternative 1 — Cultural Resources
Planned Fire Management Actions — Archeological Sites
Manual Fuel Reduction Projects

Manual fuel reduction projects include vegetation cutting and removal to reduce fire severity during wildland fire ignitions. Manual fuel reduction projects would include crews walking across the project area using hand tools to cut and remove or pile vegetative material. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Identified mitigation measures would be implemented to protect and lessen these adverse effects. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reduced risk of unwanted high severity fire would be short to long-term, local to regional, and negligible to moderate.

Impact Analysis — Alternative 1 — Cultural Resources
Planned Fire Management Actions — Archeological Sites
Prescribed Burn Projects

Managers determine fire breaks or firelines to contain fire (roads, trails, natural features, fire containment lines), and ignition strategy (fusees, drip torches, aerial ignition). Prescribed burn projects may include effects from: fire itself, fireline construction, staging areas including parked trucks and engines, location of temporary water sources, temporary camp areas, and handline construction.

Prescribed burn projects can result in inadvertent displacement, intentional theft, or vandalism of artifacts, features, structures, and ethnobotanical resources. Examples include artifact theft and carving on historic aspen dendroglyphs, rocks, cliff faces, and overhangs with prehistoric and historic rock art.

Identified mitigation measures would be implemented to protect and lessen these adverse effects to cultural resources. Effects could occur in areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reduced risk of unwanted high severity fire would be short to long term, local to regional, and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**

Unplanned fire events and fire management responses include managing wildland fire ignitions. Under Alternative 1, unplanned fires would be managed for wildland fire use for Resource Benefits (WFURB), or for wildland fire suppression. WFURB would be managed to contribute to desired future conditions, and wildland fire suppression would be managed to put the fire out.

Because these are unplanned events, mitigation measures (4.3.5) will be employed, as possible, but may not be successful. If mitigation measures are successful, there would be a reduction in adverse impacts to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems and reduce fuels. Benefits can sometimes be realized when fire exposes cultural resources for more complete inventory. Beneficial effects to cultural resources may be short to long term, local to regional, and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Use

If a natural ignition (lightning) starts a fire in an identified FMU, area managers can consider managing the fire for WFURB. If this candidate is accepted, the fire would be managed to allow natural process to benefit resources.

WFURB actions could include effects from fire itself, limited fire monitor camping areas, potential limited fireline construction, and management ignitions for burning near the external limits of a WFURB area.

Identified mitigation measures would be implemented as possible, and may be effective to protect and lessen these adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Managing WFURB events would result in short- to long-term beneficial impacts by reducing fuel loads, restoring fire to northern Arizona ecosystems, and potentially avoiding large, high severity fire outside the range of variability. Beneficial impacts would be local to regional with negligible to moderate effects.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Suppression

Management can consider suppressing any fire. Management responses could range from direct and aggressive suppression to indirect and passive tactics to suppress the fire.

Wildland fire suppression actions could include effects from fire itself, mechanical and manual fireline construction, water and fire retardant aerial applications (helicopter and airplane), and staging areas (including large command posts, large camp areas, vehicle parking areas, heavy equipment parking areas, and helicopter landing zones).

Identified mitigation measures would be implemented as possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural ecosystem element, potentially resulting in reduced fuels, and promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized when fire exposes cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**

Planned fire management actions include projects designed to contribute to desired future conditions. In Alternative 1, these actions include manual fuel reduction projects and prescribed burn projects.

Planned fire management actions may have beneficial effects on cultural resources. Reduced fuels and ecosystem restoration/maintenance could be beneficial to archeological sites, historic structures, ethnographic resources, and cultural landscapes.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Manual Fuel Reduction Projects

Manual fuel reduction projects include vegetation cutting and removal to reduce fire severity in event of wildland fire ignitions. Manual fuel reduction projects would include crews walking through project areas using hand tools to cut and remove or pile vegetative material. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects would occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Prescribed Burn Projects

Managers determine fire breaks or firelines to contain fire (roads, trails, natural features, manual fire containment lines) and an ignition strategy (fusees, drip torches, aerial ignition). Prescribed burn projects may include effects from: fire itself, fireline construction, staging areas including parked trucks and engines, location of temporary water sources, temporary camp areas, and handline. Vehicles are restricted primarily to existing roads.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects would occur in areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Planned project implementation would result in short- to long-term beneficial impacts by reducing fuel load and risk of unwanted high severity fire, and would be local to regional negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**

Unplanned fire events and fire management responses include managing wildland fire ignitions. Under Alternative 1, unplanned fires would be managed for WFURB or for wildland fire suppression. WFURB would be managed to contribute to desired future conditions, and wildland fire suppression would be managed to put the fire out.

Because these are unplanned events, mitigation measures (4.3.5) will be employed, as possible, but may not be successful. If mitigation measures are successful, there would be a reduction in adverse impacts to cultural resources.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Use

If natural ignition (lightning) starts a fire in an acceptable FMU, staff can consider managing the fire for WFURB. If accepted, fire would be managed to allow natural process to benefit resources.

WFURB actions could include effects from fire, limited camping areas for fire monitors, and potential limited fireline construction and management ignitions for burning near WFURB external limits.

Identified mitigation measures would be implemented as possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Managing WFURB events would result in short- to long-term beneficial impacts by reducing fuel loads and restoring fire to northern Arizona ecosystems, and avoiding large, high severity fire outside the range of variability. Beneficial impacts would be local to regional and have negligible to moderate effects.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Suppression

Management can consider suppressing any fire. Management responses could range from direct and aggressive suppression to indirect and passive tactics to suppress the fire.

Wildland fire suppression actions could include effects from: fire itself, mechanical and manual fireline construction, water and fire retardant aerial applications (helicopters and airplane), and staging areas (including large command posts, large camp areas, vehicle parking areas, heavy equipment parking areas, helicopter landing zones).

Identified mitigation measures would be implemented as possible, and would possibly be effective to protect and lessen these adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially resulting in reduced fuels, and potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impact Analysis — Alternative 1 — Cultural Resources
Ethnographic Resources

Regional Native American groups recognize certain tangible properties as important in traditional tribal histories. These properties, which may or may not be other types of cultural resources (archeological sites, structures, cultural landscapes), are referred to as traditional cultural properties. TCP are given consideration under NHPA. Continued traditional practices require and/or use physical elements; these physical elements are considered TCP. Examples of ethnographic resources, or TCP, in Grand Canyon may include (but are not limited to) rock art, trails, vistas, archeological sites, ethnobotanical resources, graves, boundary lines, rock formations, mineral sources, springs, and other bodies of water.

GRCA does not maintain a complete database of ethnographic resources. Ongoing communication with affiliated tribes will continue to identify and protect TCP in the course of tribal consultation and implementation of fire management actions.

Impact Analysis — Alternative 1 — Cultural Resources
Planned Fire Management Actions — Ethnographic Resources

Planned fire management actions include projects designed to contribute to desired future conditions. In Alternative 1, these actions include manual fuel reduction and prescribed burn projects.

Planned fire management actions may have beneficial effects on cultural resources. Reduced fuels and ecosystem restoration/maintenance could be beneficial to archeological sites, historic structures, ethnographic resources, and cultural landscapes.

Impact Analysis — Alternative 1 — Cultural Resources
Planned Fire Management Actions — Ethnographic Resources
Manual Fuel Reduction Projects

Manual fuel reduction projects include vegetation cutting and removal to reduce fire severity in event of wildland fire ignitions. Manual fuel reduction projects would include crews walking through project areas using hand tools to cut and remove or pile vegetative material. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; risk of unwanted high severity fire would be local to regional and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Prescribed Burn Projects

Managers determine fire breaks or firelines to contain fire (roads, trails, natural features, manual fire containment lines) and ignition strategy (fusees, drip torches, aerial ignition). Prescribed burn projects may include effects from: fire itself, construction of fireline, staging areas including parked trucks and engines, location of temporary water sources, temporary camp areas, and hand constructed fireline. Vehicles are restricted primarily to existing roads.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur in areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads and risk of unwanted high severity fire and would be local and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**

Unplanned fire events and fire management responses include managing wildland fire ignitions. Under Alternative 1, unplanned fires would be managed for wildland fire use for WFURB or for wildland fire suppression. WFURB would be managed to contribute to desired future conditions, and wildland fire suppression would be managed to put the fire out.

Because these are unplanned events, mitigation measures (4.3.5) will be employed, as possible, but may not be successful. If mitigation measures are successful, there would be reduction in adverse impacts to cultural resources.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Use

If a natural ignition (lightning) starts a fire in an identified FMU (in all but WUI areas), and this candidate is accepted, the fire would be managed to allow natural process to benefit resources.

WFURB actions could include effects from: fire, limited camping areas for fire monitors, and potential limited fireline construction and management ignitions for burning near the WFURB external limits.

Identified mitigation measures would be implemented when possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Managing WFURB events would result in short- to long-term beneficial impacts by reducing fuel loads and restoring fire to northern Arizona ecosystems, and avoiding large, high severity fire outside the range of variability. Beneficial impacts would be local to regional and have negligible to moderate effects.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Suppression

Management can consider suppressing any fire. Management responses could range from direct and aggressive suppression to indirect and passive tactics to suppress the fire.

Wildland fire suppression actions could include effects from: fire itself, mechanical and manual fireline construction, water and fire retardant aerial applications (helicopter and airplane), and staging areas (including large command posts, large camp areas, vehicle parking areas, heavy equipment parking areas, helicopter landing zones).

Identified mitigation measures would be implemented as possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially resulting in reduced fuels, and potentially promoting/maintaining culturally important vegetation (ethnobotanical resources, cultural landscapes). Benefits can sometimes come from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term local to regional negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Cultural Landscapes

Cultural landscapes are settings that humans create in the natural world. Characteristics of cultural landscapes include land uses and activities, patterns of spatial organization, response to the natural environment, cultural traditions, circulation networks, vegetation, buildings, structures, and features.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**

Planned fire management actions include projects designed to contribute to desired future conditions. In Alternative 1, these actions include manual fuel reduction and prescribed burn projects.

Planned fire management actions may have beneficial effects on cultural resources. Reduced fuels and ecosystem restoration/maintenance could be beneficial to archeological sites, historic structures, ethnographic resources, and cultural landscapes.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Manual Fuel Reduction Projects

Manual fuel reduction projects include cutting and removing vegetation to reduce fire severity in the event of wildland fire ignitions. Manual fuel reduction projects would include crews walking through project areas using hand tools to cut and remove or pile vegetative material. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire, below).

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Prescribed Burn Projects

Managers determine fire breaks or firelines to contain fire (roads, trails, natural features, fire containment lines) and ignition strategy (fusees, drip torches, aerial ignition). Prescribed burn projects may include effects from fire itself, construction of fireline, staging areas including parked trucks and engines, location of temporary water sources, temporary camp areas, and hand constructed fireline.

Identified mitigation measures would be implemented to protect and lessen these adverse effects to cultural resources. Effects will occur in areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads and risk of unwanted high severity fire, and would be local to regional negligible to moderate.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**

Unplanned fire events and fire management responses include managing wildland fires. Under Alternative 1, unplanned fires would be managed for WFURB or wildland fire suppression. WFURB would be managed to contribute to desired future conditions, and wildland fire suppression would be managed to put the fire out.

Because these are unplanned events, mitigation measures (4.3.5) will be employed, as possible, but may not be successful. If mitigation measures are successful, there would be a reduction in adverse impacts to cultural resources.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Use

If natural ignition (lightning) starts a fire in an identified FMU, managers can consider managing the fire for WFURB. If accepted, the fire would be managed to allow natural process to benefit resources.

WFURB actions could include effects from: fire, limited camping areas for fire monitors, and potential limited fireline construction and management ignitions for burning near the WFURB external limits.

Identified mitigation measures would be implemented when possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Managing WFURB events would result in short- to long-term beneficial impacts by reducing fuel loads and restoring fire to northern Arizona ecosystems, and avoiding large, high severity fire outside the range of variability. Beneficial impacts would be local to regional and negligible to moderate effects.

Impact Analysis **Alternative 1** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Suppression

Management may consider suppressing any fire. Management responses could from from direct and aggressive suppression to indirect and passive tactics to suppress the fire.

Wildland fire suppression actions could include effects from fire itself, mechanical and manual fireline construction, water and fire retardant aerial applications (helicopter and airplane), and staging areas (including large command posts, large camp areas, vehicle parking areas, heavy equipment parking areas, helicopter landing zones).

Identified mitigation measures would be implemented as possible, and would possibly be effective to protect and lessen adverse effects to cultural resources. These potentially mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to major.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural ecosystem element, potentially resulting in reduced fuels, and potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Cumulative Effects **Alternative 1** **Cultural Resources**

Cumulative effects to cultural resources are measured against a baseline of the early-to-mid 1990s when GRCA's existing Fire Management and GMP were developed and adopted.

Past actions with incremental effects on GRCA's cultural resources over the last decade include fire and fire management activities and some park construction projects. Since 1994, 18 fires (21,480 acres) were suppressed: 34 (34,203 acres) were wildland fire-use fires, 41 (25,673 acres) were prescribed fires. The majority of this acreage burned at low or moderate severity levels. Most high severity fire occurred in two North Rim wildfires: the 1,964 acre Outlet Fire (2000), and the 1,500 acre Poplar Fire (2003). Many, if not most, cultural resources in forested and wooded areas have been subjected to natural fire regimes over the centuries. However, in recent decades high severity fires outside the historical range of variability have become more common as the result of decades of fire suppression, heavy fuel loads, and, beginning in 2004, prescribed fires. Some rock shelters, rock art, and historic Native American and Euro-American sites have lost components as a result of both natural fire regimes and recent high severity wildland fires.

Repeated burning, especially by high severity fire, has contributed and continues to contribute to long-term and permanent cumulative adverse effects. Artifacts and structural components continue to degrade. Presence of stump holes from burned trees, and dead standing trees that could burn or fall and uproot soils, accelerate site and feature destabilization. Sediment transport becomes attenuated with distance, and has a much reduced impact far downstream. Activities taking place near the GRCA boundary and upstream of proposed GRCA activities could result in increased impact if they take place within a year of each other. If left unchecked, erosion results in artifact displacement and formation of structural elements such as rills and gullies. Deflation results in loss of cultural context. Repeated entries into cultural resource sites for fire management purposes have potential cause additive alteration or destruction of structures, features, and artifacts.

In the short term, cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely to be localized, minor to moderate, and adverse to cultural resources. Activities taking place well outside the GRCA boundary are not likely to have an impact on proposed GRCA activities. In the long term, cumulative effects are likely localized, minor to moderate, and adverse to beneficial, depending on activity.

Projects recently completed, currently conducted, or planned in GRCA include construction and rehabilitation work in developed and WUI areas, and hazard reduction research (Appendix G). Many identified recent or current actions are construction projects restricted to already developed areas that would have little effect on archaeological and ethnographic resources. Other actions have or had potential to adversely affect resources; however, due to NEPA compliance requirements and mitigation measures in each project, adverse impacts are unlikely. For example, in the South Rim Canyon View Information Plaza Project near Mather Point, impacts to archaeological sites were dealt with through avoidance or mitigation measures developed according to stipulations of the PA with the SHPO and ACHP.

Timing would be the most critical aspect of fire management affecting ethnographic resources, especially access to in-season plant materials. Cumulative effects to ethnographic resources would be local to regional, could be short or long term, and range from minor to major depending on timing, context, duration of impact, and return interval of individual plants.

Historic structures and cultural landscapes are largely located in developed areas. Present plans for fire management and limited manual fuels reduction treatments are written to include cultural resource specialist consultation during prescribed and wildland fire-use fires, and wildland fire suppression activities where necessary to reduce or avoid impacts to historic structures through monitoring or mitigation measures. Fire management activities, especially fuels reduction, in WUI areas that contain historic structures would have a cumulative beneficial impact that would increase through time from minor to major. Any uncontrolled fire in park boundaries, or that enters park boundaries, has potential to have long-term or even permanent adverse effects that range in intensity from minor to major on both known and unidentified historic structures.

Present plans for fire management and limited manual fuels reduction treatments are written to include cultural resource specialist consultation during prescribed and wildland fire-use fires, and wildland fire suppression activities where necessary to reduce or avoid impacts to cultural resources through monitoring or mitigation measures. Locations of all cultural resource sites are not known, and impacts to sites not previously identified cannot be mitigated or avoided. Therefore, some sites will suffer impacts. Cumulative effects to cultural resources would be localized, could be short or long term, and would range from minor to major depending on timing, context, and duration of impact. Proposed activities would restore ecosystems to a more natural state, providing potential long-term effects beneficial to resources due to reduced risk of wildland fires that could adversely impact those areas.

Conclusions **Alternative 1** **Cultural Resources**

Under Alternative 1, an estimated average 12,863 acres will receive fire management treatment annually (manual fuel reduction treatment; prescribed, wildland fire-use, and suppression fire).

Ethnographic resources were identified during tribal review while this FEIS was under development, consultation, and during development and implementation of the PA.

Potential direct effects from planned fire management activities vary depending on where projects are located and types of activities involved. In general, ground-disturbing activities can be anticipated, and vulnerable resources avoided, resulting in short-term, local, negligible to minor adverse effects under NEPA and potentially adverse effects to cultural resources for NHPA compliance.

Unplanned fire management activities and wildland fire responses are unpredictable, and it is sometimes difficult to avoid or treat cultural resources where these fire types occur. Because WFU and wildland fire suppression responses are emergencies, actions may result in short- to long-term, local to regional, negligible to major adverse effects to cultural resources.

Alternative 1 would possibly result in some major adverse (unplanned fire management activities and wildland fire responses) impacts to cultural resources, but impacts are not expected to rise to the level of impairment. Damage to cultural resources resulting from fire management actions and responses over the initial treatment period may be an unavoidable result of fire management actions necessary to prevent large-scale destructive wildfire.

Impairment **Alternative 1** **Cultural Resources**

Although Alternative 1 may result in major adverse impacts to a specific or regional resource, impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair cultural resources during Alternative 1 implementation.

Unacceptable Impacts **Alternative 1** **Cultural Resources**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent the attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on cultural resources as a result of implementation of Alterative 1.

4.3.9 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Cultural Resources

Alternative 2 includes the following changes to GRCA's existing fire management program: 1) new geographically defined FMU, 2) development of a Wildland-Urban Interface treatment program and accompanying increase in manual/mechanical treatment acreage, and 3) changes to severity limitations for unplanned fire management actions and responses in the mixed-conifer vegetation type. FMUs are shown on Map 2-2 and include Backcountry, Upland, Fire Island, Inner Canyon, Kaibab Summit, Peninsula, Plateau, Primary and Secondary WUI. Alternative 2 includes manual and mechanical fuel reduction projects (planned), prescribed burn projects (planned), WFU actions and responses (unplanned), and wildland fire suppression actions and responses (unplanned). No projects would be proposed in the Fire Island or Inner Canyon FMU, so these areas are not considered in the analysis.

Acreages for prescribed fire (planned), WFU (unplanned), and suppression fires (unplanned) are similar to acreages proposed or estimated for Alternative 1. The largest change from Alternative 1 to 2 is increased acreage proposed for manual/mechanical thinning in Primary and Secondary WUI (from 400 to approximately 2,500 acres over the first planning period; Table 4-32). Manual/mechanical fuel-reduction treatments would occur primarily in WUI piñon-juniper habitat in areas not proposed as wilderness including North Rim Developed Area, Grand Canyon Village, Hermits Rest, and Desert View and along Highway 67 (North Rim) and Highway 64 (South Rim).

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in project areas.

Alternative 2 increases the acreage of fire management activities potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Planned projects implementation would result in short- to long-term beneficial impacts by reducing fuel loads; reduced risk of unwanted high severity fire would be local to regional and negligible to moderate.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Prescribed Fire

Impacts from fire management actions would be very similar to those in Alternative 1. Increased acreage of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for mixed-conifer vegetation is relatively small; effects are expected to match Alternative 1impact levels.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Use

Impacts from fire management actions and wildland fire responses would be very similar to those in Alternative 1. Increased acreage of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match Alternative 1 impact levels.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Suppression

Impacts from fire management actions and wildland fire responses would be very similar to Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal to reduce fire severity in event of wildland fire ignitions. Manual fuel reduction projects would include crews using heavy equipment to cut, limb, crush, chip, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 2 increases acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Prescribed Fire

Impacts from fire management actions would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match Alternative 1 impact levels.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Use

Impacts from fire management actions and wildland fire responses would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Suppression

Impacts from fire management actions and wildland fire responses would be very similar to Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce project area vegetation.

Alternative 2 increases acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads and reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Prescribed Fire

Impacts from fire management actions would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Use

Impacts from fire management actions and wildland fire responses would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Suppression

Impacts from fire management actions and wildland fire responses would be very similar to Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce project area vegetation.

Alternative 2 increases acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads and reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 2** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Prescribed Fire

Impacts from fire management actions would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Use

Impacts from fire management actions and wildland fire responses would be very similar to those found in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Impact Analysis **Alternative 2** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Suppression

Impacts from fire management actions and wildland fire responses would be very similar to Alternative 1.

Section 106 Summary **Alternative 2** **Cultural Resources**

After applying the Advisory Council on Historic Preservation's criteria of adverse effects (36 CFR Sec. 800.5 Assessment of Adverse Effects), the NPS concludes that implementation of preferred alternative

(Alternative 2) describing the fire management program at GRCA may have adverse effects to cultural resources. Planned fire management projects (manual/mechanical fuel reduction and prescribed fire projects) will likely be successfully mitigated, and will likely have no adverse effects to cultural resources. Unplanned fire management actions and responses (WFU and wildland fire suppression) may or may not be successfully mitigated, and will likely have adverse effects to cultural resources. GRCA, in consultation with the SHPO, and potentially the advisory council and affiliated tribes, will complete a PA for managing Section 106 of NHPA. If adverse effects occur, a MOU will be completed in consultation with the SHPO and affiliated tribes.

Cumulative Effects Alternative 2 Cultural Resources

Cumulative effects are similar to Alternative 1 with a slight increase in potential impacts from soil disturbance and compaction in Primary and Secondary WUI. As total acreages are still low, impacts are anticipated to be minor. Proposed treatments combined with past, present, and foreseeable future projects in Primary and Secondary WUI may slightly increase impacts from soil erosion and disturbance. Additional fuels reduction, if completed near historic structures or in cultural landscapes, would have additional beneficial impacts by reducing risk of unwanted fire in cultural landscapes.

Conclusions Alternative 2 Cultural Resources

Under Alternative 2, an estimated 13,604 acres will receive fire treatment annually (prescribed, wildland fire use and suppression fire; mechanical fuels treatment).

Ethnographic resources were identified during tribal review while this FEIS was under development, consultation, and during development and implementation of the PA.

Potential direct effects from planned fire management activities vary depending on where projects are located and types of activities involved. In general, ground-disturbing activities can be anticipated, and vulnerable resources avoided, resulting in short-term, local, negligible to minor adverse effects under NEPA, and potentially adverse effects to cultural resources for Section 106 of NHPA compliance.

Unplanned fire management activities and wildland fire responses are unpredictable, and it is sometimes difficult to avoid or treat cultural resources where these fire types occur. Because WFU and wildland fire suppression responses are emergencies, actions may result in short- to long-term, local to regional, negligible to major adverse effects to cultural resources. If resources could not be avoided, appropriate strategies to mitigate moderate to major effects will be developed in consultation with the SHPO and affiliated tribes.

While Alternative 2 could result in some major adverse impacts (unplanned fire management activities and wildland fire responses) to cultural resources, impacts are not expected to rise to the level of impairment. Damage to cultural resources resulting from fire management actions and responses over the initial period may be an unavoidable result of fire management actions necessary to prevent large-scale destructive wildfire.

Impairment Alternative 2 Cultural Resources

Although Alternative 2 may result in major, adverse impacts to a specific or regional resource, impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair cultural resources during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Cultural Resources**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on cultural resources as a result of Alterative 2 implementation.

4.3.10 Alternative 3 Non-Fire Treatment Emphasis Cultural Resources

Alternative 3 increases Primary and Secondary WUI acreage treated using manual/mechanical thinning to an average 395 acres annually. Increases in non-fire treatments will reduce acreage treated using WFU and prescribed fire. Prescribed fire treatments would occur mostly around Primary and Secondary WUI. WFU fires would be included as staff time permits. GRCA staff anticipates that suppression fire acres would increase due to the decrease in effort to manage fuel loads and fire regimes in other parts of GRCA.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 3 increases the acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish fuel reduction. Because these are planned activities, mitigation measures would be applied, and would very likely be successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Prescribed Fire

Impacts from fire management actions would be less (2,540 acres annually) than Alternative 1 (5,850 acres annually). Types of impacts that could occur under Alternative 3 are similar to those under Alternative 1, but fewer acres would be burned with prescribed fire. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Use

Alternative 3 estimates 880 acres WFURB annually, compared to 5,500 acres in Alternative 1 WFURB annually. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but fewer acres would be burned under WFURB in Alternative 3. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Suppression

Alternative 3 estimates 2,607 acres of wildland fire under suppression annually, compared to 2,005 acres of wildland fire suppression actions in Alternative 1 annually. Mitigation measures would be applied when possible; their success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural ecosystem element, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 3 increases the acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. Mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Planned project implementation would result in short- to long-term beneficial impacts by reducing fuel loads; reduced risk of unwanted high severity fire would be local to regional and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Prescribed Fire

Impacts from fire management actions would be less (2,540 acres annually under Alternative 3) than those in Alternative 1 (5,850 acres annually). Types of impacts that could occur under Alternative 3 are similar to those under Alternative 1, but fewer acres would be burned in prescribed fires. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short to long term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Use

Alternative 3 estimates 880 WFURB acres annually, compared to 5,500 WFURB acres annually in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those in Alternative 1, but this alternative would reduce the number of acres burned under WFURB in Alternative 1. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short to long term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short to long term, local to regional and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Historic Structures**
Wildland Fire Suppression

Alternative 3 estimates 2,607 acres of wildland fire under suppression annually, compared to 2,005 acres of wildland fire suppression actions in Alternative 1 annually. Mitigation measures would be applied when possible; their success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and negligible to major adverse.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fire s can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 3 increases the acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Planned project implementation would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local to regional and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Prescribed Fire

Impacts from fire management actions would be less (2,540 acres annually under Alternative 3) than those found in Alternative 1 (5,850 acres annually). Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short to long term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Use

Alternative 3 estimates 880 WFURB acres annually, compared to 5,500 in Alternative 1 annually. Impacts from fire management actions and wildland fire responses would be similar to those in Alternative 1, but would include fewer acres burned under WFURB. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short to long term, local to regional and negligible to moderate.

Impact Analysis — Alternative 3 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Ethnographic Resources
Wildland Fire Suppression

Alternative 3 estimates 2,607 acres of wildland fire under suppression annually, compared to 2,005 acres of wildland fire suppression actions in Alternative 1 annually. Mitigation measures would be applied when possible; their success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural ecosystem element, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Impact Analysis — Alternative 3 — Cultural Resources
Planned Fire Management Actions — Cultural Landscapes
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 3 increases acreage potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Prescribed Fire

Impacts from fire management actions would be less (2,540 acres annually under Alternative 3) than those in Alternative 1 (5,850 acres annually). Types of impacts could occur under Alternative 3 are similar to those found under Alternative 1, but fewer acres would be burned in prescribed fires. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.
Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Use

Alternative 3 estimates 880 WFURB acres annually, compared to 5,500 WFURB acres annually in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but would burn fewer acres under WFURB in Alternative 3. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFURB is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short to long term, local to regional and negligible to moderate.

Impact Analysis **Alternative 3** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Suppression

Alternative 3 estimates 2,607 acres of wildland fire under suppression annually, compared to 2,005 acres of wildland fire suppression annually Alternative 1. Mitigation measures would be applied when possible; their success would be uncertain. Increased suppression responses may increase the number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and have negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fire s can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Cumulative Effects **Alternative 3** **Cultural Resources**

Cumulative affects are similar to Alternative 1. However, cumulative effects outside Primary and Secondary WUI are likely to be somewhat less due to reduced acreage proposed for treatment. Proposed treatments combined with past, present, and foreseeable future projects in Primary and Secondary WUI may slightly increase impacts from soil erosion and disturbance. Additional mechanical fuels reduction, if completed near historic structures or in cultural landscapes, would have additional beneficial impacts by reducing risk of unwanted fire in cultural landscapes.

Conclusions **Alternative 3** **Cultural Resources**

Under Alternative 3, an estimated average 6,422 acres will receive fire treatment annually (prescribed, wildland fire-use and suppression fire; mechanical fuels treatment).

Ethnographic resources were identified during tribal review while this FEIS was under development, consultation, and during development and implementation of the PA.

Potential direct effects from planned fire management activities vary depending on where projects are located and types of activities involved. In general, these ground-disturbing activities can be anticipated, and vulnerable resources avoided, resulting in short-term, local, negligible to minor adverse effects under NEPA, and no adverse effect for NHPA compliance.

Unplanned fire management activities and wildland fire responses are unpredictable, and it is sometimes difficult to avoid or treat cultural resources where these fire types occur. Because WFU and wildland fire suppression responses are emergencies, actions may result in short- to long-term, local to regional, negligible to major adverse effects to cultural resources.

While Alternative 3 could result in some major adverse impacts to cultural resources (unplanned fire management activities and wildland fire responses), impacts are not expected to rise to the level of impairment. Damage to cultural resources resulting from fire management actions and responses over the initial period may be an unavoidable result of fire management actions necessary to prevent large-scale destructive wildfire.

Impairment **Alternative 3** **Cultural Resources**

Although Alternative 3 may result in major, adverse impacts to a specific or regional resource, impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair cultural resources during Alternative 3 implementation.

Unacceptable Impacts **Alternative 3** **Cultural Resources**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on cultural resources as a result of Alterative 3 implementation.

4.3.11 Alternative 4 Prescribed Fire Emphasis Cultural Resources

Alternative 4 emphasizes prescribed fire for fuel management (Table 4-32). Use of WFU fires (estimated 550 acres annually) would be greatly diminished and only allowed to burn in areas already in desired condition. Because nearly all non-prescribed fires would be suppressed, wildland fire acreage could increase (estimated 2,407 acres annually). Manual/mechanical treatments would still take place in Primary and Secondary WUI areas, totaling approximately 80 acres annually.

Impacts Analysis **Alternative 4** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 4 (80 acres annually) increases acreage from Alternative 1 (40 acres annually), potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish fuel reduction. Because these are planned activities, mitigation measures would be applied, and would very likely be successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impacts Analysis **Alternative 4** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Prescribed Fire

Impacts from fire management actions under Alternative 4 (9,000 acres annually, Table 4-32) would be more than those in Alternative 1 (5,850 acres annually). Types of impacts could be similar in Alternative 4 to those in Alternative 1, but the amount of impacts potentially increases under Alternative 4. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis **Alternative 4** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Archeological Sites**
Wildland Fire Use

Alternative 4 estimates 550 WFURB acres annually, compared to 5,500 WFU acres annually in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but would be considerably less in acres of WFURB accepted. Increased high severity fire acreage allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short to long term, local to regional and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Archeological Sites
Wildland Fire Suppression

Alternative 4 estimates 2,407 acres wildland fire suppression annually, compared to 2,005 in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Increase of suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural ecosystem element, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Planned Fire Management Actions — Historic Structures
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 4 increases acreage from Alternative 1 potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1, but amount of impacts potentially increase under Alternative 4.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Planned project implementation would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local to regional, negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Planned Fire Management Actions — Historic Structures
Prescribed Fire

Impacts from fire management actions would be more (9,000 acres annually) under Alternative 4, than in Alternative 1 (5,850 acres annually). Types of impacts could be similar in Alternative 4 to those in Alternative 1, but would include more acres involved in prescribed burns. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis — Alternative 4 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Historic Structures
Wildland Fire Use

Alternative 4 estimates 550 WFURB acres annually, compared to 5,500 WFURB acres annually in Alternative 1. Impacts from fire management actions and wildland fire responses would be similar to those in Alternative 1, but less in acreage. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Historic Structures
Wildland Fire Suppression

Alternative 4 estimates 2,407 acres wildland fire suppression annually, compared to 2,005 annual acres in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Planned Fire Management Actions — Ethnographic Resources
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire, below).

Alternative 4 increases acreage from Alternative 1 potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads and reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impacts Analysis **Alternative 4** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Prescribed Fire

Impacts from fire management actions would be more (9,000 acres annually) under Alternative 4 than in Alternative 1 (5,850 acres annually). Impact type could be similar in Alternative 4 to those in Alternative 1, but would include more acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis **Alternative 4** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Use

Alternative 4 estimates 550 WFURB acres annually, compared to 5,500 WFURB acres annually in Alternative 1. Impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but a lesser acreage burned as WFURB. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Even though reduced acres would less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Ethnographic Resources
Wildland Fire Suppression

Alternative 4 estimates 2,407 acres wildland fire suppression annually, compared to 2,005 annual acres in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, and negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Planned Fire Management Actions — Cultural Landscapes
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 4 increases acreage from Alternative 1 potentially impacting cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impacts Analysis — Alternative 4 — Cultural Resources
Planned Fire Management Actions — Cultural Landscapes
Prescribed Fire

Impacts from fire management actions would be more (9,000 acres annually) in Alternative 4 than in Alternative 1 (5,850 acres annually). Impact type could be similar in Alternative 4 to Alternative 1, but would include more acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, with negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis **Alternative 4** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Use

Alternative 4 estimates 550 WFURB acres annually, compared to 5,500 in Alternative 1. Impacts from fire management actions and wildland fire responses would be similar to those in Alternative 1, but less acreage accepted as WFURB. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Though reduced acres would be less likely to produce adverse impacts to cultural resources, there is still potential for short- to long-term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis **Alternative 4** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Suppression

Alternative 4 estimates 2,407 acres wildland fire suppression annually, compared to 2,005 annual acres wildland fire suppression in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Increased suppression responses may increase number of cultural resources exposed to adverse impacts. Impacts could be short to long term, local to regional, negligible to major adverse.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short to long term, local to regional, and negligible to moderate.

Cumulative Effects **Alternative 4** **Cultural Resources**

Cumulative affects are similar to Alternative 1. However, cumulative effects outside Primary and Secondary WUI areas are likely to be somewhat less due to prescribed fire emphasis. Proposed treatments combined with past, present, and foreseeable future projects in Primary and Secondary WUI areas may slightly increase impacts from soil erosion and disturbance. Additional mechanical fuels reduction, if completed near historic structures or in cultural landscapes, would have additional beneficial impacts by reducing risk of unwanted fire in cultural landscapes.

Conclusions **Alternative 4** **Cultural Resources**

Under Alternative 4, an estimated average 12,037 acres will receive fire treatment annually (prescribed, wildland fire-use and suppression; mechanical) over the length of the fire management plan (Table 4-32).

Ethnographic resources were identified during tribal review while this FEIS was under development, consultation, and during development and implementation of the PA.

Potential direct effects from planned fire management activities vary depending on where projects are located and types of activities involved. In general, these ground-disturbing activities can be anticipated, and vulnerable resources avoided, resulting in short-term, local, negligible to minor adverse effects under NEPA, and no adverse effect for NHPA compliance.

Unplanned fire management activities and wildland fire responses are unpredictable, and it is sometimes difficult to avoid or treat cultural resources where these fire types occur. Because WFU and wildland fire suppression responses are emergencies, actions may result in short- to long-term, local to regional, negligible to major adverse effects to cultural resources.

While Alternative 4 could result in some major adverse (unplanned fire management activities and wildland fire responses) impacts to cultural resources, impacts are not expected to rise to the level of impairment. Damage to cultural resources resulting from fire management actions and responses over the initial ten-year period may be an unavoidable result of fire management actions necessary to prevent large-scale destructive wildfire.

Impairment **Alternative 4** **Cultural Resources**

Although Alternative 4 may result in major, adverse (unplanned fire management response) impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair cultural resources during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Cultural Resources**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on cultural resources as a result of Alternative 4 implementation.

4.3.12 Alternative 5 Fire Use Emphasis Cultural Resources

This alternative emphasizes WFURB for ecological restoration and maintenance, and fuel reduction treatments (8,800 acres annually; Table 4-32). WFURB fires would be allowed in all GRCA FMUs except the Primary WUI , Secondary WUI, and Inner Canyon FMUs. An increase in actions and responses to WFU fires may increase adverse impacts to cultural resources, since WFURB fires are unplanned events. Prescribed fire would be conducted only around GRCA boundaries and WUI areas. Fewer suppression fires are anticipated because more would be managed as WFURB. Manual and/or mechanical treatments would still occur in Primary and Secondary WUI FMUs.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Archeological Sites**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 5 proposes 268 acres annually for thinning; an increase from 40 annual acres in Alternative 1. Alternative 5 potentially increases impacts to cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would very likely be successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. These mitigated adverse impacts would be short to long term, local, and range in intensity from negligible to minor. Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local and negligible to moderate.

Impacts Analysis — Alternative 5 — Cultural Resources
Planned Fire Management Actions — Archeological Sites
Prescribed Fire

Alternative 5 proposes 2,990 acres prescribed burn projects annually, a decrease from 5,850 acres under Alternative 1. Impact type would be similar in Alternative 5 as Alternative 1, but would include fewer acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The acreage planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, with negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis — Alternative 5 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Archeological Sites
Wildland Fire Use

Alternative 5 estimates 8,800 WFURB acres annually, compared to 5,500 WFURB acres annually in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those in Alternative 1,but would affect more acres under WFURB in Alternative 5 . An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. Increased acres would more likely produce more adverse impacts to cultural resources, and impacts would potentially be short to long term, local to regional, with negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis — Alternative 5 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Archeological Sites
Wildland Fire Suppression

Alternative 5 estimates 1,805 acres wildland fire suppression annually, compared to 2,005 annual acres wildland fire suppression in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Decreased suppression acres may decrease the number of cultural resources exposed to adverse impacts, but potential impacts could still be short to long term, local to regional, with negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal to reduce fire severity in wildland fire ignitions. Manual fuel reduction projects would include crews using heavy equipment to cut, limb, crush, chip, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 5 proposes 268 acres annually for thinning; an increase from 40 annual acres in Alternative 1. Alternative 5 would potentially increase impacts to cultural resources, and uses a variety of heavy equipment to accomplish fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local to regional negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Historic Structures**
Prescribed Fire

Alternative 5 proposes 2,990 acres annual prescribe burn projects, a decrease from 5,850 annual acres under Alternative 1. Impact types would be similar in Alternative 5 to those in Alternative 1, but would include fewer acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, with negligible to minor adverse effects.

Implementation of planned projects would result in short to long term beneficial impacts by reducing fuel loads and reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis — Alternative 5 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Historic Structures
Wildland Fire Use

Alternative 5 estimates 8,800 acres WFURB annually compared to 5,500 annual WFURB acres in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but would include more acres burned under WFURB in Alternative 5. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

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Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis — Alternative 5 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Historic Structures
Wildland Fire Suppression

Alternative 5 estimates 1,805 acres wildland fire suppression annually, compared to 2,005 annual acres wildland fire suppression actions in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Decreased suppression acres may decrease number of cultural resources exposed to adverse impacts, but potential impacts could still be short to long term, local to regional, with negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impacts Analysis — Alternative 5 — Cultural Resources
Planned Fire Management Actions — Ethnographic Resources
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 5 proposes 268 acres annually for thinning; an increase from 40 annual acres in Alternative 1. Alternative 5 would potentially increase impacts to cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for treatment. These mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local to regional negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Ethnographic Resources**
Prescribed Fire

Alternative 5 proposes 2,990 acres annual prescribed burn projects, a decrease from 5,850 in Alternative 1. Impact type would be similar in Alternative 5 as Alternative 1, but would include fewer acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, and negligible to minor adverse effects.

Implementation of planned projects would result in short to long term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis **Alternative 5** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Use

Alternative 5 estimates 8,800 acres WFURB annually compared to 5,500 annual acres WFURB in Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but would include more acres burned under WFURB in Alternative 5. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. The increased acres would be more likely to produce more adverse impacts to cultural resources, and impacts would potentially be short to long term, local to regional, and negligible to major effects to cultural resources.

Unplanned fire activities and responses may result in beneficial impacts to cultural resources. Naturally ignited fire can restore and maintain ecosystems, and reduce fuels. Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial effects to cultural resources may be short term to long term, local to regional and negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Ethnographic Resources**
Wildland Fire Suppression

Alternative 5 estimates 1,805 acres wildland fire suppression annually compared to 2,005 annual acres wildland fire suppression actions in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Decreased suppression acres may decrease number of cultural resources exposed to adverse impacts, but potential impacts could still be short to long term, local to regional, and negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Manual/Mechanical Fuel Reduction

Manual fuel reduction projects include vegetation cutting and removal by hand and hand tools, to reduce fire severity in wildland fire ignitions. Mechanical fuel reduction projects include crews using heavy equipment to cut, limb, crush, roll, masticate, or otherwise remove or reduce vegetation in the project area. Vegetation debris is frequently piled for future prescribed pile burns (see prescribed fire below).

Alternative 5 proposes 268 acres annually for thinning; an increase from 40 annual acres in Alternative 1. Alternative 5 would potentially increase impacts to cultural resources, and uses a variety of heavy equipment to accomplish to fuel reduction. Because these are planned activities, mitigation measures would be applied, and would be very likely successful in reducing or eliminating potential adverse impacts to cultural resources. Potential mitigated impacts would be similar to those identified in Alternative 1.

Identified mitigation measures would be implemented to protect and lessen adverse effects to cultural resources. Effects will occur primarily in developed areas targeted for this treatment. Mitigated adverse impacts would be short to long term, local to regional, and range in intensity from negligible to minor.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would be local to regional negligible to moderate.

Impacts Analysis **Alternative 5** **Cultural Resources**
Planned Fire Management Actions **Cultural Landscapes**
Prescribed Fire

Alternative 5 proposes 2,990 acres annual prescribe burn projects, a decrease from 5,850 annual acres under Alternative 1. Impact types would be similar from Alternative 5 to under Alternative 1, but would include fewer acres burned in prescribed fire. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. The number of acres planned for the mixed-conifer vegetation is relatively small; effects are expected to match the impact levels of Alternative 1.

Because these projects would be planned, mitigation measures would be applied, and would very likely succeed in reducing or eliminating adverse effects to cultural resources. Mitigated adverse impacts could be short to long term, local to regional, with negligible to minor adverse effects.

Implementation of planned projects would result in short- to long-term beneficial impacts by reducing fuel loads; reducing risk of unwanted high severity fire would have local to regional, and negligible to moderate effects to cultural resources.

Impacts Analysis **Alternative 5** **Cultural Resources**
Unplanned Fire Events and Fire Management Responses **Cultural Landscapes**
Wildland Fire Use

Alternative 5 estimates 8,800 acres WFURB annually compared to 5,500 annual acres under Alternative 1. Types of impacts from fire management actions and wildland fire responses would be similar to those found in Alternative 1, but would include more acres burned under WFURB in Alternative 5. An increase in acres of high severity fire allowed in the mixed-conifer vegetation type may increase adverse effects to cultural resources. Where and how much fire is unknown; since WFU is unplanned, effects are expected to match the impact levels of Alternative 1.

Mitigation measures would be applied when possible; success would be uncertain. The increased acres would be more likely to produce more adverse impacts to cultural resources, and impacts would potentially be short to long term, local to regional, and negligible to major effects to cultural resources.

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Impacts Analysis — Alternative 5 — Cultural Resources
Unplanned Fire Events and Fire Management Responses — Cultural Landscapes
Wildland Fire Suppression

Alternative 5 estimates 1,805 acres wildland fire suppression annually, compared to 2,005 annual acres wildland fire suppression actions in Alternative 1. Mitigation measures would be applied when possible; success would be uncertain. Decreased suppression acres may decrease number of cultural resources exposed to adverse impacts, but potential impacts could still be short to long term, local to regional, with negligible to major adverse effects.

Fire suppression actions and responses may result in some beneficial impacts to cultural resources. Wildland fires can function as a natural element in the ecosystem, potentially promoting/maintaining culturally important vegetation (ethnobotanical resources; cultural landscapes). Benefits can sometimes be realized from fire exposing cultural resources for more complete inventory. Beneficial impacts may be short term to long term, local to regional, and negligible to moderate.

Cumulative Effects — Alternative 5 — Cultural Resources

Cumulative affects are similar to Alternative 1. Proposed treatments combined with past, present and foreseeable future projects in Primary and Secondary WUI may slightly increase impacts from soil erosion and disturbance. Additional mechanical fuels reduction, if near historic structures or in cultural landscapes, would have additional beneficial impacts by reducing unwanted fire risk in cultural landscapes.

Conclusions — Alternative 5 — Cultural Resources

Under Alternative 5, an estimated average 13,863 acres will receive fire treatments annually (prescribed, wildland-fire use and suppression fire; mechanical fuels treatment); see Table 4-32.

Ethnographic resources were identified during tribal review while this FEIS was under development, consultation, and during development and implementation of the PA.

Potential direct effects from planned fire management activities vary depending on projects location and types. In general, these ground-disturbing activities can be anticipated, and vulnerable resources avoided, resulting in short-term, local to regional, negligible to minor adverse effects under NEPA.
Unplanned fire management activities and wildland fire responses are unpredictable, and it is sometimes difficult to avoid or treat cultural resources where these fire types occur. Because WFU and wildland fire suppression responses are emergencies, actions may result in short- to long-term, local to regional, negligible to major adverse effects to cultural resources.

While Alternative 5 could result in some major adverse impacts to cultural resources (unplanned fire management activities and wildland fire responses), impacts are not expected to rise to the level of impairment. Damage to cultural resources resulting from fire management actions and responses over the initial FMP period may be an unavoidable result of fire management actions necessary to prevent large-scale destructive wildfire.

Impairment **Alternative 5** **Cultural Resources**

Although Alternative 5 may result in major, adverse (unplanned fire management response) impacts to a specific or regional resource, impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, impacts would not impair cultural resources during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Cultural Resources**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on cultural resources as a result of Alternative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Cultural Resources**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether by implementing mitigation measures or changing the nature of a proposed action. Thus, unavoidable adverse impacts would persist throughout the duration of the action.

Because wildland fire use and wildland fire suppression responses are emergency responses, effects from Alternatives 1-5 could be adverse, negligible to major, short- to long-term, local to regional for cultural resources. Appropriate strategies will be developed to mitigate moderate to major impacts during the Section 106 process, via a Programmatic Agreement.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Cultural Resources**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the plan's lifespan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

In Alternatives 1-5, Cultural Resources defined as historic structures or archeological sites could be lost as a result of fire management activities and responses; those losses would have an irreversible and irretrievable commitment of resources permanently due to materials loss, site structure alteration, and contextual evidence reduction. In Alternatives 1-5, the material element primarily found in ethnographic and cultural landscapes is vegetation; therefore, that vegetation could be adversely affected, which may cause irreversible, but not irretrievable commitment of ethnographic and cultural landscape resources short- to long-term due to loss of materials, access, and importance to affiliated tribes.

4.4 PHYSICAL ENVIRONMENT ENVIRONMENTAL CONSEQUENCES

4.4.1 Air Quality

4.4.1.1 Guiding Regulations and Policies — Air Quality

A number of laws guide air quality management at Grand Canyon National Park (See Appendix A for more information). Most important are the NPS Organic Act and Clean Air Act. Based on these laws, various regulations and policies have been developed to protect and enhance park air quality (and other areas), and guide smoke management efforts in concert with overall park management goals. The most important derivatives for air quality and smoke management include

- National Park Service Management Policies 2006
- Clean Air Act
- Regional Haze Rule
- Arizona State Regulations
- U.S. EPS's Interim Air Quality Policy on Wildland and Prescribed Fires

4.4.1.2 Management Objectives — Air Quality

- Conduct wildland fire management activities with the most current risk assessment and mitigation techniques available to ensure firefighter and public safety is the highest priority
- Use non-fire fuel treatments in areas where wildland fire use is not practical due to safety or smoke concerns. Even in these areas, however, fire will be used in the future as fully as possible to maintain desired conditions once restored through non-fire fuel treatment
- Minimize smoke impacts on human health
- Provide fire management workforce training, equipment, operating procedures, safety measures, and information needed to manage risks and perform activities safely
- Minimize smoke impacts on air quality values including visibility
- Conduct research to understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the Fire Management Program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, fuel reduction treatments) to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions (see Chapter 2), fire treatment priorities, and prescriptions as relevant data become available
- Conduct wildland fire prevention, education, and other activities in communities in and adjoining GRCA. Work in collaboration with local communities, county, state, and Federal fire agencies with fire-management interests
- Develop interpretive displays and educational programs with the Division of Interpretation to foster understanding of the Fire Management Program

4.4.1.3 Methodology for Analyzing Impacts — Air Quality

Calculating Wildland Fire Number and Size

In this environmental impact statement, treatment schedules were prepared for each alternative (Appendix D). These schedules include manual and mechanical fuel reduction projects, prescribed fire units, and anticipated acreage of wildland fire-use and suppression fires annually. For calculation purposes, treatment schedules were combined into a spreadsheet (Bowman 2007a). Treatment schedules represent a realistic projection of fire management activities based on overall goals of the different alternatives. Actual fire management activities through the life of the plan will be based on this schedule, but will obviously vary depending on many other factors, including weather, national and regional fire activity, actual wildland fire ignitions (human and lightning), and funding.

To aid in evaluating the different alternatives, particularly wildland fire use and suppression fires, a historical record of wildland fires from 1980 to 2005 was prepared by the GRCA Branch of Fire and Aviation. This record allowed a cumulative analysis of fire number and acreage consumed for WFU and suppression fires. Although fire frequency and size varies greatly from year to year, this 16-year record allowed correlation of fire number and size against total acreage burned. The correlation formulae for wildland fire-use and suppression fires were then applied to the anticipated total acreage burned in each alternative under these management strategies for the analysis period in a spreadsheet (Bowman 2007b).

Based on the 1980-2005 records, 640 acres was chosen as the minimum size a WFU or suppression fire generally needed to attain before air quality issues became a concern for human health or visibility. In reality, this size cutoff is not absolute, but serves as a reasonable division. A few historic fires smaller than 640 acres have caused visibility or health issues due to proximity to major park developments, while some larger fires have not raised such issues due to their remote location. Fires of less than ten acres often do not produce smoke plumes noticed by the public. Due to air quality impacts associated with visible plumes and with large fires, the predicted number of WFU and suppression fires smaller than ten and larger than 640 acres were calculated for each alternative. These predictions were combined with the projected prescribed fire treatments to prepare the Table 4-33.

Table 4-33 Anticipated Number of Fires Through 2017

Anticipated Number of Fires through 2017						
Alternative	Fire Management Type	Total Acres	Total Fires	Greater than 640 acres	10 – 640 acres	Less than 10 acres
1	Suppression	20050	42	6	31	5
	Wildland Fire Use	55000	55	15	33	7
	Prescribed	63994	45	31	14	0
	Total	139044	142	52	78	12
2	Suppression	20050	42	6	31	5
	Wildland Fire Use	55000	55	15	33	7
	Prescribed	63994	45	31	14	0
	Total	139044	142	52	78	12
3	Suppression	26070	43	6	32	5
	Wildland Fire Use	8800	43	12	26	5
	Prescribed	26541	27	16	11	0
	Total	61411	113	34	68	10
4	Suppression	24070	43	6	32	5
	Wildland Fire Use	5500	40	11	24	5
	Prescribed	111274	65	49	16	0
	Total	140844	148	66	72	10
5	Suppression	18050	41	6	30	5
	Wildland Fire Use	88000	58	16	35	7
	Prescribed	30948	29	18	11	0
	Total	136998	128	40	76	12

Emission Calculations Air Quality Methodology Air Quality

Many wildland-fire management air-quality impacts depend on type and amount of air pollutants released into the atmosphere. These pollutants may have direct effects (for example, haze and human health impacts caused by fine particles), or indirect effects (ozone health effects, which may result from chemical reactions between two fire-produced air pollutants, nitrogen oxides and hydrocarbons).

Amount of air pollution produced depends on fuel burned and combustion process. For example, burning piled forest fuels tends to release less air pollution than broadcast burning for a given fuel amount. Dry fuels burn cleaner than wet fuels. Once pollutants are released into the atmosphere, their impact on humans and park resources is further modified by weather—especially how quickly and widely wind dilutes pollutants.

Direct air pollution emissions were modeled for each of the five alternatives. For forest fuels, results from the FOFEM5 (First Order Fire Effects Model, Version 5) were used. For mechanical equipment, emission factors based on the Yosemite National Park Fire Management Plan (NPS 2004) were applied. Emissions for each project and/or treatment type were compiled in a spreadsheet (Bowman 2007b).

Forest Fuels Emission Calculations Air Quality Air Quality

FOFEM5 uses vegetation type, moisture conditions, and amount of fuel in various size classes to calculate emissions of respirable particles (PM_{10}), fine particles ($PM_{2.5}$), methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_X), and sulfur dioxide (SO_2). The program output is in emissions per acre burned. To calculate these emissions, the following procedures were used.

- For prescribed fires with burn plan, fuel, moisture, and vegetation data were taken directly from the burn plan for each unit. Emissions were then apportioned by vegetation types identified in the burn plan to calculate emissions per average acre in the prescribed fire project
- For prescribed fire unit without burn plans, vegetation types were estimated from park vegetation maps (Warren et al 1982). Fuel levels were derived from park fire-effects monitoring data from the appropriate fuel type, and whether or not the prescribed fire would be a first-entry fire for that unit. As with prescribed fires with burn plans, vegetation types were combined proportionally to calculate emissions per average acre
- For wildland fire-use fires, park fire effects monitoring data for ponderosa pine and mixed-conifer were used for fuel levels. Although other vegetation types have been burned under the WFU strategy, Grand Canyon Fire Management staff believe nearly all WFU during the planning period will be in these two vegetation types. The FOFEM5 model runs were combined to show 67% of ponderosa and 40% of mixed-conifer WFU fires will be second entry. Although some areas of piñon-juniper may also burn under a WFU strategy, acreage is anticipated to be minimal. Emissions from piñon-juniper fires are lower than those from ponderosa and mixed-conifer, but the overall reduction in WFU emissions for burning 50-150 acres of piñon-juniper annually would be negligible (less than 5%)
- For suppression fires, the historical fire record (1980-2005) was consulted. During that period, 96% of acres burned in suppression fires occurred in five vegetation types, 34% in mixed-conifer, 31% in spruce-fir, 13% in ponderosa pine, 9% in piñon-juniper, and 9% in sagebrush or blackbrush communities. Emission results from FOFEM5 for each of these vegetation types were combined in these proportions to calculate emissions from an average acre of suppression fire

Emissions per acre values calculated above then served as a basis for calculating total fire emissions under each alternative. Using the long-term treatment schedule for each alternative, the acres specified for each project were multiplied by emissions per acre calculated for that project.

For emissions due to mechanized equipment in manual and mechanical treatments, Grand Canyon Fire Management staff estimated equipment hours to thin one acre manually or mechanically. Using air pollutant emission rates for equipment from the Yosemite National Park Fire Management Plan (NPS 2004, Table IV-4), emissions per acre for each project were calculated.

These calculations produced total particulate emissions, rather than the PM_{10} and $PM_{2.5}$ desired, so conversion ratios were applied (CCPA 1995) to generate these values for mechanized equipment. As with the fire emissions, the long-term treatment plan was applied to these equipment emission values to calculate total emissions under each alternative.

Tables 4-50 and 4-51 below list total emissions for the five alternatives over the analysis period. With the exception of Alternative 3, all are very close to emissions predicted under a continuation of existing management practices in GRCA, represented by Alternative 1. In all alternatives, emissions from mechanized equipment are well less than 50 tons per year (indeed, except for methane and carbon monoxide, emissions are less than one ton/year).

Table 4-34 Annual Emissions from Mechanized Equipment

Annual Emissions from Mechanized Equipment (tons/year)					
	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_X
Alternative 1	0.09	0.09	1.82	5.90	0.02
Alternative 2	0.26	0.25	2.71	16.64	0.88
Alternative 3	0.40	0.39	4.07	25.72	1.40
Alternative 4	0.10	0.09	1.15	6.13	0.28
Alternative 5	0.29	0.28	3.07	18.21	0.93

Table 4-35 Change in Total Emissions Against the No Action Alternative

Change in Total Emissions Against the No Action Alternative (tons through 2017)								
Alternative		PM_{10}	$PM_{2.5}$	CH_4	CO	CO_2	NO_X	SO_2
1	Emissions	59,272	45,242	25,089	531,073	3,638,672	2,506	3,451
2	Emissions	59,274	45,244	25,099	531,202	3,638,672	2,517	3,451
	% Change	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%
3	Emissions	34,531	22,740	11,091	223,489	1,724,983	1,241	2,409
	% Change	-41.7%	-49.7%	-55.8%	-57.9%	-52.6%	-50.5%	-30.2%
4	Emissions	62,527	47,371	26,114	552,157	3,769,081	2,566	3,672
	% Change	5.5%	4.7%	4.1%	4.0%	3.6%	2.4%	6.4%
5	Emissions	55,407	42,426	23,502	496,435	3,450,035	2,437	3,277
	% Change	-6.5%	-6.2%	-6.3%	-6.5%	-5.2%	-2.8%	-5.1%

4.4.1.4 Air Quality Standards

Air Quality Standards for Human Health

Compliance with the National Ambient Air Quality Standards (NAAQS) is determined by monitoring according to EPA requirements with a "federal reference monitor." GRCA has a Federal reference method monitor for ozone, but not particulates. No official measurements for determining compliance with the NAAQS for particulates can be made. However, public health and safety are a primary concern in the NPS fire management program. Consequently, park staff deploys portable particulate monitors during wildland fires when potential for adverse health effects exists. These monitors are set to measure $PM_{2.5}$, the size class with the greatest effect on both visibility and health. Monitors are placed to characterize particulate levels where members of the public spend the night (such as Grand Canyon Village, Tusayan, Inner Canyon campgrounds, etc.). These instruments are not as accurate as the Federal reference method would require. They do characterize particulate concentrations well enough to be suitable for public health protection.

Particulate monitoring data from a number of large fires were evaluated against the current Air Quality Index established by the EPA, as well as the recently revised NAAQS for fine particles ($PM_{2.5}$). Not every large fire has been monitored for particulate levels. Occasionally, equipment malfunctions precluded collecting enough hourly data for calculation of the daily Air Quality Index. More often, fires were far enough away that even though visibility impacts were seen, these impact levels did not warrant particulate monitoring (the 2000 Outlet Suppression Fire and 2003 Powell Fire are good examples of the latter). Results for evaluated fires are expressed in Table 4-36.

All of these fires were larger than the 640-acre size assumed to have potential for adverse air quality impacts. From these results, it is obvious that the size of a wildland fire alone is not a good indicator of severity of any unhealthy conditions in particular visitor use and residential areas. Nor do these fires affect all areas equally. For example, the 2004 Outlet and Bright Fires caused unhealthy conditions in Bright Angel Canyon (as shown), yet monitors in the North Rim Developed Area and Grand Canyon Village did not record unhealthy levels of $PM_{2.5}$ during this period. Likewise, the Long Jim II and Lonetree Fires created unhealthy conditions in Tusayan, but not in Grand Canyon Village. Unhealthy levels were not seen during the larger North Rim and Poplar Complex Fires because they were further away from these heavily used areas, and smoke was carried away from, or dispersed sufficiently, before reaching them (although they did produce heavy visibility impacts).

Table 4-36 Health Impacts from Recent Large GRCA Fires

Health Impacts from Recent Large Fires in Grand Canyon					
Fire	Acres	Year	Days Meeting Air Quality Index Calculation Criteria	Air Quality Index at Unhealthy Levels	Days Above New 2006 $PM_{2.5}$ NAAQS
North Rim Complex WFU	11,010	2001	13	0	0
Poplar Complex WFU and Suppression	15,825	2003	27	0	0
Outlet Rx and Bright WFU	2,173	2004	8	2	2
Dragon WFU	8,011	2005	21	3	4
Long Jim II Rx	1,656	2006	14	2	2
Lonetree Rx	925	2007	14	2	3
Rx=prescribed burn					

Avoiding unhealthy conditions and potential NAAQS violations has become more of a challenge with the new $PM_{2.5}$ NAAQS (effective December 2006). At that time, the 24-hour standard dropped from 65 µg/m3 to 35 µg/m3, and adjustments to the Air Quality Index are expected soon. As illustrated in Table 4-36, four park fires since 2004 would have violated this new standard. Adherence to these national standards is critical to protect public health. State and tribal governments have been delegated authority to develop programs to meet these standards, and their authority extends over Federal programs and state, county, and local governments within the state. Arizona has developed and implemented an enhanced smoke management program that addresses both health and visibility standards. Monitoring and appropriate mitigation measures will be extremely important for fires close to, above, or upwind of heavily used areas.

Standards for Visibility **Air Quality Standards** **Air Quality**

In 1998, GRCA air quality staff began measuring visibility impacts of major wildland fires using an NPS transmissometer. This device measures light extinction (a numeric expression of visibility) between Phantom Ranch on the canyon floor and Yavapai Point near Grand Canyon Village. Visibility impacts were judged unacceptable when the rolling 24-hour average visibility was in the haziest 20th percentile for 24 hours or more. From 1998 through 2006, there were 14 fires larger than 640 acres, and each burned for an average 25 days. Visibility impacts from two of these fires were concurrent with two other fires, for a total of 12 major fires. Of the 12, two were in remote park areas and did not affect primary visitor-use areas on North and South Rim (nor the transmissometer). Another grew so slowly that its visibility impacts never warranted monitoring. The remaining nine fires produced varying degrees of visibility impacts with an average of ten days with unacceptable visibility per fire.

This historic pattern, that 75% of fires larger than 640 acres produce unacceptable visibility for ten days, was then applied to the wildland fire-use and suppression fires anticipated under the five alternatives over the analysis period.

In similar fashion, number of fires larger than ten acres was predicted to determine number of smoke plumes visible under the various alternatives (fires smaller than ten acres often do not produce noticeable plumes). Fires from 10 to 640 acres were assumed to burn 14 days. Based on these projections, Table 4-37 was generated in a spreadsheet (Bowman 2007b).

In using the visibility impacts table (Table 4-37) to compare the alternatives, the episodic nature of fire and its impacts cannot be over-emphasized. Particularly when dealing with smoke impacts, very small weather changes (wind speed and direction or barometric pressure) may have dramatic effects on smoke impacts. Inter-annual variability may produce virtually no fires one year, but many the next. Thus, numbers in tables above are good for comparing alternatives on a level playing field, but may or may not be reflected in the real world. It is best to view these data as indicators rather than predictions. The number of Plume Days, for example, is not the same as the number of days when plumes are visible, since a single calendar day may have several smoke plumes visible. It is also possible (although much less likely) for two large fires to cause unacceptable visibility simultaneously. However, based on these indicators, alternatives under consideration can be compared.

Table 4-37 Anticipated Visibility Impacts through 2017

Anticipated Visibility Impacts through 2017				
	Total		Annual Average	
	Number of Plume Days	Days with Unacceptable Visibility	Number of Plume Days	Days with Unacceptable Visibility
Alternative 1	1655	161	138	13
Alternative 2	1655	161	138	13
Alternative 3	1394	137	116	11
Alternative 4	1538	130	128	11
Alternative 5	1607	166	134	14
% Change from Existing Management				
Alternative 1	n/a	n/a	n/a	n/a
Alternative 2	0%	0%	0%	0%
Alternative 3	-16%	-15%	-16%	-15%
Alternative 4	-7%	-19%	-7%	-19%
Alternative 5	-3%	3%	-3%	3%

4.4.1.5 Impact Thresholds — Air Quality

Context The geographic scale of air quality impacts are categorized as local or regional. Local impacts are those confined to the Grand Canyon and immediately adjacent air drainage basins (such as Tusayan or the Upper Basin). Regional impacts are those affecting more distant areas such as Kanab, Tuba City, or Page

Duration

Short term Less than five days of emissions

Long term Greater than five days of emissions

Timing Time of day (day vs. night) is important for dispersal of emissions (winds generally shift at sunset). Also, seasons contribute to impacts; seasonal weather patterns contribute to concentrations or dispersal of emissions (windy days in spring disperse smoke faster). Timing is considered in burn plan development for individual prescribed fire projects and in the Wildland Fire Situation Analysis prepared for WFU fires

Intensity Thresholds for intensity are adapted from the Colorado River Management Plan, the Yosemite Fire Management Plan Environmental Impact Statements, and guidelines from the NPS Intermountain Region. Smoke emissions under any fire management scenario are well above the Intermountain Region tonnage thresholds identified. Because of the fire's necessity to restore and maintain park ecosystems, and given flexibility allowed under air quality regulations, smoke emissions are compared on a percentage basis.

Thresholds	Activity Analyzed (Direct Impacts)		Current Air Quality (Cumulative or Indirect Impacts)
Negligible	Equipment emission levels are less than 50 tons per year for each pollutant and Annual smoke emissions are within 5% of current levels and Number of plume days is within 5% of current levels	And	The first highest three-year maximum for each pollutant is less than 60% of the national ambient air quality standards and There is no observed ozone injury to plants and SUM06[2] ozone exposure is less than 12 parts per million hours (ppm/hr)
Minor	Equipment emission levels are less than 100 tons per year for each pollutant and Annual smoke emissions are within 20% of current levels and The number of plume days is within 20% of current levels	And	The first highest three-year maximum for each pollutant is less than 80% of the national ambient air quality standards and SUM06 exposures are less than 15 ppm/hr
Moderate	Emission levels are greater than or equal to 100 tons per year for any pollutant and Annual smoke emissions are within 50% of current levels and The number of plume days is within 50% of current levels	Or	The first highest three-year maximum for each pollutant is greater than 80% of the national ambient air quality standards and Ozone injury symptoms are identifiable on plants and SUM06 exposures are less than 25 ppm/hr
Major	Emission levels are greater than or equal to 250 tons per year for any pollutant and Annual smoke emissions are more than 50% above or below current emissions and The number of plume days is more than 50% above current levels	And	The first highest three-year maximum for each pollutant is greater than 80% of the national ambient air quality standards and Ozone injury symptoms are identifiable on plants and SUM06 exposures are higher than 25 ppm/hr

4.4.1.6 Mitigation Measures — Air Quality

Fire and smoke are natural components of GRCA ecosystems. However, determining how much wildland fire smoke is "natural" and how much is "anthropogenic" (the result of human actions, including past

[2] SUM06 is the sum of all hourly ozone concentrations equal to or above 60 ppb (0.060 ppm) for hours between 8 a.m. and 8 p.m. The SUM06 index is an indicator of ozone exposure plants receive during a 3-month growth season.

management decisions) is not straightforward. The Western Regional Air Partnership developed guidance on making this determination (Policy for Categorizing Fire Emissions, Western Regional Air Partnership, Nov. 15, 2001, at http://wrapair.org/forums/fejf/documents/nbtt/FirePolicy.pdf) which can be summarized as

1. Suppression fire smoke is natural (as part of fire suppression, all practicable measures are being taken to reduce smoke production)
2. Wildland fire use fire smoke is natural (because of the natural ignition of these fires)
3. Prescribed Fire smoke from fires used to maintain a naturally functioning ecosystem is natural, and
4. Prescribed Fire smoke from fires used to restore an ecosystem is anthropogenic.

While the guidelines provide a framework for differentiating natural and anthropogenic smoke, they also call for smoke management to reduce emissions from all wildland fires.

A variety of measures can be taken to reduce or manage smoke produced by wildland fires. Some measures apply during the planning phase, for example, when defining the prescription window for a prescribed fire. Other measures apply during the fire itself. No single measure is applicable to all fires, but all fires can be managed using some of these measures.

In preparing prescribed fire burn plans and wildland fire implementation plans, appropriate computer smoke-dispersion models will be run to predict smoke impacts at critical receptor locations. These critical receptors include population centers and developments nearby and in GRCA including Grand Canyon Village, Tusayan, Desert View, the Cross-Canyon Corridor (Kaibab and Bright Angel Trails), North Rim developed area, Kaibab Lodge, Supai, and Tuweep.

- Plans for any fire that result in predicted exceedences of NAAQS or Unhealthy conditions under the Air Quality Index will be refined until such impacts are not expected at critical receptor locations. Since current models do not model nocturnal smoke drainage well, computer model outputs will be treated with caution and results interpreted in light of previous experience
- Grand Canyon staff will coordinate closely with the Interagency Smoke Coordinator regarding any burning upslope of any critical receptor site to mitigate impacts of nocturnal smoke drainage

Timing can affect smoke dispersal and transport. To take advantage of windows when smoke impacts can be reduced, the following actions will be taken when appropriate.

- Burning ahead of cold fronts and/or precipitation, or anticipating effects of predicted precipitation to reduce smoke production and improve dispersion when consistent with other program goals (especially safety and risk management)
- Burning between March 15 and September 15 for optimal smoke dispersion, unless other project goals necessitate burns earlier or later, especially to mitigate wildlife impacts early in the year or manage wildland fire-use fires that burn into fall
- Ignite prescribed fires under good-to-excellent ventilation conditions
- Suspend ignitions for projects that do not use mass ignition techniques under poor smoke dispersion conditions unless continued ignition is necessary to protect human health and safety or for effective management of an ongoing fire
- Complete, whenever possible, daily ignitions by 3:00 p.m. to maximize burning during optimum mid-day dispersion hours, and avoid trapping smoke in inversions or diurnal wind flow patterns

Reducing fuel burned reduces smoke produced. Fuel reduction is often a primary goal of wildland fire. When consistent with program goals, these fuel reduction mitigation measures will be used when possible

- Dispose of slash by methods other than burning, if feasible, including transfer of thinning slash to the Bureau of Indian Affairs for distribution to neighboring tribes, or mulch slash for use in vegetation management and other projects
- Since large logs and snags are important wildlife habitat, they will not be specifically targeted for burning. Critical snags may also be lined to prevent their burning

- Burn before deciduous litter fall when possible
- Although fuels are often too moist to meet ecosystem goals, some prescribed fires may be conducted before green-up to reduce available fuels, but only when consistent with project goals including minimal impact to wildlife and ethnobotanical resources

The same fuel burned differently will produce different amounts of smoke. Generally, piles produce the least and smoldering the most for a given fuel amount. Consistent with program and project goals, the following mitigation measures will be taken to encourage cleaner fuel burning.

- When consistent with other program goals, mass ignition techniques such as aerial ignition by helicopter will be used to produce shorter fire duration. Aerial ignition is commonly employed for prescribed fire ignition and wildland fire-use management, and GRCA has this equipment onsite
- Pile burning produces fewer emissions than broadcast burning and will be considered on thinning projects such as WUI and boundary fuel reduction where non-burning alternatives are not feasible. Piles will be constructed by hand to reduce soil content, and burning will be conducted when other smoke impacts are not present
- Burning fuels with an air curtain destructor will be considered when non-burning options are not available and slash transport to the burner is practicable (such as thinning projects in developed areas and along existing roads)
- Extinguishing or mopping-up of smoldering fuels can be used when a decision is made to not fully suppress a fire. However, fuel consumption is generally a goal of wildland fire in Grand Canyon, and mop-up may damage cultural resources and/or wildlife habitat
- Chunking of piles and other consolidations of burning material will be used to enhance flaming and fuel consumption and minimize smoke production when consistent with other resource goals

Effective communications do not reduce smoke, but help increase public acceptance of smoke impacts. In case of unhealthy conditions, prompt notification is essential to protect public health.

- To aid public understanding of fire management plans and actions, park staff will ensure fire management information is available for the public (visitors, residents, contractors, etc.)
- Provide neighboring jurisdictions (land managers, communities, and tribal governments) with information on planned fire activities on an annual basis and with updates as needed before particular projects or incidents relevant to them
- Make information available to interpretive staff, guides, and others whose jobs include frequent public contact to explain the need for fire in park ecosystems and the nature of fire and smoke management
- During fire operations, disseminate public information on fire and its impacts (beneficial and adverse)
- If unhealthy conditions are present, promptly notify all people in the affected area (visitors, employees, contractors, etc.). The NPS will follow the most current EPA guidelines for public notification at http://airnow.gov/index.cfm?action=aqibroch.aqi#2

Smoke from any kind of wildland fire can adversely impact air quality. The following mitigation measures will be taken when monitoring shows such adverse impacts have reached potentially unacceptable levels.

- When visibility is Very Poor (daily average in the worst 10th percentile for the month) for three or more consecutive days, fire managers should either, a) take fire management action to reduce smoke impacts, or b) obtain written concurrence from park management that fire benefits to other park resources outweigh visibility impacts. Documentation for either action will be forwarded to the Interagency Smoke Coordinator and the park Air Quality Specialist
- When monitoring in sensitive receptor sites indicates the Air Quality Index is 100 or more (Unhealthy to Sensitive Individuals), begin immediate notification of people in the affected area (see Table 4-38). Fire managers should also begin assessing options to reduce smoke production and implementing actions as soon as practicable
- When monitoring in sensitive receptor sites indicates the Air Quality Index is 150 or more (Unhealthy), protection of public health will become park management's highest priority (see Table 4.54). Public

notification in the affected area will be immediate and aggressive. Area closures may be made by the Superintendent, and smoke production from contributing fires should be reduced as quickly as possible

4.4.1.7 Cumulative Impacts — Air Quality

Smoke from wildland fires is only one source of air pollution affecting GRCA air quality. Many fires are so small they have little impact on overall conditions, but a few are so large that they effectively overwhelm any other sources. Weather conditions are important factors in determining location and severity of impacts—good smoke dispersion can allow a relatively large fire to have few impacts, while stable or stagnant air may allow a smaller fire to cause problems.

Real-time air-quality monitoring instruments used to assess smoke impacts can not distinguish the source of the haze they measure. Fog, precipitation, regional haze, or wildfire smoke generally look the same to these instruments. Human observation and meteorological data generally allow screening of weather effects from other haze sources, and are invaluable in ascertaining the general nature of the haze. Beyond this screening, air quality monitoring conducted during a fire measures cumulative impacts, and thus, any actions taken to manage air quality (especially those taken to protect human health) are also in response to cumulative impacts.

The Interagency Smoke Coordinator's office plays a critical role in managing cumulative effects from wildland fires in Arizona. The Coordinator is the central contact for burn requests and accomplishment reports for all Federal, state, private, and many tribal forest burning activities, and advises the Arizona Department of Environmental Quality on issuing permits for additional fires statewide. Thus, they can monitor total smoke production in various airsheds and have some ability to manage these loads through approval (or denial) of new burn requests.

Background air pollution levels are usually not subject to park control. Regional haze, the uniform haze thickest in late spring and summer, is generally the result of pollution sources so far upwind that it arrives in the park well-mixed, rather than as identifiable plumes. The NPS continues to work with individual states and regional planning organizations to reduce regional haze and its impacts on park resources. These reductions generally affect chronic sources (transportation, urban plumes, industrial facilities, and wildland fire-management policies), but are not responsive to episodic events like particular wildland fires. Even so, as state and regional initiatives reduce such chronic sources, they can diminish background haze levels during a particular fire, thus helping to reduce cumulative impacts.

4.4.1.8 Assumptions for Modeling — Air Quality

To model air-quality impacts into the future under five different scenarios, a number of assumptions must be made. These assumptions can be grouped as Environmental and Computational.

Environmental Assumptions — Air Quality Modeling — Air Quality

There is considerable inter-annual variability in fire occurrences of any management type. One year may see no, or very few, fires with serious air quality impacts, while another may see several. However, over the period of analysis, total impacts are expected to generally mirror impacts modeled here, based on experience over the previous 16 years.

Weather conditions during a particular fire have tremendous influence on a particular fire's on-the-ground impacts. Weather and fuel parameters specified for prescribed fires are designed, in part, to reduce air quality impacts. However, the unplanned nature of WFU and suppression fires do not have such ignition criteria (although WFU fires are managed to mitigate these impacts, their ignition and duration can not be as closely tied to weather predictions and actual conditions). Overall, it is assumed future fires will burn under the same mix of weather conditions as past fires.

Technology and methodology are assumed to remain constant through the analysis period. Over the course of the analysis period, it is reasonable to assume that both will improve, but the magnitude or applicability of possible improvements can not be known. Such improvements would likely be applied regardless of alternative. Consequently, assuming constant technology and methodology is appropriate for comparing alternatives now, even if actual conditions in the future have improved by some unknown amount in some unknown direction.

It is assumed that mitigation measures listed above will be applied and effective. While this is generally the case, it does not guarantee unforeseen events may cause a particular fire to exceed acceptable impacts. However, in most cases mitigations are assumed to keep air quality impacts within acceptable levels.

The largest assumption in modeling air quality impacts is that underlying data are sound. The fuel, vegetation type, and environmental conditions used in the FOFEM5 fire emission model are based on actual measurements made in GRCA. Fire Effects staff provided monitoring data and reviewed those subsets used in this analysis.

Another computational assumption underlying analysis is that models used, particularly FOFEM5, are accurate. In reality, any computer model has stronger and weaker points (for example, FOFEM5 is less accurate at predicting emissions from pile burning). Consistent model application throughout analysis should, however, level the playing field. In other words, modeled results for all alternatives should share the same strengths and weaknesses, and thus, be valid for comparison purposes.

Computational Assumptions Air Quality Modeling Air Quality

4.4.1.9 Incomplete or Unavailable Information

Perhaps the most obvious example of incomplete or unavailable information in air quality analysis is effect of climate change. Recent studies have found changes in fire season length and wildfire severity linked to recent temperature increases (Westerling et al. 2006), and predicted increasing difficulty with initial control of wildfires (Fried et al. 2006). Climate change drives changes in plant species distributions (Cole et al. 2005), which would alter plant communities and fire ecology. In spite of the possibility of such fundamental changes, current research looks at changes over decades to a century, and is unlikely to have the temporal precision to address changes during the analysis period. Thus, this analysis cannot address changes in fire management driven by climate change through 2017. Nevertheless, some studies do suggest benefits of ecological restoration in helping plant communities adapt to climatic changes through successional rather than catastrophic change (Westerling 2006).

Modeling for all five alternatives found mechanical emissions to be well below the negligible level of 50 tons per year. Indeed, only carbon monoxide emissions under Alternative 3 reached even half that amount. Consequently, impacts for mechanized equipment are negligible. They will not be analyzed further, except as they contribute to overall emissions under each alternative.

No special mitigation measures are proposed for air quality impacts specific to the alternatives. Rather, for each fire, appropriate mitigation measures will be applied by fire managers from the listing above.

Table 4-38 Public Alert Messages Regarding Unhealthy Air Quality Conditions

Air Quality Index	Current $PM_{2.5}$ 24-hour average ($\mu g/m^3$)	Descriptor	Group Notified	Sample Message
0 to 50	0 – 15.4	Good	none	none
51 to 100	15.5 – 40.4	Moderate	none	none
101 to 150	40.5 – 65.4	Unhealthy for Sensitive Groups	**Sensitive Groups** EPA defines as *People with respiratory or heart disease, the elderly and children are the most at risk*	**Employees** *$PM_{2.5}$ pollution conditions in the park have reached or are expected to reach unhealthy levels for sensitive groups. A health advisory has been issued for today (or tomorrow). Sensitive groups at increased risk to $PM_{2.5}$ effects include outdoor workers who regularly engage in outdoor activities and people with preexisting respiratory diseases (asthma, chronic obstructive lung disease). This sensitive group should avoid strenuous or prolonged moderate outdoor activities and should limit exposure until levels have dropped below unhealthy levels. Please consult your supervisor for guidance on work activities.* **Visitors** *Unhealthy $PM_{2.5}$ levels for sensitive groups have or are expected to occur today. Sensitive groups at increased risk to PM-$_{2.5}$ effects include active children and people who regularly engage in outdoor activities and people with preexisting respiratory diseases (asthma, chronic obstructive lung disease) This sensitive group should limit exposure by reducing duration or intensity of physical exertion or by rescheduling activities until levels have dropped below unhealthy levels.*
151 to 200	65.5 – 150.4	Unhealthy	General Public	**Employees** *$PM_{2.5}$ pollution conditions in the park have or are expected to reach unhealthy levels. A $PM_{2.5}$ health advisory has been issued for today (or tomorrow). All park employees should avoid strenuous or prolonged moderate exertion outdoors. All employees should limit exposure and outside physical activities until levels have dropped below unhealthy levels. Please consult your supervisor for guidance on work activities.* **Visitors** *Unhealthy $PM_{2.5}$ levels have or are expected to occur today. This may cause irritation to lungs and discomfort breathing for healthy individuals and more pronounced symptoms in people with respiratory disease, such as asthma. Individuals should limit exposure by reducing duration or intensity of physical exertion or by rescheduling outside physical activities until levels have dropped below unhealthy levels*
201 to 300	150.5 – 350.4	Very Unhealthy	General Public	Although the NPS has not developed specific language for this level, the EPA states *Health Alert: everyone may experience more serious health effects.*
301 to 500	greater than 350.5	Hazardous	General Public	Although the NPS has not developed specific language for this level, the EPA states *Health warnings of emergency conditions. The entire population is more likely to be affected.*

4.4.1.10 Impact Analysis Air Quality
Impacts Common to All Alternatives

4.4.1.11 Alternative 1 No Action, Existing Program Air Quality

Alternative 1 represents a continuation of current fire management strategies, and is the alternative against which the others are compared.

Direct and Indirect Effects Alternative 1 Air Quality

Under Alternative 1, Table 4-39 shows annual anticipated emissions.

For visibility indicators, 138 plume days and 13 days of unaccepted visibility are anticipated annually. Of course, these are averages, and considerable year-to-year variations are possible.

Table 4-39 Anticipated Annual Emissions, Alternative 1

Alternative 1	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_x	SO_2	CO_2
Emissions, tons/year	5,000	3,855	2,154	45,726	213	287	310,380

Cumulative Effects Alternative 1 Air Quality

In 2002, an emission microinventory was completed for GRCA (EA Engineering 2002). This micro-inventory was refined for the Final Environmental Impact Statement, Colorado River Management Plan (NPS 2005a). This refined inventory represents the most recent snapshot of air pollution generated in GRCA. In that year, the Outlet Fire dominated park emissions. Removing wildland fire emissions from the microinventory, and substituting emissions anticipated from Alternative 1 implementation, finds wildland fire would produce 99% of PM_{10} and sulfur dioxide, 98% of carbon monoxide, 92% of volatile organics (represented by methane), and 68% of nitrogen oxides generated in the park.

Conclusion Alternative 1 Air Quality

Since Alternative 1 represents a continuation of existing management practices, changes in direct impacts on human health and air-quality related values will be negligible. Regionally, cumulative impacts on human health will remain negligible for carbon monoxide and particulates (PM_{10}) and moderate for ozone. Cumulative impacts on air-quality related values will remain negligible for carbon monoxide and moderate for ozone and particulates. Continuation of the existing program should keep local risk of impacts to human health at about the current level, and mitigation measures (including both monitoring and notification) should reduce direct adverse effects to individuals. Local impacts to other air-quality related values should also remain at about the same level.

Impairment Alternative 1 Air Quality

There are no major adverse impacts in Alternative 1, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair air quality during Alternative 1 implementation.

Unacceptable Impacts Alternative 1 Air Quality

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on air quality as a result of Alterative 1 implementation. Although potential unhealthy smoke levels may result from fire management activities, no unacceptable impacts will occur due to implementation of mitigation measures listed in 4.4.1.6.

4.4.1.12 Alternative 2 — Preferred Alternative, Mixed Fire Treatment Program — Air Quality

Alternative 2 represents minimal change to the existing fire management program. Changes introduced under this alternative have little effect on air quality indicators.

Direct and Indirect Effects — Alternative 2 — Air Quality

Alternative 2 shows negligible (less than 5%) change in emissions of all modeled pollutants and is not likely to affect current park air quality. This alternative does include increased acreage for non-fire treatments, especially in the two WUI FMUs, but these treatments will not increase risk of unhealthy particulate concentrations in major use areas. Indeed, by reducing risk of wildfires they will actually reduce health risks. Alternative 2 includes the same acreages of various fire treatments, so risk of unhealthy particulate concentrations remains unchanged. Under Alternative 2, Table 4-40 shows emissions anticipated annually and compares them to Alternative 1.

Table 4-40 Anticipated Annual Emissions, Alternative 2

Alternative 2	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_x	SO_2	CO_2
Emissions, tons/year	5,000	3,855	2,155	45,738	213	287	310,380
% Difference from Alt. 1	0%	0%	0%	0%	0%	0%	0%

Alternative 2 shows negligible change in emissions of visibility indicators. The number of smoke plume days (138) and risk of unacceptable visibility (13 days) are the same as Alternative 1. Implementation of this alternative is very unlikely to change current park air quality.

Cumulative Effects — Alternative 2 — Air Quality

Compared against parkwide emissions, Alternative 2 wildland fire would produce 99% of PM_{10} and sulfur dioxide, 98% of carbon monoxide, 92% of volatile organics (represented by methane), and 68% of nitrogen oxides generated in the park. These levels are the same as those for Alternative 1.

Conclusion — Alternative 2 — Air Quality

Alternative 2 represents minimal changes to existing management practices, and air quality indicators (including fires number and size, tons of emissions, plumes, and other characteristics described above) are essentially identical to Alternative 1. Consequently, changes in direct impacts to human health and air-quality related values will be negligible. Regionally, cumulative human-health impacts will remain negligible for carbon monoxide and particulates (PM_{10}) and moderate for ozone. Cumulative impacts on air-quality related values will remain negligible for carbon monoxide and moderate for ozone and particulates. Alternative 2 would keep local risk of human-health impacts at about the current level, and mitigation measures (including monitoring and notification) should reduce direct adverse effects to individuals. Local impacts to other air-quality related values should also remain at about the same level.

Impairment **Alternative 2** **Air Quality**

There are no major adverse impacts in Alternative 2, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair air quality during Alternative 2 implementation.

Unacceptable Impacts **Alternative 2** **Air Quality**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on air quality as a result of Alterative 2 implementation. Although potential unhealthy smoke levels may result from fire management activities, no unacceptable impacts will occur due to implementation of mitigation measures listed in 4.4.1.6.

4.4.1.13 Alternative 3 Non-Fire Treatment Emphasis Air Quality

Alternative 3 focuses fire management efforts on the WUI, and contains considerably more manual and mechanical treatments than other alternatives. With less fire, air quality indicators (emissions, visibility, etc.) are considerably less under this alternative in spite of the increase in mechanical emissions.

Direct and Indirect Effects **Alternative 3** **Air Quality**

Alternative 3 shows moderate to major reductions in all pollutants modeled and would provide a moderate to major benefit to park air quality. Given fire's episodic nature, benefits would be episodic as well. Table 4-41 shows emissions anticipated annually and compares them to Alternative 1.

Table 4-41 Anticipated Annual Emissions, Alternative 3

Alternative 3	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_x	SO_2	CO_2
Emissions, tons/year	2,497	1,639	804	16,222	88	172	123,851
% Difference from Alt. 1	-50%	-57%	-63%	-60%	-58%	-40%	-60%

Particulate levels measured in the park ($PM_{2.5}$) may have exceeded short-term NAAQS. However, the park's instruments are not EPA-certified, so such measurements are, at best, indicators rather than violations. High particulate levels are always associated with wildland fire smoke (although not always from fires in the park). Thus, moderate reductions in particulates predicted under this alternative are likely to have a moderate episodic health benefit. Although Alternative 3 includes substantially fewer acres treated by burning (61,411 acres vs. 139,044 acres in Alternative 1), fire treatments near developed areas are largely the same. Thus, potential for unhealthy conditions remains unchanged for most park visitors and residents. Fewer fire treatments planned in other park areas does reduce potential for unhealthy conditions in backcountry areas (although these areas are still susceptible to wildland fire use and suppression fire impacts).

In spite of reductions in nitrogen oxides and hydrocarbons current chronic ozone impacts are not likely to be reduced. Most park ozone is transported into the park, as shown by very subdued diurnal variation in ozone concentrations. In-park emissions are likely to drift away from the park as ozone-forming reactions occur. Park ozone concentrations have remained below the NAAQS, but have risen steadily since monitoring began in 1989. Park ozone exposure levels are high enough to cause foliar injury to sensitive plant species, although surveys for damage have not been conducted since such high-exposure levels commenced in the mid-1990s. Ozone-sensitive species (including aspen, ponderosa pine, and skunkbush) could likely benefit slightly from any NO_x and hydrocarbon reductions that may occur, although a substantial reduction in ozone exposure would not be expected as a result of this alternative.

A major reduction in carbon monoxide is modeled from this alternative. CO is not routinely monitored at Grand Canyon, although research in 2001–02 measured very low average CO levels in the park's southeast area (averaging 0.12 ppm in summer and 0.05 ppm in winter) (Martin et al. 2002), and CO produced by wildland fires is generally only a concern in close proximity to a fire (Core et al. 2001). CO reduction benefits would thus only be apparent in close proximity to the fire (for example, fewer fireline exposures).

Moderate particulates reductions predicted under Alternative 3 are likely to have a moderate episodic benefit. Visibility may show an overall benefit, with a 16% reduction in number of plume days (116). Progress on reaching the national visibility goal is based on improving the worst 20th percentile of days, and 15% fewer of these unacceptable days are predicted under Alternative 3 (11). Since smoke is a major contributor to these worst days, the moderate reduction in particulates (PM_{10} and $PM_{2.5}$) could improve the park's worst visibility. Ironically, the greatest visibility benefits would be expected away from the major visitor developments in Grand Canyon Village, Tusayan, and North Rim developed area, since the same number of prescribed fires are planned for these areas under Alternative 3 as Alternative 1.

Cumulative Effects — Alternative 3 — Air Quality

Under Alternative 3, wildland fire would still be the largest source of air pollution generated in the park—98% of particulates and sulfur oxides, 96% of carbon monoxide, 81% of volatile organics, and 47% of nitrogen oxides as compared to the 2000 park emission microinventory.

Conclusion — Alternative 3 — Air Quality

Alternative 3 focuses fire management efforts on the WUI, and on more non-fire treatments. Reduced emissions under Alternative 3 have a major beneficial direct impact regionally for all pollutants except sulfur dioxide, where a moderate benefit accrues. Regionally, cumulative human health impacts will remain negligible for carbon monoxide and particulates (PM_{10}) and moderate for ozone, since most long-term sources for these pollutants lie outside the park. Cumulative impacts on air-quality related values will remain negligible for carbon monoxide and moderate for ozone and particulates for the same reason. Visibility shows the greatest benefit under Alternative 3, with a 16% reduction in plume days and 15% fewer days of unacceptable visibility (although planned fire treatments are near the most visited park sections). Local risk of human-health impacts in developed areas in and adjacent to the park would remain at about the current level, since treatments in these areas are similar to those under Alternative 1. The risk of local impacts over the majority of the park would diminish, since few treatments are planned away from developed areas. In both cases, mitigation measures (including monitoring and notification) should reduce direct adverse effects to individuals. Local impacts to other air-quality related values should also follow the same pattern, that is, similar to Alternative 1 in developed areas, but reduced impacts elsewhere in the park.

Impairment — Alternative 3 — Air Quality

There are no major adverse impacts in Alternative 3, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair air quality during Alternative 3 implementation.

Unacceptable Impacts — Alternative 3 — Air Quality

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on air quality as a result of Alterative 3 implementation. Although potential unhealthy smoke levels may result from fire management activities, no unacceptable impacts will occur due to implementation of mitigation measures listed in 4.4.1.6.

4.4.1.14 Alternative 4 Prescribed Fire Emphasis Air Quality

Alternative 4 relies on prescribed fire as the preferred (although not exclusive) method to restore vegetative communities. Reliance on prescribed fire presents something of an air quality dilemma. Although air quality indicators analyzed below show some adverse increases, careful planning for prescribed fire offers the opportunity to avoid adverse impacts, and shorter duration of prescribed fire reduces risk of unanticipated conditions (especially weather). However, to meet prescriptions, prescribed fires are often conducted in spring or fall, when dispersion conditions are not as good as summer, and when other fire types are more common. It is important to keep these elements in mind while considering the more numeric analysis presented below.

Direct and Indirect Effects Alternative 4 Air Quality

Alternative 4 shows negligible change in most modeled pollutants. A minor increase in PM_{10} could have a minor impact on human health depending on location of fires and current weather. Current SO_2 levels in the park are well below the NAAQS, and the minor increase under this alternative would not pose a treat to human health. Under Alternative 4, Table 4-42 shows emissions anticipated annually and compares them to Alternative 1.

Table 4-42 Anticipated Annual Emissions, Alternative 4

Alternative 4	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_x	SO_2	CO_2
Emissions, tons/year	5,235	3,983	2,204	46,668	214	305	316,409
% Difference from Alt. 1	+5%	+3%	-2%	+2%	+1%	+6%	+2%

Alternative 4 has the most acreage treated by fire of any alternative. Units in WUI FMUs are the same as Alternative 1, thus posing about the same risk of unhealthy particulate concentrations for park residents and most visitors. Alternative 4 also includes the highest percentage of prescribed fire. Prescribed fire offers more opportunities for impact mitigation through the prescription process. Consequently, with careful mitigation, Alternative 4 can reduce risk of unhealthy particulate levels in park backcountry areas.

Since Alternative 4 shows negligible change in most modeled pollutants, negligible changes in ozone concentrations and plant exposures are anticipated. The increase in carbon monoxide is negligible as well. The minor increase in PM_{10} and SO_2 could result in a minor decline in visibility, due to the direct visibility impact of the former, and transformation of the later into haze-causing ammonium sulfate. Such impacts would be episodic, based on fire location, and would likely be overwhelmed by reduced smoke impacts anticipated from prescribed fire in this alternative. Alternative 4 relies the most heavily on prescribed fire to accomplish fire management goals. Part of the planning for these fires is to minimize air quality impacts. Consequently, Alternative 4 does show a 7% decrease in number of plumes visible (128) and fewest number of days (11) with smoke-driven visibility in the worst 20^{th} percentile, 19% less than Alternative 1. Reduction in number of unacceptable days would improve progress in restoring natural visibility conditions called for under the Clean Air Act and defined by the Regional Haze Rule.

Cumulative Effects **Alternative 4** **Air Quality**

Fire supplies the same proportion of total park emissions under Alternative 4 as from Alternatives 1 and 2 (and only varies slightly from Alternative 5). Fires would produce 99% of the park's particulates and sulfur oxides, 98% of the carbon monoxide, 92% of volatile organics (represented by methane), and 68% of nitrogen oxides. Consequently, wildland fire would remain the dominant air pollution source in the park under Alternative 4.

Conclusion **Alternative 4** **Air Quality**

Alternative 4 emphasizes prescribed fire treatments. Although air quality indicators (including numbers and sizes of fires, tons of emissions, plumes, and other characteristics described above) are very similar to Alternative 1, the planning process for, and shorter durations of prescribed fire (as opposed to Wildland fire use and suppression fires) may reduce risk of adverse impacts. Changes in direct impacts to human health and air-quality related values may be beneficial, but their magnitude is likely to be largely negligible, although particulates (PM_{10}) and sulfur dioxide show minor, adverse increases. Regionally, cumulative impacts on human health will remain negligible for carbon monoxide and particulates (PM_{10}) and moderate for ozone. Cumulative impacts on air-quality related values will remain negligible for carbon monoxide and moderate for ozone and particulates. Visibility shows beneficial improvements under Alternative 4, reflecting the more controlled nature of prescribed fire. Alternative 4's emphasis on prescribed fire may reduce local risk of impacts to human health compared to Alternative 1, even though emission levels remain about the same. Mitigation measures (including both monitoring and notification) should reduce direct adverse effects to individuals. Fire prescriptions may also reduce risk to other air-quality related values with reliance on more prescribed fire.

Impairment **Alternative 4** **Air Quality**

There are no major adverse impacts in Alternative 4, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair air quality during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Air Quality**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on air quality as a result of Alterative 4 implementation. Although potential unhealthy smoke levels may result from fire management activities, no unacceptable impacts will occur due to implementation of mitigation measures listed in 4.4.1.6.

4.4.1.15 Alternative 5 Fire Use Emphasis Air Quality

Alternative 5 relies on Wildland fire use as the preferred (although not exclusive) method to restore vegetative communities. Reliance on Wildland fire use presents something of an air quality dilemma. Although air quality indicators analyzed below show some beneficial decreases, careful planning for prescribed fire offers the opportunity to avoid adverse impacts, while longer duration of wildland fire-use fires may increase risk of unanticipated conditions (especially weather). Wildland fire-use fires most often occur in summer, when conditions to disperse smoke are generally best (although a few fires may last well into fall). It is important to keep these qualitative elements in mind while considering the more numeric analysis presented below.

Direct and Indirect Effects **Alternative 5** **Air Quality**

Emissions under Alternative 5 show generally minor benefits to park air quality, as seen in Table 4-43.

Table 4-43 Anticipated Annual Emissions, Alternative 5

Alternative 5	PM_{10}	$PM_{2.5}$	CH_4	CO	NO_x	SO_2	CO_2
Emissions, tons/year	4,656	3,625	2,034	43,128	208	269	296,002
% Difference from Alt. 1	-7%	-6%	-6%	-6%	-2%	-6%	-5%

Minor reductions in hydrocarbons (CH_4) could reduce ozone, but negligible reductions in its co-reactant NO_x make noticeable change unlikely. Minor reductions in particulates (PM_{10} and $PM_{2.5}$) could reduce potential for unhealthy levels of particulates in the park on an episodic basis, but to a smaller degree than benefits seen in Alternative 3. These benefits would be strongly controlled by fire locations and current weather conditions. Since the same prescribed fire units are proposed as under Alternative 1, risk of unhealthy particulate levels in park developed areas remains the same. Alternative 5 also proposes the largest percentage and acreage of wildland fire use. This management strategy is less amenable to impact mitigation, and thus risk of unhealthy particulate levels in the park backcountry areas could increase.

As in Alternative 3, the minor benefit of reduced carbon monoxide exposure is realistically limited to reduced fireline exposure.

Visibility benefits would be strongly controlled by fire locations and current weather conditions, but compared to Alternative 1, only a 3% reduction in plume-days is anticipated (134), and greater reliance on a wildland fire use strategy increases potential for unacceptable visibility by 3% (14 days). Since a change of 3% is equivalent to one day per year, either change would be difficult to notice.

Cumulative Effects **Alternative 5** **Air Quality**

Fire supplies nearly the same proportion of total park emissions under Alternative 5 as from Alternatives 1, 2, and 4. Fires would produce 99% of the park's particulates and sulfur oxides, 98% of carbon monoxide, 92% of volatile organics (represented by methane), and 67% of nitrogen oxides (the only difference). Consequently, wildland fire would remain the dominant air pollution source in the park under Alternative 5.

Conclusion **Alternative 5** **Air Quality**

Alternative 5 emphasizes wildland fire use. Air quality indicators (including fire number and size, tons of emissions, plumes, and other characteristics described above) show negligible to minor beneficial reductions under Alternative 5 as compared to Alternative 1. These benefits may be tempered somewhat by slightly greater risk inherent in wildland fire use, with longer fire duration and less intense planning (as compared to prescribed fire). Changes in direct impacts to human health and air-quality related values under Alternative 5 will be minor for all pollutants except carbon dioxide and nitrogen oxides which show negligible beneficial reductions. Regionally, cumulative impacts on human health will remain negligible for carbon monoxide and particulates (PM_{10}) and moderate for ozone. Cumulative impacts on air-quality related values will remain negligible for carbon monoxide and moderate for ozone and particulates. Visibility may show a small (negligible) decline with a small increase in number of unacceptable visibility days (but a beneficial decrease in the more easily mitigated plume days). Implementation of Alternative 5 may reduce local risk of impacts to human health, since fires are likely to be more widespread (more acreage will be further from developed areas). Mitigation measures (monitoring and notification) should reduce direct adverse effects to individuals. Local impacts to other air-quality related values may also show minor, beneficial reductions compared to Alternative 1, again tempered by the somewhat greater risks inherent in wildland fire use.

Impairment Alternative 5 Air Quality

There are no major adverse impacts in Alternative 5, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair air quality during Alternative 5 implementation.

Unacceptable Impacts Alternative 5 Air Quality

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, or concessioner or contractor operations, there would not be unacceptable impacts on air quality as a result of Alterative 5 implementation. Although potential unhealthy smoke levels may result from fire management activities, no unacceptable impacts will occur due to implementation of mitigation measures listed in 4.4.1.6.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts Air Quality

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action. Thus, unavoidable adverse impacts would persist throughout the duration of the action.

Alternatives 1-5 would have adverse, moderate, regional impacts on human health regarding ozone levels. However, air quality impacts at Grand Canyon occur from local, regional, and long-transport sources outside the park. Management actions designed to reach desired conditions would contribute to unavoidable impacts to air-quality-related values during fire management activities in and outside the park.

Alternatives 3 and 5 would have adverse, moderate impacts from particulates (PM_{10}) due mostly from long-term sources outside the park.

Alternative 4 would have adverse, minor impacts for particulates (PM_{10}) and sulfur dioxide.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources Air Quality

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the plan's lifespan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's life.

There would be no irreversible or irretrievable commitments of resources.

4.4.2 Soils And Watersheds

4.4.2.1 Guiding Regulations And Policies — Soils and Watersheds

Existing law and management direction for soils and watersheds resources in GRCA include
- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Clean Water Act of 1972
- Safe Drinking Water Act of 1974
- NPS Management Policies 2006
- GRCA General Management Plan
- GRCA Resource Management Plan
- Arizona State Water Quality Standards 2003

The NPS Organic Act of 1916 mandates that park activities do not impair park resources. The Clean Water Act of 1972 provides for protection of water quality in U.S. jurisdictional waters. Arizona State Water Quality Standards (2003) set standards for water quality and use to enforce Federal requirements of the Safe Drinking Water Act (1974).

GRCA soil protection is covered under NPS Management Policies 2006 and the 1995 GRCA GMP. NPS Management Policies 2006 state
- Understand and preserve park soil resources
- Prevent, to the extent possible, unnatural erosion, physical removal, or contamination of soil, or its contamination of other resources
- Management action will be taken to prevent or at least minimize adverse, potentially irreversible impacts on soils
- Minimize human disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams

NPS Management Objectives as stated in GRCA Resource Management Plan are
- Keep soil erosion rates due to human activities, such as visitor use or construction, within acceptable limits as defined by USDA Natural Resources Conservation Service (formerly Soil Conservation Service) and/or university soil scientists
- Preserve soil health and maintain natural soil-forming processes
- Maintain all components and processes of naturally evolving park ecosystems including recognizing that natural change is part of these systems that helps prevent resource degradation
- Recognize that some processes may need active management to restore them as close as possible to natural conditions. In this case, natural condition is defined as conditions prevalent prior to European influences. Prescribed fire and wildland use fire are considered part of active management. These processes include runoff, erosion, and disturbance to vegetation and soil caused by fire
- Monitor effects of wildland and prescribed fires on natural resources, including soils and water. Monitoring efforts should focus on easily erodible and sensitive soils, including biological soil crust

4.4.2.2 Management Objectives — Soils And Watersheds

Goals and objectives for the proposed FMP related to soils and watersheds include

Goal 2 Restore and maintain Park ecosystems in a natural, resilient condition
- Maintain ecosystems that are within the range of desired conditions (Chapter 2) through natural processes within policy constraints

- Restore ecosystems that are not within the range of natural variability to desired conditions (Chapter 2) and maintain them through natural processes within policy constraints
- Set priorities for treatment activities based on site-specific information including departure from natural fire return intervals, desired conditions (Chapter 2), and other relevant factors

Goal 3 Protect the park's natural, cultural, and social values

- Managing the ecosystem and natural processes are the primary objectives that will lead to healthy critical habitat for listed threatened, endangered and sensitive species.
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species
- Minimize smoke impacts on air quality values including visibility

Goal 4 Promote a science-based program that relies on current and best-available information

- Conduct research to help understand natural fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the fire management program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, and fuel reduction treatments) to assess effects on natural and cultural resources and social values
- Update fire return interval departures, desired conditions, prescriptions, and fire treatment priorities, as relevant data becomes available

4.4.2.3 Methodology For Analyzing Impacts

Soils And Watersheds Methodology

Tools Used To Analyze Effects To Soils And Watersheds

Many soil types exist in GRCA; to conduct the analyses, soil types were grouped by similar characteristics. GRCA soils were grouped by NRCS selected soil ratings combined to predict soil's response to fire or disturbance including off-road erosion, road erosion, and fire damage hazards. Soils were also grouped by soil type, which focuses more on soil productivity. Erosion and fire damage hazard ratings use selected soil and site characteristics to evaluate soil susceptibility to erosion and productivity loss. Hazards are rated as slight, moderate, severe, and very severe.

Fire impacts on soil erosion are estimated based on annual acreage proposed for fire treatment, calculated fire severities areas, andmodeledsediment yield for different soil types and fire severities. Analysis was conducted on average estimated treated acreage by year because soils begin to recover within a year of treatment. As recovery progresses, potential for erosion, sediment transport, and hydrographic changes lessens. Thus, analysis was conducted for the first year following treatment, which provides maximum potential effects.

The analysis is also broken out by vegetation type to account for differing fire behaviors in the four dominant vegetation types. Except for the mixed-conifer and spruce-fir vegetation types in Alternative 1, fire severity patterns used in this analysis are calculated from historic fire severity mapping and information provided in the vegetation analysis. While fire severity is based on effects to vegetation, it also provides an approximate indication of impacts to soils. It is assumed that these fire severity patterns represent current levels of treatment conditions.

For Alternative 1, prescribed and wildland fire-use fires in mixed-conifer and spruce-fir vegetation are limited to low intensity fires. There is high risk that fires will not meet this limitation, but analysis for Alternative 1 was conducted using the low fire intensity assumption. The other alternatives are analyzed by how much acreage is affected by low, moderate, and high severity fire and how much sediment may be produced by different treatments.

Potential for erosion and sediment transport was modeled using the Water Erosion Prediction Project Fuel Management tool (WEPP FuME). WEPP FuME is an interface with the WEPP model developed at the State University of New York at Buffalo. The WEPP model is a continuous simulation, process-based model that allows simulation of small watersheds and hillslope profiles in those watersheds for assessing various soil and water conservation management options for agricultural, rangeland, and forest sites (Renschler 2006). The WEPP model was designed for use on small watersheds less than 640 acres; therefore, it was not directly applicable to larger GRCA areas proposed for treatment.

The WEPP FuME tool has been developed by the USFS to use with fuel management practices including prescribed fire, thinning, and road development (Elliot 2006). Developed specifically for forest and rangeland conditions, WEPP FuME has provided outputs consistent with actual situations. This model can be used anywhere in the U.S. using existing climate, soil, and slope databases. WEPP FuME uses the hillslope profile function to predict potential sediment generation and transport. Multiple runs were conducted to evaluate different forest and soil types, climate, slope, and aspect. Results are then extrapolated to the local area.

Model output provides values for sediment generation and transport. However, output should be considered as relative, rather than absolute, values due to uncertainty of post-disturbance weather and limited area covered in each model run. Results must be extrapolated to other areas in the watershed.

WEPP FuME model output was combined with fire severity patterns of historic fires to estimate relative quantities of sediment yield from dominant forest types for each alternative.

4.4.2.4 Impact Thresholds — Soils And Watersheds

Analysis area includes GRCA soil and water resources. Effects on soils and watersheds are assessed by considering likely scale and effect severity. Do proposed management activities affect a sufficient portion of the drainage to have impact on water yield, peak flows, sediment yield, nutrient yield, and/or stream system response? Do proposed management activities severely affect a sufficient portion of soils to affect overall productivity, integrity, stability, and/or fertility?

Type of Impact

Adverse — Moves the system outside or away from the natural range of variability for soils (i.e., productivity, fertility) and watershed conditions (i.e., water yield, peak flows, sediment yield, nutrient yield, or stream system response)

Beneficial — Moves the system toward or maintains it within the natural range of variability for soils (i.e., productivity, fertility) and watershed conditions (i.e., water yield, peak flows, sediment yield, nutrient yield, or stream system response)

Intensity

Negligible — Chemical, physical, or biological changes to water quality are not detectable, well below state and Federal water quality standards, and within historical baseline or desired water quality conditions. Watersheds are essentially unchanged. Any effects to soil productivity, integrity, stability, or fertility would be imperceptible

Minor — Chemical, physical, or biological changes to water quality are detectable but well within or below state and Federal water quality standards and within historical baseline or desired water quality conditions. Watersheds are slightly altered with some increased

	erosion potential. Any effects to soil productivity, integrity, stability or fertility would be small and reversible
Moderate	Chemical, physical, or biological changes to water quality are detectable, within or below state and Federal water quality standards, but historical baseline or desired water quality conditions are being approached, equaled, or slightly exceeded. Watersheds are altered with a measurable increased erosion potential. Effects to soil productivity, integrity, stability, or fertility would be readily apparent, and result in a change to soil character
Major	Chemical, physical, or biological changes to water quality significantly alter historical baseline water quality conditions. State and/or Federal water quality standards are approached, equaled, or slightly and singularly exceeded. Watersheds are significantly altered with potential for severe erosion. Effects to soil productivity, integrity, stability, or fertility would be readily apparent and substantially change soil character
Context	
Regional	Sub-basin to watershed level hydrologic units delineated by USGS
Local	Proposed treatment areas and drainages within 200 yards downslope and downstream
Duration	
Short term	Following treatment, recovery would take less than 20 years
Long term	Following treatment, recovery would take more than 20 years
Timing	During spring run-off and monsoons, a greater likelihood of erosion exists (i.e., gullying, channel incision, stream bank failure, sheet erosion, etc.). This leads to elevated turbidity and sedimentation, which affect habitat and state and Federal water quality standards

4.4.2.5 Mitigation of Effects — Soils And Watersheds

The following mitigation measures are common to all five alternatives and applicable to soils and watershed effects. These mitigation measures are part of each alternative description and addressed in other sections of this chapter.

- Locate control lines, helispots, fire camps, and other soil-disturbing fire management activities to minimize damage to biological resources
- Protect aquatic habitat, riparian and wetland areas, meadows, and other sensitive resource areas by defining and avoiding these areas, especially with wheeled vehicles and fire retardant application. Water drops are preferred over fire retardant under all circumstances except for protection of life and safety. Avoidance zones will be identified in fire planning documents and maps, and may be flagged on the ground if deemed necessary by resource advisors or management staff.
- Rehabilitate affected sites (e.g., control lines, staging areas, helispots) as soon as possible following disturbance. Develop BAER plans as appropriate
- Monitor wildland fires to provide information necessary for adaptive management. Efforts will include monitoring fire behavior while fires are ongoing and providing feedback to fire managers. Long-term monitoring will be conducted through the existing fire effects program. Remote-sensing will monitor burn severity
- Rehabilitate fire line construction according to the GRCA Resource Advisor Handbook (NPS 2006c). Examples include pulling soil, duff, litter, woody debris, and rocks back onto the line to bring it up to grade and blend with the surrounding area

4.4.2.6 Cumulative Impacts — Soils And Watersheds

Cumulative effects on soils and watersheds were evaluated for each alternative combined with other past, present, and reasonably foreseeable future activities. These activities may occur in or outside GRCA, but are in the same hydrologic sub-basins as proposed treatments. Cumulative effects boundaries for soils and watersheds are the boundaries of hydrologic sub-basins in which proposed treatments will take place.

These include the Grand Canyon, Marble Canyon, Havasu Canyon, and Lower Little Colorado River sub-basins as shown on Map 4-2. Soil disturbing activities occurring in a watershed can have impacts to the immediate area which then migrate downstream, potentially affecting lower watershed reaches.

Areas outside GRCA but in the cumulative effects boundary include lands in the Kaibab National Forest; lands managed by the Bureau of Land Management; the Havasupai, Hualapai, Kaibab, and Navajo Indian Reservations; Arizona State Trust Land; and private lands. Activities may take place during the lifespan of the plan. The magnitude of activities may vary from several acres to thousands.

With the exception of the Marble Canyon sub-basin, total affected acreages of proposed GRCA treatment activities are 2% or less of the total sub-basin areas. Approximately 20% of the Marble Canyon sub-basin may be affected by past, present, and reasonably foreseeable future activities.

Projects outside GRCA but in the same hydrologic sub-basins include grazing; fuel management projects using prescribed and WFU fire, mechanical thinning, piling, and burning; habitat improvement using thinning, broadcast seeding, and herbicide treatments; fuel break construction; tree planting; meadow restoration; road maintenance and upgrades; and community construction projects. In addition, prescribed, wildland fire-use, and suppression fires will continue in and outside GRCA.

Most projects outside GRCA boundaries range from a few hundred acres to a few thousand. A few projects are anticipated to affect tens of thousands of acres and extend over several years, reducing affected acreage in any year. Appendix G lists projects considered in the cumulative effects analysis.

4.4.2.7 Assumptions — Soils and Watersheds

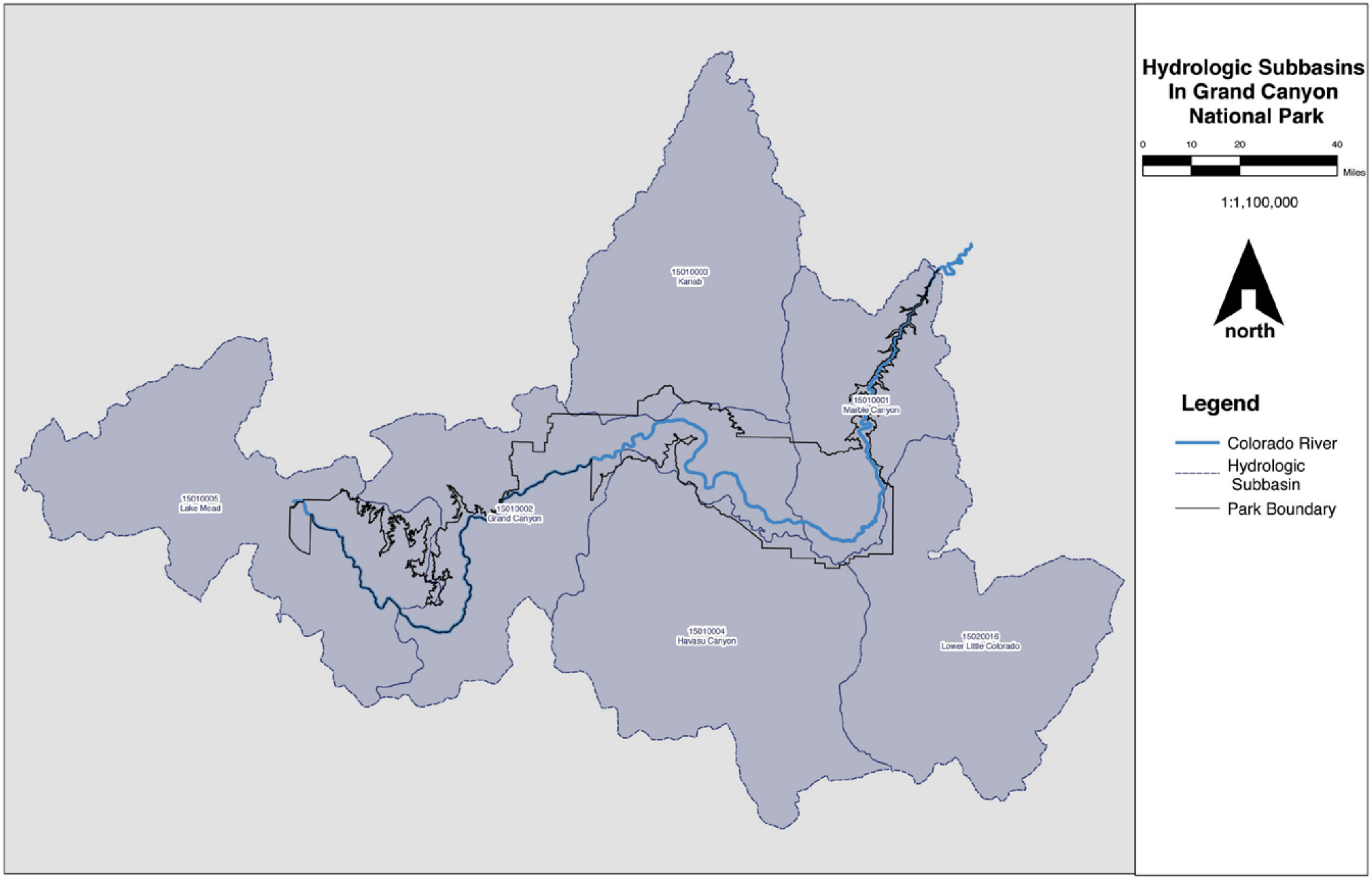
For purposes of this analysis, it was assumed that NRCS soils types and characteristics for the GRCA area are sufficiently detailed and accurate to represent a reasonable approximation of actual soil conditions. Input parameters used for sediment generation and transport modeling were obtained from the NRCS database. For specific soils not rated by the NRCS, ratings were assigned based on soil descriptions. Soils and streams in proposed treatment areas are assumed similar to pre-settlement conditions, with the exception of the Colorado River, which was dammed upstream of GRCA in 1968.

Existing erosion and sediment transport models are not capable of processing the large areas included in proposed treatment areas; therefore, potential erosion and sediment transport are based on modeled fire severity classes and extent, correlated with mapped vegetation, soil, and terrain characteristics. Modeling output reflects potential effects in the first year after treatment. Soil recovery is assumed to begin in the first year after treatment, gradually reducing impacts as recovery progresses. Fire severity mapping conducted on historic GRCA fires was used to derive severity percentages for prescribed, WFU, and suppression fires. Mapping is assumed representative of general fire severity patterns when initial treatments take place.

4.4.2.8 Incomplete and/or Unavailable Information — Soils and Watersheds

Some physical soil characteristics have not been determined for all areas in proposed GRCA treatment areas due to wide variability in soil characteristics and/or remoteness or inaccessibility of locations. Some of these characteristics were estimated based on the physical description of soil type.

Information regarding subsurface biotic community fire response is limited and often contradictory. A lack of consensus exists regarding this issue. Studies of bacteria, fungi, and invertebrate responses are ongoing, but nearly all fail to account for biotic community variability over space and time, as well as variability in fire severity and duration in a single burn event.



Map 4-2 GRCA Hydrologic Sub-Basins

Several weather stations collect data from both North and South Rims. However, predicting post-fire weather conditions is not feasible. Soil erosion and transport modeling is based on historic weather patterns but the first few precipitation events after a fire are most critical in influencing how much erosion occurs. The soil erosion and transport model assumes that moderate precipitation events will occur. More severe precipitation events may increase levels of erosion and sediment transport, and less severe conditions may decrease levels.

Fire behavior modeling predicts various fire characteristics including type of fire (i.e., surface, passive crown, or active crown) and fireline intensity (a measure of energy released by the fire as the flame front passes). However, the model cannot predict fire duration at any location. Rough burning duration estimates can be made from anticipated fuel load in the vegetation type. Precise locations of probable long duration burns cannot be predicted on a large scale as they are typically local to areas of high ground fuel loads, such as fallen trees, stumps, or snags.

Fire behavior modeling for this project only modeled effects of prescribed fire. Wildland fire-use and suppression fires cannot be modeled because location and size cannot be predicted.

Information regarding projects conducted or proposed outside GRCA is incomplete. Detailed descriptions, location maps, acreages, and timing of proposed or ongoing projects were unavailable. Potential cumulative effects from these projects were estimated based on limited available data.

4.4.2.9 Impact Analysis — Soils and Watersheds

Impact analysis is focused on four areas: potential fire impacts on soil erosion and sediment transport; fire effects on soil biota and nutrients; actions that cause soil compaction; and potential impacts on stream hydrography, groundwater, and water quality.

Direct and Indirect Effects — Effects Common to All Alternatives
General Effects from Fire — Soils and Watersheds

Wells and others (Wells 1979; National Wildfire Coordinating Group 2001) conducted an extensive review of existing literature regarding general fire effects on soils. Fire affects soils in a number of ways, and effects vary with fire intensity and duration. Effects can be beneficial or adverse, but are generally short term (less than 20 years). Fire removes varying amounts of vegetation and duff, reducing soil cover and organic matter. This could cause indirect adverse impacts by increasing erosion potential, and beneficial impacts by allowing solar radiation to increase soil temperature. Fire alters soil chemistry, changing nutrient balances, increasing pH, and sometimes decreasing water infiltration capacity (i.e., hydrophobicity). Chemical changes in soil and fire residue can have beneficial effects by temporarily increasing availability of certain soil nutrients to plants, such as phosphorus, potassium, nitrogen, magnesium, and sulfur. Fire's heat can also volatize these nutrients, some at relatively low temperatures, removing some nutrients, and causing an adverse effect.

Degree of adverse or beneficial impacts to soils is dependent on fire intensity (amount of heat the fire produces) and burning duration at any location. Both are dependent on several factors, including weather conditions, fuel loads, slope, and fuel moisture content. Fireline intensity and duration have not been mapped; however, fire severity has been mapped for historic fires in and near GRCA. Fire severity mapping is based on effects to vegetation, but does provide approximate indication of impacts to soils.

Table 4-44 displays percentages of fire severity expected for the four vegetation types in proposed treatment areas. The moderate/low and moderate/high fire severity categories have been combined because effects on soils are similar. Due to mitigation measures incorporated into Alternative 1 which require low fire intensity for prescribed and fire-use fires, these figures will not be used as part of the analysis for the mixed-conifer and spruce-fir vegetation types for these two fire types. Data in this table are crucial to ponderosa pine, piñon-juniper, and suppression fires analysis in Alternative 1, and all vegetation types and fire types in Alternatives 2 through 5.

Table 4-44 Historic Fire Severity by Forest Type and Fire Type

Fire Severity		Ponderosa Pine (%)	Mixed-Conifer (%)	Spruce-Fir (%)	Piñon-Juniper (%)
Prescribed Fire	High	3	10	20	3
	Moderate	30	50	40	14
	Low	51	20	10	47
	Unburned	16	20	30	36
Wildland Use Fire	High	1	9	20	N/A*
	Moderate	31	50	40	N/A
	Low	60	39	10	N/A
	Unburned	8	3	30	N/A
Suppression Fire	High	3	11	31	2
	Moderate	32	55	55	80
	Low	51	22	10	14
	Unburned	14	12	4	4

*Very limited wildland fire use activity is proposed for research and monitoring purposes to better understand the fire ecology of piñon-juniper. The total area affected by WFU activity would be negligible for this vegetation type, to meet cultural resource protection concerns.

Data indicate prescribed fire tends to have the lowest percentage of high and moderate severity burned areas and highest percentage of unburned areas. Suppression fires tend to have highest percentage of high burn severity areas. Wildland fire-use fires tend to last longer than prescribed fire and have greater variability in severity patterns, resulting in highest percentage of moderate burn severity areas. Overall, most severe adverse impacts to soils due to fire would occur during suppression fires.

The ponderosa pine forest type tends to have lower fire severity patterns, likely due to lower fuel loads and fire resistant trees. Mixed-conifer and spruce-fir tend to burn at higher severities, likely due to higher fuel loads, presence of more ladder fuels, and less fire-resistant trees. The piñon-juniper forest type tends to exhibit lower fire severity patterns for prescribed fire and higher severity for suppression fire.

Data reflect existing conditions prior to proposed treatments. As areas are treated, fire severity patterns would likely change, increasing percentage of low/moderate burn severity areas after initial treatment.

Direct and Indirect Effects **Effects Common to All Alternatives**
Soil Erosion and Sediment Transport **Soils and Watersheds**

Erosion and sediment transport are generally greater in burned areas due to soil cover removal (litter and vegetation) and decreased infiltration capacity (hydrophobicity). Greater sediment volumes are estimated lost from areas of higher severity fire. These volumes will diminish rapidly in subsequent years due to re-establishment of vegetation and fall of dead needles and leaves from scorched trees; therefore, generally erosion and sediment transport from fire would be a short-term indirect adverse impact.

Sediment yield volume would reduce significantly one-to-three years after burning due to revegetation and litter fall. Sediment yields can also be reduced by conducting mitigation measures designed to decrease erosion and sediment transport (see mitigation measures proposed in this section). Recovery is more rapid in areas of low and moderate burn severity. Soil burned at moderate/low fire severity has been cleared of competing plants, has increased nutrient availability, and is warmer (National Wildfire Coordinating Group 2001). These characteristics encourage plant growth from seed as well as plants that re-sprout after fire. Fire patchiness provides islands of seed stock from which burned areas could be revegetated. This process is slowed in severely burned areas, from which soil nutrients and biotic communities may be lost completely, reducing area productivity for several years (Merrill 2006).

Rate of predicted sediment yield increases with increasing fire severity. In suppression fires, this adverse impact would be greater than the other two fire types (prescribed and fire-use fires). Thus, lower severity fires tend to have lower sediment yield rates. Ponderosa pine has higher sediment yield rates predicted for prescribed fire than other vegetation types, due to soil types in these areas. Thus, even lower severity fires in ponderosa pine forests are likely to produce greater sediment volumes than other vegetation types.

Mixed-conifer and spruce-fir forest types have relatively higher percentages of high severity fire, so potential for adverse local impacts due to soil erosion is greater. Overall sediment yield for prescribed and wildland fire-use fires is similar, reflecting similarity of fire severity patterns.

Initial sediment yield could be much less or much greater depending on fire timing, and timing and intensity of initial precipitation events. An intense storm soon after a fire will mobilize more sediment than a series of milder storms over several months. Treatments conducted prior to or during monsoon season may produce much higher sediment volumes if treated areas are subjected to intense rainfall.

Direct and Indirect Effects
Soil Biota and Nutrients

Effects Common to All Alternatives
Soils and Watersheds

The biologic community in soils (bacteria, fungi, invertebrates, and other microorganisms) is affected by fire. Microorganisms recycle nutrients, create pathways for air and water to infiltrate soil, and support plant vigor. Reduction, species composition change, or elimination of part or all of this community can have adverse impacts on soil productivity (National Wildfire Coordinating Group 2001, Merrill 2006).

Soil heating is based on ground surface fire temperature, burning duration, and soil characteristics like moisture content and grain size. Crown fires would likely have lower ground temperatures than surface fires. Higher ground fuel loads would increase fire temperature and duration, leading to increased soil heating.

Most soils are poor heat conductors, and soil temperatures during fires typically drop rapidly with depth. Surface temperatures can range from approximately 212° F (100° C) in low severity fires to over $1{,}292^{\circ}$ F (700° C) in areas with heavy fuel loads (National Wildfire Coordinating Group 2001). Soils at about two inches (5 cm) below ground surface are rarely heated above 392° F (200° C), and soils in the 8- to 12-inch (20 to 30 cm) depth range are generally not heated at all (DeBano 2000). However, in heavy fuel load areas or under smoldering logs, where surface soil temperatures can reach 932° F (500° C) to $1{,}292^{\circ}$ F (700° C) (DeBano 2000), increased soil temperatures can reach depths of 16 to 20 inches (40 to 50 cm) below ground surface (Frandsen 1987).

Data presented by Wells (1979) provides measured temperatures at various fire severities. Low severity fire produced maximum ground surface temperatures of 351° F (177° C) and 250° F (121° C) at 0.3 inches (0.8 cm) below ground surface. Moderate severity fire produced a maximum surface temperature of 750° F (399° C) and 550° F (288° C) at 0.3 inches below ground surface. High severity fire produced a maximum surface temperature of 950° F (510° C) and 750° F (399° C) at 0.3 inches below ground surface. Thus, even though temperatures drop rapidly with depth, it is evident that even low severity fire can produce temperature increases at shallow depths.

Soil temperatures are likely to be lower if litter and duff layers and soil are moist. Increased moisture not only reduces fire severity, but can slow heat transmission into soil.

Most mycorrhizal fungi populations exist in or just below the surface organic layer, and are thus particularly vulnerable to fire that consumes the litter layer. Heat transferred to soil by fire kills mycorrhizal fungi at temperatures as low as 140° F (60° C). Bacteria can be present throughout the soil column. Bacteria and most other soil organisms are killed at temperatures exceeding 212° F (100° C) (Merrill 2006). Microorganisms that exist deeper in the soil column are more likely to survive fire effects.

With few exceptions, soil biota studies after low to moderate severity fires report recovery to normal or near-normal conditions in one or two years. Nitrogen-fixing bacteria populations have been found to recover function within a year after a burn (Busse and DeBano 2005). Plant communities typically begin to reestablish within one year as well. There generally appear to be no long-term adverse effects from low to moderate severity fire although this has been difficult to quantify. High severity fire areas are more severely affected and may take longer to recover (Busse and DeBano 2005). Results of various studies report a range of generally adverse effects short-term adverse to beneficial long-term (Merrill 2006).

While bacteria and other microorganisms may recover from fire effects quickly, mycorrhizal fungi populations may require more time, although results of existing studies are variable. Recovery is thought to be from surviving propagules, wind-blown spores, and chipmunk droppings (National Wildfire Coordinating Group 2001). Mycorrhizal fungi populations have been found to vary in density over short distances. This patchy distribution, combined with the patchy nature of most burns, may allow islands of surviving populations to re-colonize sterilized areas. Fire may also affect species composition in the mycorrhizal community, causing certain species to become more abundant in years following fire (Merrill 2006). Long-term effects of repeated fire on mycorrhizal communities are unknown.

Suppression fires contained much larger areas of higher severity fire. All burned areas contained vigorous forbs and grass growth within one year. However, halos of reddish, bare, sterilized soil extended one to several feet from large downed logs or stumps that burned or smoldered for long periods. These areas exhibited much slower plant growth rates, showing only thinly scattered vegetation after three years. These nearly barren areas covered a very small percentage of the burned areas and represent the extreme high end of fire severity effects.

Fires affect soil nutrient quantity and availability, particularly nitrogen and potassium. Large woody material locks up quantities of nutrients in forms unavailable to plants, and creates heavy fuel loads. When this material burns, some nutrients are lost through volatization and blowing ash. Ash that remains on the ground contains nutrients converted to forms usable by plants through chemical change and bacterial action causing a short-term indirect beneficial impact. Depending on site characteristics, fire severity, fuel load, and post-fire erosion, nutrient levels available to plants may increase or decrease. Studies in ponderosa forests found that plant-available nutrients generally increase after prescribed fire (Covington and Sackett 1986; Harris and Covington 1983).

Lower fire severity areas in prescribed, wildland fire-use, and suppression fires should have short- to long-term overall effects on soil biota likely local beneficial by recycling nutrients. High severity areas in these fire types, but typically more with suppression fires, could have local, short-term direct adverse effects. Given the patchy nature of fire severity patterns, even these areas should recover within 20 years. Long-term effects are unknown. Some very local major effects may occur over a small fraction of treated area. Short- to long-term effects to soil nutrients are likely local, minor to moderate, and beneficial.

While North Rim plateaus are too high in elevation to host biological soil crust, this plant community exists in some South Rim areas (Rasmussen 2006). Biological soil crust is a delicate, yet critical component of arid plant communities. It helps protect soil from erosion and provides organic matter and nutrients for other plants. Biological soil crust is easily damaged and may take decades to recover (Merrill 2006). However, Cole (1990) conducted a study of biological soil crust damage and recovery in GRCA and found substantial recovery within the first year. More study is needed to evaluate long-term recovery.

Little mapping of biological soil crust communities has been conducted. Thus, it is unknown if biological soil crust communities would be adversely affected by plan implementation. Short- to long-term local direct adverse effects on biological soil crust would occur if treatments take place where it exists.

Direct and Indirect Effects **Effects Common to All Alternatives**
Soil Compaction **Soils and Watersheds**

Compaction causes adverse soil effects by changing soil structure, reducing pore space, reducing infiltration capacity, and increasing surface runoff and erosion. Extent of these adverse impacts is based on acreage treated using manual (all alternatives) or mechanical thinning (Alternatives 2 through 5), type of equipment used (rubber-tire equipment causes more compaction than track-based equipment), treatment season, and non-fire treatment type. In general, equipment tends to create more compaction and disturbed areas than crews. Residue disposal practices could also reduce compaction (masticators leave shredded fuel residue onsite, providing a buffer between equipment and soil during treatment). Soil moisture would also play a key role in soil compaction. Moist soils are more readily compacted than drier soils. A proposed mitigation measure would reduce this adverse affect by avoiding applicable treatments during moist soil conditions.

Prescribed fire preparation and fire suppression activities (vehicle traffic off pavement and foot traffic on fire lines) could also result in soil compaction. Mitigation measures, including fireline and other disturbed area rehabilitation, and restricting traffic to a minimum in burned areas would reduce adverse effect.

Direct and Indirect Effects **Effects Common to All Alternatives**
Stream Hydrography, Groundwater, and Water Quality **Soils and Watersheds**

Fire effects on watersheds are due to soil cover removal and addition of fire residue to surface and groundwater. Removal of cover and hydrophobicity can increase overland flow, which could increase stream flow and alter peak flows. Shallow subsurface water storage may increase due to reduced interception and transpiration, or decrease due to increased soil heating. Sediment and nutrient transport to surface and groundwater may increase, potentially affecting water quality. In general, the greater the burned acreage and the higher the fire severity, the greater potential for adverse impacts to watersheds.

Local sediment pulses transported to drainages or streams are normal for the area. Flow rates of a few perennial streams were measured intermittently between 1992 and 1995 (NPS 2006e). Flow rate variation ranged from approximately double to more than an order of magnitude. For example, many proposed treatments will take place in Bright Angel Creek, Crystal Creek, and Shinumo Creek watersheds. Flow in Bright Angel Creek was measured nine times between 1992 and 1995, and ranged from 20 to 50 cubic feet per second (cfs). In a report by a GRCA hydrologist (Rihs undated), a flood event recorded in March 1995 produced a flow of approximately 2,800 to 3,000 cfs, calculated to be a 30-year storm event. Flow in Crystal Creek was measured 18 times between 1992 and 2005, and ranged from 0.48 to 6.5 cfs. Shinumo Creek flow was measured 13 times between 1992 and 2002, and ranged from 7 to 155 cfs. Based on this data, potential effects on peak flow of proposed treatments would likely remain within the area’s normal range of variability.

Erosion and sediment transport occurred on the 2003 Poplar Fire. Due to a local, intense precipitation event, boulders up to two feet in diameter were washed out of a very small drainage forming an alluvial fan at the slope base. The tributary drainage and main channel were downcut for a short distance. Evidence of excess sediment and down cutting disappeared a few hundred yards down the main channel. The storm date is unknown, but grasses and forbs are re-establishing on the new material.

The 1995 flood event in Bright Angel Creek caused extensive damage to a trail and pipeline in Bright Angel Canyon due to the large volume of water and sediment in the stream, indicating that flood and debris-flow events occur periodically, even without treatments on canyon rims.

This evidence indicates sediment transport takes place during intense rainfall events typically occurring during monsoon season. However, larger sediment particles are transported relatively short distances during any one storm. Sediments are moved gradually through the drainage system until they reach a perennial stream. In Alternatives 1, 2, and 4, Bright Angel, Crystal, and Shinumo Creeks are likely to receive somewhat increased sediment volumes because many treatments will take place in these watersheds. However, proposed treatments will occur over a number of years, reducing potential impacts to within natural variability.

Fire treatments on canyon rims have potential to cause indirect adverse impacts by adding some sediment as well as ash, nutrients, and charcoal to streams affecting stream water quality for a short period by increasing levels of turbidity, bicarbonates, nitrates, ammonium, and organic nitrogen. Ash and nutrients in runoff typically decline substantially after the first few storms, and are insignificant in one or two years (National Wildfire Coordinating Group 2001). Due to GRCA's steep-gradient, perennial streams, ash, and nutrients should rapidly flush downstream, minimizing water quality impacts beyond the initial flush.

Non-fire treatments are likely to have negligible indirect effects on watersheds, groundwater, and water quality due to low acreages, treatment protocols, and mitigation measures proposed. Most non-fire treatments are proposed in South Rim WUI where there are no perennial streams. Proposed treatments are designed to leave some ground cover to reduce potential invasive species encroachment. Presence of ground cover also reduces runoff and erosion. Mitigation measures that reduce sediment transport include use of wattles and straw bales.

Sediments, ash, and nutrients can also impact GRCA groundwater. Groundwater is recharged by water migrating from the surface through sinkholes, fractures, and faults in rock. Groundwater quality can thus be affected by runoff from proposed treatment areas in the same ways surface waters are affected. Effects are likely to be short-lived because groundwater migrates rapidly through openings in rock, emerging as canyon wall springs. Perennial streams are fed by these springs, so surface water quality may receive indirect adverse effects through impacted groundwater.

Vehicle and mechanical equipment use, with all alternatives, could also risk potential for pollutants which could have local adverse direct impacts to soils and watersheds. The proposed mitigation measure of designating areas to fuel and service vehicles with appropriate spill measures would reduce this risk.

4.4.2.10 Mitigation of Effects — Soils and Watersheds

In addition to mitigation measures in 4.4.2.5 that would decrease adverse impacts to soils and watersheds, additional mitigation measures proposed to minimize potential adverse impacts to the resource area are
Instruct crews to avoid biological soil crust during fire management activities

- Prohibit non-emergency wheeled or tracked equipment off-road when moisture causes soils to be easily compacted and rutted
- Conduct fueling and servicing only in designated areas with appropriate spill-control measures to prevent pollutants, such as fuels and lubricants, from impacting soil and drainages
- Restrict foot and wheeled traffic to a minimum in burned areas
- Install stabilizing structures such as water bars, check dams, straw bales, wattles, or other measures such as seed-free mulch or fine woody debris to reduce sediment transport, if sensitive areas require additional protection

Application of these mitigation measures are addressed in impact analysis throughout this section.

4.4.2.11 Cumulative Effects — Soils and Watersheds

As noted in 4.4.2.6, soil-disturbing activities occurring in a watershed can have impacts to the immediate area that migrate downstream, potentially affecting lower watershed reaches. With the exception of the Marble Canyon sub-basin, total affected acreages of proposed activities are 2% or less of total sub-basin areas. Thus, regional cumulative effects on these sub-basins are likely to be negligible. Approximately 20% of the Marble Canyon sub-basin may be affected by past, present, and reasonably foreseeable future activities. The cumulative impact on GRCA proposed treatments may be small due to estimated low to moderate impacts of most projects and presence of the northern GRCA boundary along a surface water drainage divide. Thus, projects outside GRCA's boundary that could affect stream flow or water quality will not affect GRCA streams. Impacts to the Colorado River, where all streams in Marble Canyon sub-basin drain, are likely to be within the natural range of variability for this region.

Past, on-going, and proposed projects in GRCA that could impact soils and watersheds include structure construction and rehabilitation, road maintenance and improvements, trail maintenance and upgrades, hazard tree removal, and nonnative species removal. These projects are local, cover small areas, and many will take place in already disturbed WUI. If these projects comply with standard erosion control measures for construction, they would have local, short-term, negligible adverse cumulative effects on soils.

Regarding past, present, and reasonably foreseeable projects outside GRCA noted in 4.4.2.6, local stream channels may be affected by higher runoff and sediment increase until rehabilitation is conducted and areas begin to recover. Herbicide treatment may introduce contaminants into stream channel sediments by direct application or in runoff. Properly managed grazing should have little overall impact on soils. However, cattle can impact areas where they congregate for water, compacting soils, damaging stream banks, damaging or removing ground cover, and introducing waste products into surface water. Although exact locations for many of these projects are unknown, most proposed projects appear to be well outside GRCA. Soil erosion and stream effects attenuate quickly with downstream distance, particularly in the region's climate. Projects well outside GRCA would likely have negligible cumulative effects on proposed projects in GRCA. Projects adjacent to GRCA could have short- to long-term minor to moderate adverse impacts to soils and watersheds in the cumulative effects boundary.

Some of these projects could result in improvements to soil and watersheds including some habitat improvement projects, tree planting, and meadow restoration. These projects could have short- to long-term, minor to moderate, beneficial impacts to soils and watersheds in the cumulative effects boundary.

4.4.2.12 Alternative 1 — No Action Existing Program — Soils and Watersheds

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. There are three FMUs divided into Ponderosa Pine, Mixed-Conifer, and Grass-Shrub-Piñon-Juniper. Alternative 1 assumes the same level of suppression of approximately 20,050 acres; 58,500 acres treated through prescribed fire (primarily in the ponderosa pine and mixed-conifer FMUs); 55,000 acres treated through wildland fire use; and 400 acres manually treated (primarily in piñon-juniper habitat). Manual treatment includes chainsaw use with cut vegetation chipped, piled, or otherwise disposed of offsite. Chapter 2 contains a full description of Alternative 1.

Direct and Indirect Effects — Alternative 1 — Soils and Watersheds
Soil Erosion and Sediment Transport

Soil erosion hazard and fire severity were used to analyze impacts by soil erosion and sediment transport. Map 4-3 shows GRCA's off-road erosion hazard. All proposed treatment areas have slight to moderate erosion hazard in off-road areas, largely due to soil types and moderate slopes. Erosion and sediment transport were modeled using WEPP FuME. Table 4-45 provides the park estimated average acreages per year for prescribed fire; calculated areas of high, moderate, and low severity fire based on historic fire mapping; and predicted average sediment volume transported from burned areas in the first year after fire using the WEPP type FuME model. Table 4-46 provides the same information for suppression fires using historical fire severity data by vegetation type.

Results should not be interpreted as precise calculations of erosion and sediment transport, but as relative magnitude of potential erosion for the various treatments. Data are divided into primary vegetation types in proposed treatment areas due to different fire severity patterns and soil types in each vegetation type.

Table 4-45 Predicted First Year Sediment Yield for Alternative 1 Prescribed Fire Treatments*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		2,450	2,150	310	850
Estimated area (acres)	High severity fire	75	0	0	0
	Moderate severity fire	730	0	0	0
	Low severity fire	1,255	1,720	220	540
	Unburned	390	430	90	310
Average predicted sediment yield (tons/acre)	High severity fire	0.10	0.06	0.04	0.06
	Moderate severity fire	0.07	0.03	0.02	0.04
	Low severity fire	0.06	0.03	0.02	0.03
Total predicted sediment yield (tons)		134	52	4	16

*Acreages of fire severity levels were calculated using the total acreage to be treated and the percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640.
Note Unburned areas are assumed to yield insignificant volumes of sediment and so are not included in sediment yield calculations

Table 4-46 Predicted First Year Sediment Yield for Alternative 1 Suppression Fires*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		240	675	615	185
Estimated area (acres)	High severity fire	10	75	195	5
	Moderate severity fire	80	375	335	150
	Low severity fire	120	150	65	25
	Unburned	30	75	20	5
Average predicted sediment yield (tons/acre)	High severity fire	1.31	3.38	2.62	0.74
	Moderate severity fire	0.30	0.47	0.37	0.14
	Low severity fire	0.11	0.07	0.05	0.07
Total predicted sediment yield (tons)		50	440	638	26

*Acreages of fire severity levels were calculated using the total acreage to be treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640.
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations.

Because WFU fire location and size cannot be predicted, fire severity patterns were averaged over the four primary forest types, and average annual acreages estimated by GRCA staff were used. Data are presented in Table 4-47.

Table 4-47 Predicted First Year Sediment Yield for Alternative 1 Wildland Fire Use*

		WFU Fire
Average annual burned area (acres)		5,500
Estimated area (acres)	High severity fire	550
	Moderate severity fire	2,210
	Low severity fire	1,990
	Unburned	750
Average predicted sediment yield (tons/acre)	High severity fire	0.07
	Moderate severity fire	0.05
	Low severity fire	0.04
Total predicted sediment yield (tons)		229

*Acreages of fire severity levels were calculated using the total acreage to be treated and the percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640.

Data from these three tables show that sediment yield rates approximately double in areas burned by high severity fire over low severity fire. Total predicted sediment yield for suppression fire is approximately five times that of prescribed or wildland fire-use fires, even though estimated suppression fire acreage is only about one-third. Thus, adverse erosion impacts from suppression fires would be much greater than those from prescribed or wildland fire-use fires.

As noted in 4.4.2.9, mixed-conifer and spruce-fir forest types have relatively higher percentages of high severity fire so soil erosion potential is greater. The relatively small spruce-fir acreage proposed for treatment means that overall adverse impacts would be minor and local. Overall sediment yield for prescribed and wildland fire-use fires are similar, reflecting similar fire severity patterns.

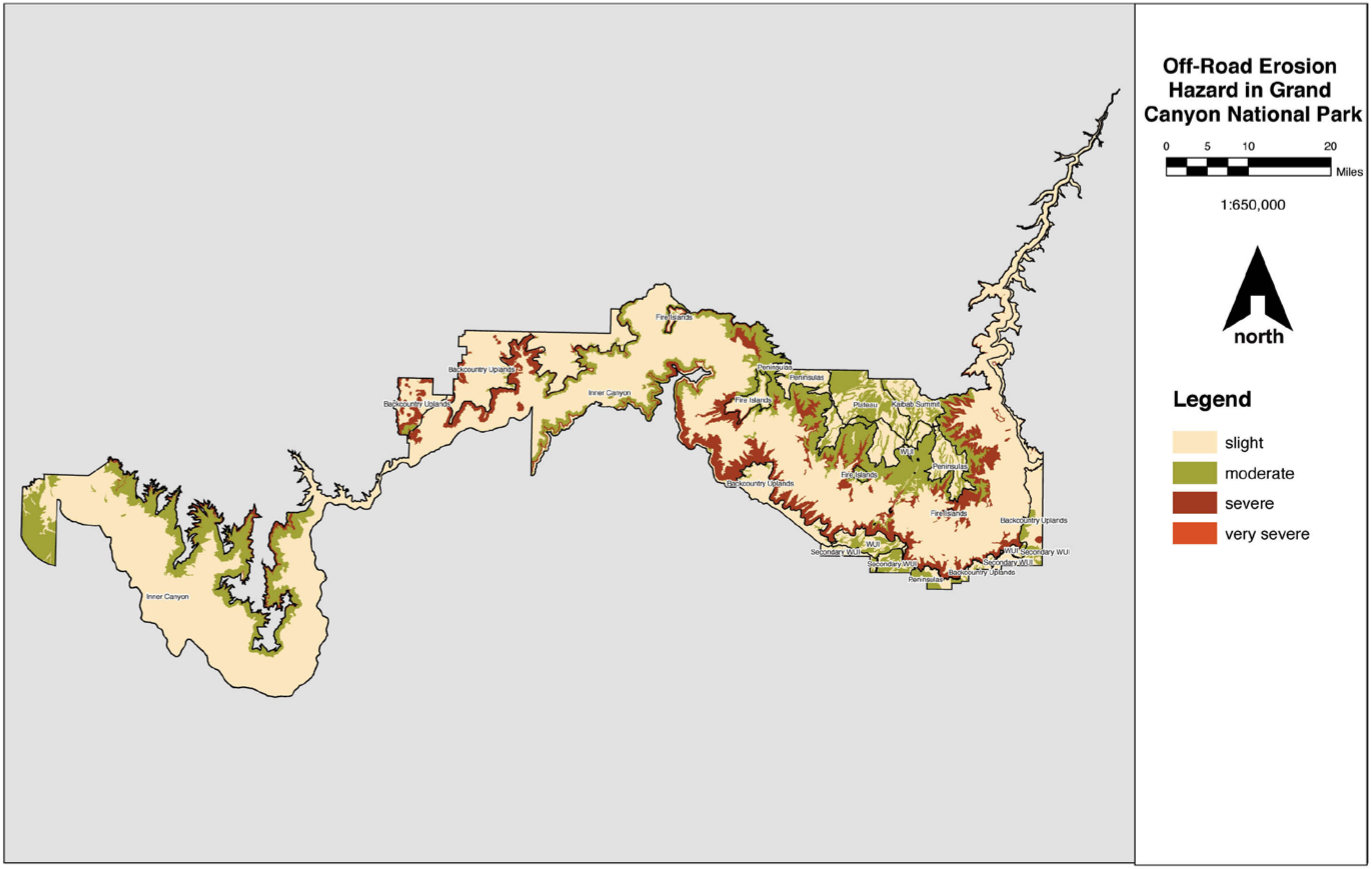
Because this alternative requires low intensity fires for all prescribed and wildland fire-use fires in mixed-conifer and spruce-fir vegetation types, soil erosion and sediment yield would be lower than the other alternatives when using these fire treatment methods. In addition, approximately one to two miles of handline construction per year is proposed. Overall, prescribed or wildland fire-use fires effects on soil erosion and sediment yield are likely minor, local, adverse in the short term. Adverse effects would be in the range of natural variability due to proposed low intensity fire. Long-term effects would likely be beneficial, minor, and local by reducing likelihood of large, high severity fires.
Suppression fires would burn at far higher severities than the two fire treatments proposed for this alternative. In addition, 6.5 miles of handline per year is anticipated as part of suppression activities. Considering these impacts, adverse impacts to soil erosion and sediment yield would be local minor to moderate short-term. Impacts from manual treatment on soils are addressed in soil compaction below.

Direct and Indirect Effects — Alternative 1 — Soils and Watersheds
Soil Biota and Soil Nutrients

Studies of soil biota after low/moderate severity fires report recovery to normal or near-normal in one or two years. Nitrogen-fixing bacteria populations recover function within a year after a burn (Busse and DeBano 2005). Plant communities typically begin to re-establish within one year as well. There generally appear to be no long-term adverse effects from low/moderate severity fire, although this is difficult to quantify. Direct adverse impact from prescribed and wildland fire-use fires to biota would be local short term negligible. For higher severity suppression fires, biota would be more severely affected and may take longer to recover (Busse and DeBano 2005). Results of various studies report a range of effects, generally adverse short term and adverse to beneficial long term (Merrill 2006). Given the patchy nature of fire severity patterns, even these areas should recover within 20 years.

As noted earlier, depending on site characteristics, fire severity, fuel load, and post-fire erosion, nutrients levels available to plants may increase or decrease. Studies in ponderosa forests have found that plant-available nutrients generally increase after prescribed fire (Covington and Sackett 1986, Harris and Covington 1983). Short- to long-term affects to soil nutrients, from any fire activity with this alternative, would likely to be local, minor to moderate, beneficial.

As noted above, the biological soil crust plant community exists in some South Rim areas (Rasmussen 2006). For Alternative 1, most fire treatment is proposed for North Rim, which should not impact biological soil crust communities. Any proposed South Rim fire and manual treatment could impact areas with biological soil crust. Since it is not clear how extensive this plant community is or where it exists, effects are hard to determine. Areas where this plant community is found could be avoided by pre-implementation surveys for prescribed fire and manual treatments. However, this would not be possible for wildland fire-use and suppression fires. Where biological soil crust would be directly impacted, short-to long-term, local, moderate, adverse effects would occur.



Map 4-3 Off-Road Erosion Hazard GRCA

Direct and Indirect Effects   Alternative 1   Soils and Watersheds
Soil Compaction

Proposed manual treatments could result in soil disturbance and compaction from crews; however, proposed acreage for manual treatment is small (40 acres annually). Other areas subject to soil compaction include the approximately eight miles of handline proposed per year related to fire activities (prescribed, wildland fire-use, and suppression fires) and helispots. This disturbance and compaction would result in some increased erosion and sediment yield. This direct adverse impact would be local, negligible, short term due to the small amount of disturbance. Implementation of mitigation measures included in 4.4.2.5 and 4.4.2.10 would further reduce adverse impact from soil compaction.

Direct and Indirect Effects   Alternative 1   Soils and Watersheds
Stream Hydrography, Groundwater, and Water Quality

Treatments for Alternative 1 are proposed in four of the five GRCA sub-basins. These include Marble Canyon, Lower Little Colorado, Havasu Canyon, and Grand Canyon. Proposed treated areas cover 0.1 to 2.3% of the four sub-basins that contain treatment areas. Because treatment amount, both fire and non-fire, effects very little of the sub-basins, there would be no effect of proposed treatments to watersheds at a regional scale. There may be very local, short-term, minor adverse effects to individual drainages in or adjacent to proposed treatments. Map 4-4 shows sub-basins, perennial streams, and selected springs.

Estimated acreage that may be burned by suppression fire is less than half of the proposed prescribed and wildland fire-use fires, but severities would be much higher than in proposed treatment areas. However, overall estimated acreage is low enough to have negligible effects to stream hydrology at the regional scale. However, if suppression fires occur, especially before or during monsoon season, much higher sediment volumes could be transported to perennial streams. There may be local, short-term, minor adverse effects to individual drainages in or adjacent to suppression fire areas.

There are very few perennial streams in these sub-basins, and nearly all are located in side canyons draining directly to the Colorado River. None of the proposed treatment areas are adjacent to perennial stream reaches, so there are not likely to be any direct effects. Indirect adverse effects include potential for pulses of sediments and ash to enter streams after severe precipitation events. These are likely to be local, minor, short term, and within the range of natural variability. Potential for these effects is significantly greater in the first few years after proposed fire treatment or suppression fire.

Groundwater may be indirectly affected by changes in recharge rates due to changes in soil infiltration rates and runoff. Whether changes increase or reduce recharge is impossible to predict. Increases in recharge would be beneficial, short term, minor, local; decreases would be adverse, short term, minor, local. Groundwater quality could be indirectly adversely affected by increased turbidity, suspended sediment, and ash after storms following all fire types. Effects from all fire types would be local, short-term, minor, adverse. Effects would be less for prescribed and wildland fire-use fires due to lower intensity than suppression fires.

Manual treatments are proposed primarily on South Rim in areas with no perennial streams. Manual treatments would result in negligible, short-term, local, adverse effects due to increases in turbidity and sediment to runoff in ephemeral drainages. Implementation of mitigation measures in 4.4.2.5 and 4.4.2.10 would further reduce adverse impact from manual treatments.

Mitigation of Effects   Alternative 1   Soils and Watersheds

In addition to mitigation measures described in 4.4.2.5, and additional proposed measures in 4.4.2.10, Alternative 1 includes the following mitigation measures that also affect soils and watersheds.

- Manage prescribed fires as low intensity to minimize negative effects on habitat and on primary constituent elements of MSO critical habitat
- Manage wildland fire-use fires as low intensity to minimize negative effects on habitat. Objective will be to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- Natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), but occasionally up to 10% mortality may occur in large trees

Mitigation measures will decrease adverse impacts related to soils and watersheds. None of the adverse impacts in Alternative 1 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased. There is a discussion on effectiveness of these measures in the indirect and direct impact section for this alternative.

Cumulative Effects — Alternative 1 — Soils and Watersheds

In the short term, cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely local, minor to moderate, adverse to soils, and within the natural range of variability. Effects to surface water, groundwater hydrology, and water quality are anticipated within the normal range of variability. Activities taking place well outside GRCA are not likely to have cumulative adverse impacts. Sediment transport and hydrologic effects become attenuated with distance and have a much reduced impact far downstream. Activities taking place near GRCA and upstream of proposed GRCA activities could result in an increased impact if they take place within a year of each other. This cumulative adverse impact would be local, minor, short term, adverse. In the long term, cumulative effects are likely local, minor to moderate, adverse to beneficial, depending on the activity.

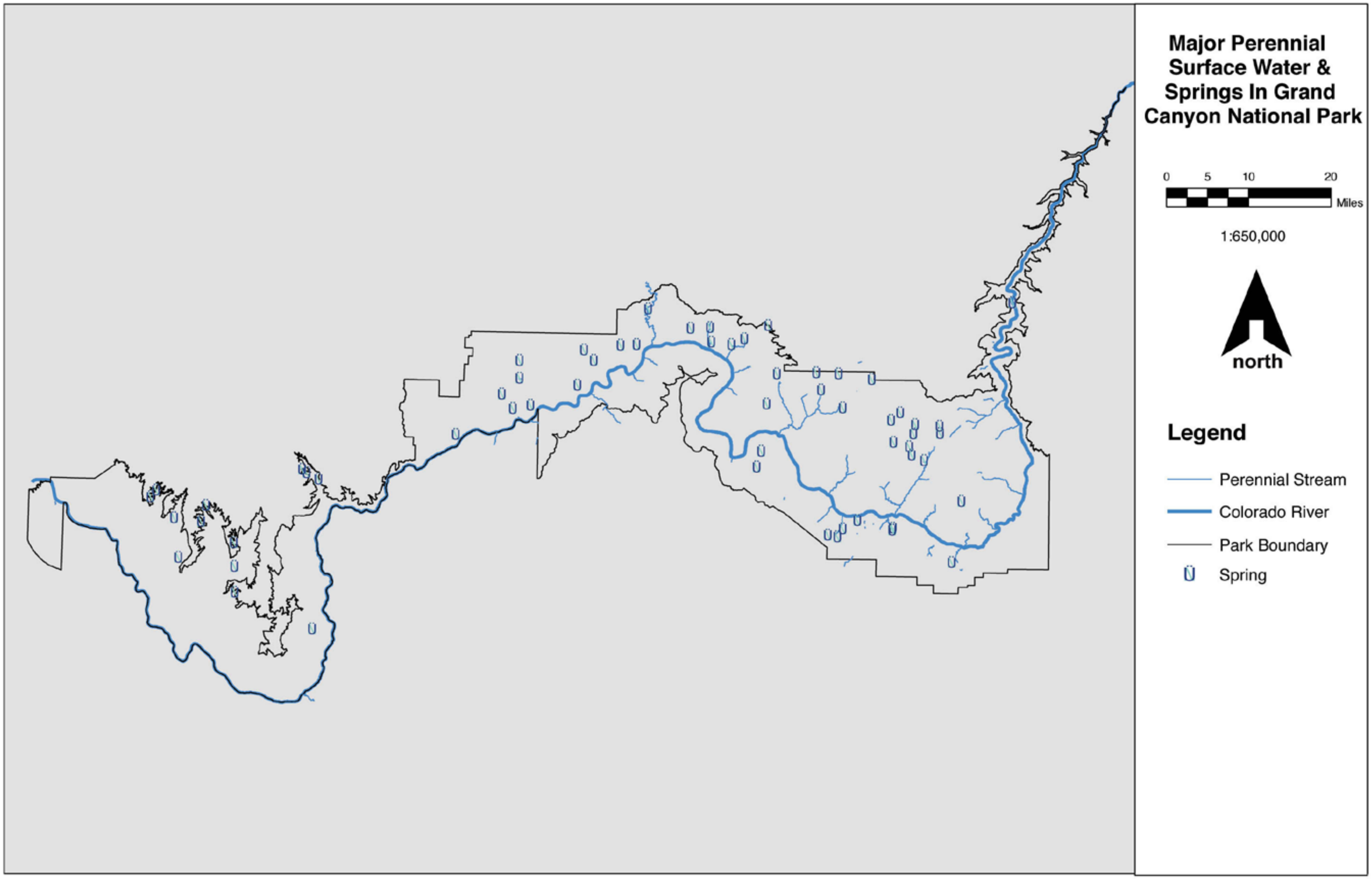
Conclusion — Alternative 1 — Soils and Watersheds

Proposed treatments and suppression fires are anticipated to have local, minor to moderate, adverse effects to soils short term. Suppression fire areas would experience more effects in the moderate range and have longer recovery times than prescribed or wildland fire-use fires. Long-term effects would likely be beneficial, minor, local for erosion and sediment transport by reducing likelihood of large, high severity fires.

Increased erosion and sediment transport of up to 0.10 ton per acre may occur in the first one to three years following prescribed or wildland fire-use fire treatments. Suppression fires could increase these rates 10 to 30 times. Lower severity fire areas would have fewer adverse effects and more beneficial effects than higher severity fire areas. Overall acreage proposed for prescribed and wildland fire-use fire treatments are low when compared to overall acres in sub-basins and scattered over North and South Rims, reducing overall impacts. It is anticipated vegetation would begin to re-establish within a year.

Soil nutrient levels in burned areas would be altered, with some nutrients increasing and some decreasing. Overall, low/moderate severity fire areas appear beneficial to soil nutrient availability and cycling. Initially, soil biota populations would be reduced or eliminated in some small areas. Recovery from this adverse impact to most soil biota should take place in one to five years, although species composition may change. Biological soil crust on South Rim could be damaged during proposed treatments or from suppression fires and/or activities associated with fire suppression. Should this occur, recovery of this resource could take a few years to decades.

For soil biota and soil nutrients, impacts from prescribed and wildland fire-use fires would be adverse, local, short term, negligible. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur. Short- to long-term effects to soil nutrients, from any fire activity with this alternative, would likely be local, minor to moderate, beneficial.



Map 4-4 Major Perennial Surface Water and Springs GRCA

Disturbance and compaction from proposed manual thinning operations would result in some increased erosion and sediment yield. This direct adverse impact would be local, negligible, short term due to the small disturbance amount.

Drainages in the immediate vicinity of proposed prescribed, wildland fire-use, and suppression fire areas may receive sediment pulses and increased turbidity the first and second year after treatment. These are likely to be within the normal range of sediment transport for GRCA, although volumes from suppression fire areas are likely to be greater than the other fire types. Eroded sediment volumes should decrease significantly after one or two years as vegetation is re-established.

There may be very local, short-term, minor adverse effects to individual drainages in or adjacent to proposed treatments. There may be local, short-term, minor adverse effects to individual drainages in or adjacent to suppression fire areas. Indirect adverse effects include potential for pulses of sediments and ash to enter streams after severe precipitation events. These are likely to be local, minor, short-term, and within the range of natural variability. Potential for these effects is significantly greater in the first few years after proposed fire treatment or suppression fire.

Groundwater may be indirectly affected by changes in recharge rates due to changes in soil infiltration rates and runoff. Increases in recharge would be beneficial, minor, short-term, local; decreases would be adverse, minor, short-term, local. Groundwater quality could be indirectly adversely affected by increased turbidity, suspended sediment, and ash after storms following all fire types causing local, short-term, local, adverse effects. Effects would be less for prescribed and wildland fire-use fires due to lower intensity than suppression fires.

Activities taking place near GRCA and upstream of proposed GRCA activities could result in increased impact if they take place within a year of each other. This cumulative adverse impact would be local, minor, short term, adverse. In the long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial, depending on the activity.

Impairment **Alternative 1** **Soils and Watersheds**

There are no major adverse impacts in Alternative 1, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair soils and watersheds during Alternative 1 implementation.

Unacceptable Impacts **Alternative 1** **Soils and Watersheds**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operation, there would not be unacceptable impacts on soils and watersheds as a result of Alternative 1 implementation.

4.4.2.13 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Soils and Watersheds

Alternative 2 makes minor changes to the existing GRCA fire management program. Changes are 1) use of new FMUs; 2) non-fire treatments would include manual/mechanical fuel reduction methods in Primary and Secondary WUI and be more extensive (2,490 acres total); and 3) mitigation measures incorporated in the alternative description are changed (e.g. low fire intensity requirements for prescribed and wildland fire-use fires are removed).

New FMUs are categorized by geographic area. These FMUs are shown on Map 2-2 and include Backcountry Uplands, Fire Islands, Inner Canyon, Kaibab Summit, Peninsulas, Plateaus, WUI, and Secondary WUI. Prescribed fire and manual/mechanical thinning will not take place in Fire Islands or Inner Canyon so are not considered in the analysis.

Acreages for prescribed, wildland fire-use, and suppression fires are the same as Alternative 1. Acreage proposed for manual/mechanical thinning in Primary and Secondary WUI areas increases from 400 to approximately 2,490 acres. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 2** **Soils and Watersheds**
Soil Erosion and Sediment Transport

Areas treated by prescribed and wildland fire-use fires would produce increased sediment volumes in the first few years following the burn. Sediment yield would be higher than Alternative 1 because higher severity burns would be expected, but overall these volumes would be similar to those of Alternative 1 and within the natural range of variability for this area. Tables 4-48 and 4-49 show predicted sediment yield for prescribed and suppression fire, and Table 4-50 provides predicted sediment yield for wildland fire-use fires. Depending on fire severity, vegetation recovery should begin in one to two years after the fire, reducing adverse impacts to negligible after two years. The soil biological community would also begin to recover within a year, except in areas of high severity fire. Severely burned soil may take five to ten years to revegetate sufficiently to reduce erosion to normal levels. Areas of high burn severity in these fire types are predicted to be restricted to a one- to three-foot halo around downed logs and stumps. Wildland fire-use and prescribed fire treatment would cause indirect, local, minor, adverse, short-term impacts due to soil erosion and sediment transport.

As with Alternative 1, areas burned by suppression fires would likely produce far greater sediment volumes and have more high severity burn acres than prescribed and wildland fire-use fire treatment areas. Table 4-49 shows total sediment volume produced as approximately five times that predicted for prescribed and wildland fire-use fire treated areas. Vegetative and biotic recovery from suppression fires would likely be slowed by the greater acreage burned under high severity fire conditions. This would cause a longer timeframe for erosion to occur during high-rain events. Overall, suppression fires would have local, short-term, minor to moderate, adverse impacts due to soil erosion and sediment transport. Non-fire treatment effects on erosion and sediment transport are addressed under Soil Compaction.

Table 4-48 Predicted First Year Sediment Yield for Alternative 2 Prescribed Fire Treatments*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		2,450	2,150	330	850
Estimated area (acres)	High severity fire	75	220	70	25
	Moderate severity fire	730	1,075	130	120
	Low severity fire	1,255	435	30	400
	Unburned	390	425	100	305
Average predicted sediment yield (tons/acre)	High severity fire	0.10	0.06	0.04	0.06
	Moderate severity fire	0.07	0.03	0.02	0.04
	Low severity fire	0.06	0.03	0.02	0.03
Total predicted sediment yield (tons)		134	59	6	18

*Note Fire severity acreage levels were calculated using total acreage to be treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

Table 4-49 Predicted First Year Sediment Yield for Alternative 2 Suppression Fires*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		240	675	615	185
Estimated area (acres)	High severity fire	10	75	195	5
	Moderate severity fire	80	375	335	150
	Low severity fire	120	150	65	25
	Unburned	30	75	20	5
Average predicted sediment yield (tons/acre)	High severity fire	1.31	3.38	2.62	0.74
	Moderate severity fire	0.30	0.47	0.37	0.14
	Low severity fire	0.11	0.07	0.05	0.07
Total predicted sediment yield (tons)		50	440	638	26

*Fire severity acreage levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640.
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

Table 4-50 Predicted First Year Sediment Yield for Alternative 2 Wildland Fire-Use Fires*

		WFU Fire
Average annual burned area (acres)		5,500
Estimated area (acres)	High severity fire	550
	Moderate severity fire	2,210
	Low severity fire	1,990
	Unburned	750
Average predicted sediment yield (tons/acre)	High severity fire	0.07
	Moderate severity fire	0.05
	Low severity fire	0.04
Total predicted sediment yield (tons)		229

*Acreages of fire severity levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Because location and size of WFU fires cannot be predicted, these fires were not split out by vegetation type for the analysis

Direct and Indirect Effects Alternative 2 Soils and Watersheds
Soil Biota and Soil Nutrients

Anticipated effects to soil biota would be somewhat greater than Alternative 1 due to higher fire intensities in mixed-conifer and spruce-fir allowed in this alternative. Effects from suppression fire should be the same as Alternative 1.

Areas of low/moderate fire severity would be adversely affected but would recover within a few years. Areas burned by high severity fire would experience greater adverse impacts and take longer to recover. Small sterilized soil areas surrounding logs and stumps could take five to ten years to recover. The patchy nature of most fires should leave islands of unburned vegetation and soil biota to provide seed stores for burned areas. Adverse impacts to biota from implementing this alternative would be local, short term, minor to moderate. Beneficial impacts to soil nutrients available for plants would be local, short-term, minor to moderate.

As with Alternative 1, biological soil crust areas may exist in some South Rim treatment areas. Because more acreage of non-fire treatment is proposed on South Rim, risk to adversely affecting this vegetation type would be higher than Alternative 1. As with Alternative 1, it is difficult to predict impacts when vegetation type extent and location is unknown. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

Direct and Indirect Effects **Alternative 2** **Soils and Watersheds**
Soil Compaction

Increased acreage treated by manual/mechanical thinning would result in greater areas of soil disturbance and compaction. As with Alternative 1, approximately eight miles of handline per year is proposed related to fire activities (prescribed, wildland fire-use, and suppression fires). Average predicted sediment yield would be 0.78 tons per year or approximately 14 cubic feet per year in the first few years after treatment. This would be higher than Alternative 1, but within the natural range of variability for this area. Sediment yield due to manual and mechanical thinning could be minimized through mitigation measures. Adverse impacts would be minor, local, and short term.

Direct and Indirect Effects **Alternative 2** **Soils and Watersheds**
Stream Hydrography, Groundwater, and Water Quality

Proposed treated areas cover 0.1 to 2.3% of the four sub-basins that contain treatment areas; therefore, there would be no effect from proposed treatments to watersheds at a regional scale. Sediment and nutrient delivery to perennial streams and groundwater is anticipated similar to Alternative 1. These impacts would be attenuated by distances from perennial reaches and be short lived. However, if suppression fires occur, especially before or during monsoon season, much higher sediment volumes could be transported to perennial streams. Impacts are anticipated within the natural range of variability.

This alternative would result in local, short- to long-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. Impacts to surface water and groundwater are anticipated within the natural range of variability for the area.

Mitigation of Effects **Alternative 2** **Soils and Watersheds**

Mitigation measures described in 4.4.2.5 and proposed 4.4.2.10 will decrease adverse impacts related to soils andwatersheds. None of the adverse impacts in Alternative 2 were considered major (significant), but if mitigation measures are implemented, adverse impacts would be further decreased. A discussion on effectiveness of these measures is in the indirect and direct impact section for this alternative.

Cumulative Effects **Alternative 2** **Soils and Watersheds**

In the short term, cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely to be local, minor to moderate, adverse to soils, and within the natural range of variability. Effects to surface water, groundwater hydrology, and water quality are anticipated within the normal range of variability. Activities taking place well outside GRCA are not likely to have cumulative adverse impacts. Sediment transport and hydrologic effects become attenuated with distance and have a much reduced impact far downstream. Activities taking place near GRCA and upstream of proposed GRCA activities could result in an increased impact if they take place within a year of each other. This cumulative adverse impact would be local, minor, short term, adverse. Long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial, depending on activity.

Cumulative effects are the same as for Alternative 1 with a slight increase in potential soil impacts in Primary and Secondary WUI FMUs. As total acreages are still low when compared to the sub-basins, cumulative adverse impacts with this added impact would be minor.

Conclusion **Alternative 2** **Soils and Watersheds**

Anticipated impacts for Alternative 2 would be similar to Alternative 1. Wildland fire use and prescribed fire treatment would cause local, minor, adverse, short-term impacts due to soil erosion and sediment transport. Overall, suppression fires would have local, short-term, minor to moderate, adverse impacts due to soil erosion and sediment transport. Adverse impacts to biota from implementing this alternative would be local, short term, minor to moderate. Beneficial impacts to soil nutrients available for plants would be local, short term, minor to moderate. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

Sediment yield and compaction due to manual/mechanical thinning could be minimized through mitigation measures. Adverse impacts would be minor, local, short-term.

Proposed treated areas cover 0.1 to 2.3% of the four sub-basins that contain treatment areas; therefore, there would be no effect from proposed treatments to watersheds at a regional scale. This alternative would result in local, short- to long-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. Impacts to surface water and groundwater are anticipated within the natural range of variability for the area.

Activities taking place near GRCA and upstream of proposed GRCA activities could result in increased impact if they take place within a year of each other. This cumulative adverse impact would be local, minor, short term, adverse. Long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial depending on the activity, with a slight increase in potential soil impacts in Primary and Secondary WUI FMUs.

Impairment — Alternative 2 — Soils and Watersheds

There are no major adverse impacts in Alternative 2, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair soils and watersheds during Alternative 2 implementation.

Unacceptable Impacts — Alternative 2 — Soils and Watersheds

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operation, there would not be unacceptable impacts on soils and watersheds as a result of Alterative 2 implementation.

4.4.2.14 Alternative 3 — Non-Fire Treatment Emphasis — Soils and Watersheds

Alternative 3's emphasis would be fuel reduction achieved through non-fire mechanical/manual treatments. Approximately 3,950 acres would be treated in WUI with mechanical/manual treatment. This alternative treats the lowest number of total acres, with estimates of 25,400 acres for prescribed fire; 8,800 acres for wildland fire-use fire; and a projected 26,070 acres for fire suppression. The majority of additional suppression acres are assumed to be primarily in North Rim forests. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects — Alternative 3 — Soils and Watersheds
Soil Erosion and Sediment Transport

This alternative decreases acreage for prescribed and wildland fire-use fire treatments, decreasing fire impacts to soils. Tables 4-51, 4-52, and 4-53 present acreages and sediment yield for prescribed, suppression, and wildland fire-use fires, respectively. Tables 4-51 and 4-53 show lower sediment yield volumes for prescribed and wildland fire-use fires in this alternative. This alternative provides the smallest overall treatment area and lowest volumes of predicted sediment yield. Adverse impact to soil erosion and sediment transport from prescribed and fire-use fires would be short term minor local.

However, suppression fire areas are anticipated to be somewhat larger than other alternatives. Table 4-52 shows that predicted sediment yield for estimated suppression fires would be approximately 15 times that of prescribed fire treatments. Suppression fires would also likely have larger areas of higher severity burning, affecting soil chemistry, structure, and biota to a greater degree than prescribed or wildland fire-use fires. This would lead to longer recovery times and greater potential for increased erosion. Adverse impact to soil erosion and sediment transport from suppression fires would be short term moderate local. Non-fire treatment effects on erosion and sediment load are addressed under Soil Compaction.

Direct and Indirect Effects **Alternative 3** **Soils and Watersheds**
Soil Biota and Soil Nutrients

Impacts to soil biota for this alternative would decrease when compared to other alternatives due to decreased acreage proposed for prescribed and wildland fire-use fires. Because the most suppression fires are predicted for this alternative, effects to soil biota would be greater and have longer recovery times. Suppression fire acreage is not much greater than other alternatives (600 more annual acres than Alternatives 1 and 2); therefore, increased adverse impact would be negligible.

Adverse impacts to biota from this alternative would be short term, minor, local. Beneficial impacts to soil nutrients available for plants would be short to long term, minor, local. As noted in effects common to all alternatives, areas of biological soil crust may exist in some South Rim treatment areas. This alternative, compared with the other alternatives, has the highest acreage of non-fire treatment on South Rim and highest acres expected for suppression fires.

Table 4-51 Predicted First Year Sediment Yield for Alternative 3 Prescribed Fire Treatments*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		1,230	460	270	550
Estimated area (acres)	High severity fire	35	50	50	20
	Moderate severity fire	370	230	110	70
	Low severity fire	630	90	25	260
	Unburned	195	90	85	200
Average predicted sediment yield (tons/acre)	High severity fire	0.12	0.07	0.04	0.05
	Moderate severity fire	0.08	0.04	0.02	0.03
	Low severity fire	0.07	0.04	0.02	0.02
Total predicted sediment yield (tons)		78	16	5	8

*Fire severity acreage levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in the sediment yield calculations

Table 4-52 Predicted First Year Sediment Yield for Alternative 3 Suppression Fires*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		360	900	810	245
Estimated area (acres)	High severity fire	10	100	255	5
	Moderate severity fire	115	490	445	195
	Low severity fire	185	200	80	35
	Unburned	50	110	30	10
Average predicted sediment yield (tons/acre)	High severity fire	1.28	3.78	2.62	0.65
	Moderate severity fire	0.33	0.52	0.37	0.12
	Low severity fire	0.14	0.08	0.05	0.06
Total predicted sediment yield (tons)		77	649	837	29

*Acreages of fire severity levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant volumes of sediment and so are not included in sediment yield calculations

Table 4-53 Predicted First Year Sediment Yield for Alternative 3 Wildland Fire-Use Fires*

		WFU Fire
Average annual burned area (acres)		880
Estimated area (acres)	High severity fire	85
	Moderate severity fire	355
	Low severity fire	320
	Unburned	120
Average predicted sediment yield (tons/acre)	High severity fire	0.09
	Moderate severity fire	0.06
	Low severity fire	0.05
Total predicted sediment yield (tons)		45

*Acreages of fire severity levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Because WFU fire location and size cannot be predicted, these fires were not split out by vegetation type for the analysis

As with all the alternatives, it is difficult to predict impacts when vegetation type extent and location is unknown. Where biological soil crust would be directly impacted, short and long-term local moderate adverse effects would occur.

Direct and Indirect Effects Alternative 3 Soils and Watersheds
Soil Compaction

Increased manual/mechanical treatment increases acreage subject to soil compaction and disturbance in WUI areas, which are already disturbed to some degree. In addition, approximately nine miles of handline per year is proposed related to fire activities (prescribed, wildland fire-use, and suppression fires). Average sediment yield of proposed treatment is predicted by WEPP FuME model to be less than two tons or approximately 35 cubic feet per year. This alternative would result in the greatest sediment loss in Primary and Secondary WUI FMUs. Sediment yield due to compaction caused by manual/mechanical thinning and additional traffic could be minimized through mitigation measures. Adverse impacts would be minor to moderate local short term.

Direct and Indirect Effects Alternative 3 Soils and Watersheds
Stream Hydrography, Groundwater, and Water Quality

Proposed treated areas cover 0.002 to 1.1% of the four sub-basins that contain treatment areas; therefore, there would be no effect from proposed treatments to watersheds at a regional scale. Sediments transported to drainages would eventually work their way to perennial streams such as Bright Angel Creek and ultimately the Colorado River. The relatively smaller areas treated would reduce potential sediment and turbidity impacts to streams. However, if suppression fires occur especially before or during monsoon season, much higher sediment volumes could be transported to perennial streams. Because of wide variability in the natural range of sediment transport in GRCA, impacts would still likely be within the natural range of variability.

This alternative would result in local, short-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. Impacts to surface and groundwater are anticipated to be within the natural range of variability.

Mitigation of Effects **Alternative 3** **Soils and Watersheds**

Mitigation measures described in 4.4.2.5 and 4.4.2.10 will decrease adverse impacts related to soils andwatersheds. None of the adverse impacts in Alternative 3 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased. There is discussion of mitigation measure effectiveness in the indirect and direct impact section for this alternative.

Cumulative Effects **Alternative 3** **Soils and Watersheds**

Cumulative adverse effects outside Primary and Secondary WUI would likely be less than other alternatives due to reduced treatment acreage proposed. Proposed treatments combined with past, present, and foreseeable future projects in Primary and Secondary WUI may slightly increase impacts from soil erosion and disturbance, but cumulative effects to soils and watersheds would be minor. This cumulative adverse impact would be local, minor, short-term, adverse. Long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial.

Conclusion **Alternative 3** **Soils and Watersheds**

Alternative 3 treatments would likely produce lower sediment yields and impacts to soil biota compared to other alternatives due to smaller acreage proposed for fire treatment. Adverse impact to soil erosion and sediment transport from prescribed and fire-use fires would be short term, minor, local. Increased acreage in suppression fires could have local, moderate, short-term adverse effects.

Adverse impacts to biota from this alternative would be short term, minor, local. Beneficial impacts to soil nutrients available for plants would be short to long term, minor, local. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

More acreage would be subject to soil disturbance and compaction due to increased areas proposed for manual/mechanical treatments in Primary and Secondary WUI. Adverse impacts to soils from compaction would be local, short term, minor to moderate. This alternative would result in local, short-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. Impacts to surface water and groundwater are anticipated within the natural range of variability.

Activities taking place near GRCA and upstream of proposed GRCA activities could result in an increased impact if they take place within a year of each other. This cumulative adverse impact would be local, minor, short term, adverse. Long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial depending on activity, with an increase in potential soil impacts in Primary and Secondary WUI FMUs.

Impairment **Alternative 3** **Soils and Watersheds**

There are no major adverse impacts in Alternative 3, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair soils and watersheds during Alternative 3 implementation.

Unacceptable Impacts — Alternative 3 — Soils and Watersheds

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soils and watersheds as a result of Alterative 3 implementation.

4.4.2.15 Alternative 4 — Prescribed Fire Emphasis — Soils and Watersheds

In Alternative 4, fire management program emphasis for vegetation treatment would be with prescribed fire burning approximately 90,000 acres. Approximately 24,070 acres would burn from suppression fires; wildland fire-use fire would be used least of all the alternatives, at 5,500 acres; and mechanical/manual treatments would occur on 800 acres in top priority areas. This alternative would emphasize prescribed fire in ponderosa pine habitat, continuing the trend toward a historic fire regime. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects — Alternative 4 — Soils and Watersheds
Soil Erosion and Sediment Transport

This alternative includes more prescribed fire treatment areas than other alternatives. Additional areas are primarily in ponderosa pine and piñon-juniper forest types. As shown in Table 4-54, predicted rate of sediment yield would be lower in these forest vegetation types than in Alternative 1 and 2. This is likely due to different soil types in the additional areas to be treated and increased treatment areas on South Rim, which receives less precipitation. Even though total acres to be treated in these forest types are higher, total predicted sediment yield from prescribed fire areas would only be slightly greater than in Alternatives 1 and 2. As shown in Table 4-54, other forest vegetation types show slightly increased total sediment yield due to increased acreage to be treated.

Table 4-54 Predicted First Year Sediment Yield for Alternative 4 Prescribed Fire Treatments*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		3,190	2,315	480	2,805
Estimated area (acres)	High severity fire	100	230	90	80
	Moderate severity fire	960	1,165	195	395
	Low severity fire	1,625	460	45	1,320
	Unburned	505	460	150	1,010
Average predicted sediment yield (tons/acre)	High severity fire	0.08	0.06	0.04	0.05
	Moderate severity fire	0.06	0.03	0.02	0.03
	Low severity fire	0.05	0.03	0.02	0.02
Total predicted sediment yield (tons)		147	63	8	42

*Acreages of fire severity levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

As with the other alternatives, suppression fires are predicted to produce higher sediment yield than prescribed or wildland fire-use fires. As shown in Table 4-55, sediment yield from suppression fire could be more than four times greater than for prescription fire. Areas of wildland fire-use fires are smallest of all alternatives and predicted to produce negligible sediment yield as shown in Table 4-56. Adverse impact to soil erosion and sediment transport from prescribed fires and, to a lesser extent, wildland fire-use fires would be minor to moderate, local, short term. Adverse impact to soil erosion and sediment transport from suppression fires would be moderate, local, short term. Non-fire treatment effects on erosion and sediment load are addressed under Soil Compaction.

Direct and Indirect Effects **Alternative 4** **Soils and Watersheds**
Soil Biota and Soil Nutrients

Impacts to soil biota would be more extensive due to increased fire-treated acreage. Because increased acreage would be treated using prescribed fire, overall fire severities would be lower than wildland fire-use or suppression fires. However, increased burned areas could diminish nearby viable seed or spore stock available to re-establish vegetation and soil biota in burned areas, leading to longer recovery times. Adverse impacts to biota from this alternative would be local, minor to moderate, short term. Beneficial impacts to soil nutrients available for plants would be local, minor to moderate, short to long term.

More treatment areas are proposed for South Rim than other alternatives, increasing potential to impact biological soil crust. As with all the alternatives, it is difficult to predict impacts when extent and location of vegetation type is unknown. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

Table 4-55 Predicted First Year Sediment Yield for Alternative 4 Suppression Fires*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		300	825	740	215
Estimated area (acres)	High severity fire	10	90	230	5
	Moderate severity fire	95	455	400	175
	Low severity fire	150	180	75	30
	Unburned	45	100	35	5
Average predicted sediment yield (tons/acre)	High severity fire	1.45	3.38	2.97	0.68
	Moderate severity fire	0.30	0.47	0.41	0.12
	Low severity fire	0.10	0.07	0.05	0.05
Total predicted sediment yield (tons)		58	531	851	26

*Acreages of fire severity levels were calculated using total acreage treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

Direct and Indirect Effects **Alternative 4** **Soils and Watersheds**
Soil Compaction

Manual/mechanical treatment subjects soil to compaction and disturbance in WUI areas already disturbed to some degree. In addition, approximately ten miles of handline per year is proposed related to fire activities (prescribed, wildland fire-use, and suppression fires). Average sediment yield of proposed treatment due to soil compaction is predicted by the WEPP FuME model to be 0.3 ton or approximately six cubic feet per year. This is a relatively low volume and sediment yield due to manual/mechanical thinning; traffic could be minimized through proposed mitigation measures. Adverse impacts would be minor, local, short term.

Table 4-56 Predicted First Year Sediment Yield for Alternative 4 Wildland Fire-use fires*

		WFU Fire
Average annual burned area (acres)		550
Estimated area (acres)	High severity fire	55
	Moderate severity fire	220
	Low severity fire	200
	Unburned	75
Average predicted sediment yield (tons/acre)	High severity fire	0.08
	Moderate severity fire	0.06
	Low severity fire	0.05
Total predicted sediment yield (tons)		18

*Acreages of fire severity levels were calculated using total acreage to be treated and percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Because location and size of WFU fires cannot be predicted, these fires were not split out by vegetation type for analysis

Direct and Indirect Effects Alternative 4 Soils and Watersheds
Stream Hydrography, Groundwater, and Water Quality

Proposed treated areas cover 0.2 to 3.2% of the four sub-basins that contain treatment areas; therefore, there would be no effect from proposed treatments to watersheds at a regional scale. Adverse impacts to nearby streams would likely be slightly increased compared with Alternative 1 due to greater number of treated areas and increased sediment load. Because treatments will be spread over a number of years, impact in any one year would likely be within the range of natural conditions. However, if suppression fires occur, especially before or during monsoon season, much higher sediment volumes could be transported to perennial streams. This alternative would result in local, short-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. These effects would likely be within the range of natural variability.

Mitigation of Effects Alternative 4 Soils and Watersheds

Mitigation measures described in 4.4.2.5 and 4.4.2.10 will decrease adverse impacts related to soils andwatersheds. None of the adverse impacts in Alternative 4 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased. There is a discussion on effectiveness of these measures in the indirect and direct impact section for this alternative.

Cumulative Effects Alternative 4 Soils and Watersheds

Cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely to be local, minor to moderate, adverse to soils, and within the natural range of variability. Effects to surface water and groundwater hydrology and water quality are anticipated within the normal range of variability. Proposed fuel treatment projects immediately outside GRCA, primarily in Kaibab National Forest, may contribute minor sediment yield impacts if projects are conducted in one to two years of GRCA treatments near the GRCA boundary. However, these impacts attenuate with distance and are unlikely to exceed the natural range of variability by the time they reach GRCA perennial streams.

Conclusion Alternative 4 Soils and Watersheds

Adverse impact to soil erosion and sediment transport from prescribed fires and to a lesser extent wildland fire-use fires would be minor to moderate, local, short term. Adverse impact to soil erosion and sediment transport from suppression fires would be moderate, local, short term.
Adverse impacts to biota from this alternative would be local, minor to moderate, short term. Beneficial impacts to soil nutrients available for plants would be local, minor to moderate, short to long term. More

treatment areas are proposed for South Rim than other alternatives, increasing potential to impact biological soil crust. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

There is a relatively low volume and sediment yield due to manual/mechanical thinning, and traffic could be minimized through proposed mitigation measures. Adverse impacts would be minor, local, short term.

This alternative would result in local, short-term, minor to moderate, adverse effects to stream hydrography, groundwater, and water quality. Effects would likely be in the range of natural variability.

Cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely to be local, minor to moderate, adverse to soils, and within the natural range of variability. Long term, cumulative effects are likely local, minor to moderate, adverse to beneficial, depending on the activity, with an increase in amount of treated acres from prescribed fire.

Impairment Alternative 4 Soils and Watersheds

There are no major adverse impacts in Alternative 4, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair soils and watersheds during Alternative 4 implementation.

Unacceptable Impacts Alternative 4 Soils and Watersheds

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soils and watersheds as a result of Alterative 4 implementation.

4.4.2.16 Alternative 5 Fire Use Emphasis Soils and Watersheds

Alternative 5's fire management program emphasis is to restore and maintain forest types with wildland fire use, which anticipates approximately 88,000 acres treated. With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative deemphasizes prescribed fire treatments, with a treatment of 29,900 acres. Mechanical/manual treatments would total 2,675 acres and occur in the WUI and along Highway 67 on North Rim. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 5 Soils and Watersheds
Soil Erosion and Sediment Transport

Limited acreage treated using prescribed fire would produce a relatively lower sediment volume due to prescribed fire, as shown in Table 4-57. As shown in Table 4-58, suppression fire areas are anticipated similar to Alternatives 1 and 2, and predicted to produce a similar total sediment yield. Sediment yield for suppression fire is predicted to be approximately eight times that of prescribed fire treatment areas. Adverse impact to soil erosion and sediment transport from prescribed and fire-use fires would be short term, minor to moderate, local. Adverse impact to soil erosion and sediment transport from suppression fires would be moderate, local, short term.

Exact locations and sizes of wildland fire-use fires cannot be predicted, but severity patterns and effects would be similar to prescribed fire. Table 4-59 shows predicted sediment yield for wildland fire-use fire is greater than for other alternatives due to increased acreage. Actual impacts would depend on locations and actual acreages burned. Sediment volume produced from wildland fire-use fires would be greater than other alternatives.

Direct and Indirect Effects Alternative 5 Soils and Watersheds
Soil Biota and Soil Nutrients

Similar to Alternative 4, impacts to soil biota would be more extensive due to increased fire-treated acreage. Because increased acreage would be treated using wildland fire use, overall fire severities would be lower than suppression fires, but higher than prescribed fire. Adverse impacts to biota from implementing this alternative would be local, minor to moderate, short term. Beneficial impacts to soil nutrients available for plants would be local, minor to moderate, short to long term.

As noted in effects common to all alternatives, biological soil crust areas may exist in some South Rim treatment areas. This alternative, compared with other alternatives, has the highest acreage of wildland fire-use fire. However, this treatment type will not be allowed in Primary and Secondary WUI areas, significantly reducing acreage potentially affected on South Rim.

This alternative has a risk similar to Alternative 3 to adversely affect this vegetation type due to prescribed fire and manual/mechanical treatments. As with all the alternatives, it is difficult to predict impacts when vegetation type extent and location is unknown. Where biological soil crust would be directly impacted, short and long-term, local, moderate, adverse effects would occur.

Direct and Indirect Effects Alternative 5 Soils and Watersheds
Soil Compaction

Manual/mechanical treatment subjects soil to compaction and disturbance in WUI areas and along side Highway 67. In addition, approximately eight miles of handline per year is proposed related to fire activities (prescribed, wildland fire-use, and suppression fires). Average sediment yield of proposed treatment is predicted by the WEPP FuME model at 1.1 tons or approximately 20 cubic feet per year. This adverse impact from erosion and sediment yield is mid-range of alternatives, and planned soil cover replacement and mitigation measures should minimize erosion effects. Direct adverse impact would be local, minor, short term, and with implementation of mitigation measures described in 4.4.2.65and 4.4.2.10, adverse impact from compaction of soils would be further lessened.

Table 4-57 Predicted First Year Sediment Yield for Alternative 5 Prescribed Fire Treatments*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		1,245	890	275	550
Estimated area (acres)	High severity fire	35	85	60	20
	Moderate severity fire	370	445	110	75
	Low severity fire	640	180	25	255
	Unburned	200	180	80	200
Average predicted sediment yield (tons/acre)	High severity fire	0.13	0.06	0.04	0.05
	Moderate severity fire	0.09	0.04	0.02	0.03
	Low severity fire	0.08	0.03	0.02	0.02
Total predicted sediment yield (tons)		89	28	5	8

*Acreages of fire severity levels were calculated using the total acreage to be treated and the percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

Table 4-58 Predicted First Year Sediment Yield for Alternative 5 Suppression Fires*

		Ponderosa Pine	Mixed-Conifer	Spruce-Fir	Piñon-Juniper
Average annual treated area (acres)		240	600	565	155
Estimated area (acres)	High severity fire	5	65	180	5
	Moderate severity fire	75	330	310	125
	Low severity fire	125	130	55	20
	Unburned	35	75	20	5
Average predicted sediment yield (tons/acre)	High severity fire	1.22	3.50	2.62	0.65
	Moderate severity fire	0.34	0.48	0.37	0.12
	Low severity fire	0.15	0.07	0.05	0.06
Total predicted sediment yield (tons)		50	395	589	19

*Acreages of fire severity levels were calculated using the total acreage to be treated and the percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Unburned areas are assumed to yield insignificant sediment volumes and so are not included in sediment yield calculations

Direct and Indirect Effects — Alternative 5 — Soils and Watersheds
Stream Hydrography, Groundwater, and Water Quality

Proposed treated areas cover 0.002 to 1.0% of the four sub-basins containing treatment areas; therefore, there would no effect from proposed treatments to watersheds at a regional scale. Increased sediments delivered to perennial streams should be similar to Alternative 4 and within the range of natural variability. However, if suppression fires occur, especially before or during monsoon season, much higher sediment volumes could be transported to perennial streams.

This alternative should result in local, short-term, minor, adverse effects on stream hydrography, groundwater, and water quality. These effects will likely be within the range of natural variability. Long-term effects should be minor to moderate, local beneficial.

Table 4-59 Predicted First Year Sediment Yield for Alternative 5 Wildland Fire-use Fire*

Average annual burned area (acres)		WFU Fire 8,800
Estimated area (acres)	High severity fire	880
	Moderate severity fire	3,540
	Low severity fire	3,180
	Unburned	1,200
Average predicted sediment yield (tons/acre)	High severity fire	0.09
	Moderate severity fire	0.06
	Low severity fire	0.05
Total predicted sediment yield (tons)		451

*Acreages of fire severity levels were calculated using the total acreage to be treated and the percent of each fire severity level. WEPP results in tons/sq. mi. were converted to tons/acre by dividing by 640
Note Because location and size of WFU fires cannot be predicted, these fires were not split out by vegetation type for analysis

Mitigation of Effects — Alternative 5 — Soils and Watersheds

Mitigation measures described in 4.4.2.5 and 4.4.2.10 will decrease adverse impacts related to soils andwatersheds. None of the adverse impacts in Alternative 5 were considered major (significant), but if mitigation measures are implemented adverse impacts would be further decreased. There is discussion on effectiveness of these measures in the indirect and direct impact section for this alternative.

Cumulative Effects **Alternative 5** **Soils and Watersheds**

Minor increases in cumulative effects could occur if more wildland fire-use fires burn near GRCA. Proposed treatments near GRCA boundaries could result in slightly increased sediment delivery if conducted in a year or two of GRCA treatments. Proposed treatments combined with past, present, and foreseeable future projects in the cumulative effects boundary for these resources may slightly increase adverse impacts from soil erosion and disturbance but cumulative effects would still be minor.

Conclusion **Alternative 5** **Soils and Watersheds**

Adverse impact to soil erosion and sediment transport from prescribed and fire-use fires would be short term, minor to moderate, local. Adverse impact to soil erosion and sediment transport from suppression fires would be moderate, local, short term.

Adverse impacts to biota from this alternative would be local, minor to moderate, short term. Beneficial impacts to soil nutrients available for plants would be local, minor to moderate, short to long term. Where biological soil crust would be directly impacted, short- to long-term, local, moderate, adverse effects would occur.

Direct adverse impact to soil compaction would be local, minor, short term, and with implementation of mitigation measures described in 4.4.2.5 and 4.4.2.10, adverse impact from soil compaction would be further lessened.

This alternative should result in local, short-term, minor, adverse effects on stream hydrography, groundwater, and water quality. These effects will likely be within the range of natural variability. Long-term effects should be minor to moderate local beneficial.

Cumulative effects of proposed treatments and past, present, and reasonably foreseeable activities in and outside GRCA are likely local, minor to moderate, adverse to soils, and in the natural range of variability. Long term, cumulative effects are likely to be local, minor to moderate, adverse to beneficial, depending on activity, with an increase in amount of treated acres from wildland fire use.

Impairment **Alternative 5** **Soils and Watersheds**

There are no major adverse impacts in Alternative 2, thus impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair soils and watershed during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Soils and Watersheds**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future park enjoyment; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operation, there would not be unacceptable impacts on soils and watersheds as a result of Alterative 5 implementation.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Soils and Watersheds**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternatives 1-5 would have adverse, minor to moderate, local, short-term impacts from proposed treatments and suppression fires on soil erosion and sediment transport.

Alternatives 2, 4, and 5 would have adverse, minor to moderate, local, short-term impacts to soil biota and soil nutrients.

Alternatives 1-5 would have adverse, moderate, local, short- to long-term direct impacts to biological soil crust if impacted.

Alternative 3 would have adverse, minor to moderate, local, short-term impacts to soil compaction from manual/mechanical thinning.

Alternatives 2, 3 and 4 would have adverse, minor to moderate, local, short- to long-term impacts to stream hydrography, groundwater, and water quality.

Loss in Long-Term Availability or Productivity of the Resource To Achieve Short-Term Gain
There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Soils and Watersheds**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during the implementation of the plan and could not be reused or recovered during the lifespan of the plan.

Due to potential for trampling biological soil crusts by fire management activities there may be irretrievable commitments of resources. Biological soil crusts damaged during trampling may or may not recover during the plan's lifespan. Mitigation measures exist to reduce possibility of trampling by fire management activities. There will not be irreversible commitments of resources because commitment could be changed through implementation of mitigation measures.

4.4.3 Soundscape

4.4.3.1 Guiding Regulations and Policies **Soundscape**

- Grand Canyon National Park Enlargement Act, 1975 (Public Law 93-620)
- National Parks Overflights Act of 1987 (Public Law 100-91)
- Executive Memorandum April 22, 1996, Regarding Impact of Transportation in National Parks
- NPS Report to Congress on Effects of Aircraft Overflights on the National Park System, July 1995
- NPS Management Policies 2006, Section 4.9

See Appendix A for more information.

4.4.3.2 Management Objectives **Soundscape**

Chapter 1 lists proposed FMP management objectives. Although objectives below describe other resources, the objective's intent also relates to natural soundscapes. Objectives for natural soundscapes as they relate to fire management in GRCA are

- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species

- Conduct research that will increase understanding of natural fire regimes and refine prescriptions, provide data for fire behavior models, and effectively implement the Fire Management Program
- Monitor and evaluate fire management activities (managed wildland fires, prescribed burns, fuel reduction treatments) to assess effects on natural and cultural resources and social values

4.4.3.3 Methodology for Analyzing Effects Soundscape

Effects specific to natural soundscape are characterized for each alternative based on methodology and impact thresholds presented below.

Context, timing (frequency of occurrence, time between noise events), duration, and intensity all interact in a complex manner to determine noise impact level from an activity in a specific location. In some cases analysis of all factors can indicate a certain impact level whereas analysis of a single factor may indicate a much different impact level. To help the reader understand how these varying factors combine to arrive at an impact level, criteria or factors considered in impact analysis are explained below.

Baseline information used to assess impacts to natural soundscape includes information and sources described in the methodology section at the beginning of this chapter and in the Affected Environment section on Natural Soundscapes (Chapter 3.5.1). It also includes park staff knowledge of resources and sites, review of existing literature and park studies, information provided by NPS and other agency specialists, and professional judgment. Park natural ambient sound conditions used as baseline for this analysis are described in the Affected Environment section on Natural Soundscapes (Chapter 3.5.1).

Representative Noise Data Methodology Soundscape

Noise measurements of GRCA equipment currently used to support fire management operations were made in 2007 for this EIS (NPS 2007a and 2007b). Measurements are summarized in Table 4-60 below, as maximum A-weighted decibel levels (L_{max}) recorded at 100 feet and 400 feet from equipment operating in the same manner as it typically would during park fire management activity. The last column shows approximately how many times louder measured values would be perceived at 100 feet (using 10 dBA as a perceived doubling of loudness) when compared to measured park average natural ambient sound levels (approximately 20 dBA) shown in Table 3-22. Thus, a measurement of about 50 dBA would be perceived as about eight times louder than the average natural ambient, whereas a measurement of about 90 dBA would be perceived as about 128 times louder than average natural ambient.

In Table 4-60, two helicopter types normally used in GRCA are listed first during takeoff and landing at 100 feet and 400 feet to the side of the helicopter, and then as an overflight at 400 feet above ground level (AGL) directly above the sound level meter. Next, three different chainsaws types are shown, both cutting through wood at full throttle and at idle, followed by a leaf blower used to clear litter from fire lines at full throttle and at idle. A large water pump on a wildland fire engine is shown next at two different pumping pressures and at idle, followed by a four-stroke portable water pump at full throttle and at idle. Finally, measurements are shown for three fire vehicles types typically used for GRCA fire activities: an all-terrain vehicle (ATV), the turbodiesel wildland fire engine with the large pump used in pump measurements, and a gasoline-powered pickup truck used to transport people and gear. All vehicle measurements are reported for a typical drive-by scenario on a dirt road, and at idle, with an additional measurement for the fire engine backing up with its safety beep sounding.

Table 4-61 provides noise exposure levels for wood-industry occupations similar to jobs involved in park fire management activities. Due to noise levels produced, operators of several tools (chainsaws, feller bunchers, chippers) are required to wear hearing protection and be assessed for long-term noise exposure effects (Michigan 2005).

Fire Management-Related Noise Sources Methodology Soundscape

Techniques to reduce or remove hazardous fuels in forest systems proposed in all alternatives include prescribed fire, wildland fire-use, suppression fires, and manual thinning. In addition, mechanical thinning is proposed in all alternatives except Alternative 1, No Action, Current Program.

Aircraft Noise Methodology Soundscape

Helicopters are the primary aircraft used in GRCA fire management activities. Although most aircraft flying over the park are confined to fixed routes and altitudes below 14,500 feet mean sea level (MSL) as part of the Grand Canyon National Park Special Flight Rules Area, helicopters used for park management, including fire operations, are not bound by such restrictions. Although park aircraft usually fly the most efficient route to access a fire-related location, avoiding noise-sensitive locations to the extent feasible, they may also conduct reconnaissance of a different area (check on a wildland fire-use fire), or they may combine flights to accomplish other unrelated missions in addition to the fire mission (i.e., collect water samples in a nearby area). Aircraft are not normally used in mechanical/manual thinning treatments. For prescribed fire, helicopters are used to ignite fires, observe fire spread and behavior, drop retardant or water, and transport fire personnel and/or equipment. For wildland fire use and suppression, helicopters are used primarily to drop water or retardant and for observation and transport, but may also be used to ignite backfires by aerial ignition. At least one flight per day would normally be flown over active fires, many of which would be in proposed wilderness. As fires grow, reconnaissance area and flight duration may increase as well. For suppression, fixed-wing aircraft may be employed to drop retardant or water, for observation, and air support coordination for all air operations. Fixed-wing aircraft have been rarely used in support of GRCA fire operations.

Park helicopters were measured at over 95 dBA at 100 feet, an uncomfortably loud sound (Table 4-60). In relative loudness, this would be more than 128 times louder than the average natural ambient sound levels measured in the park (approximately 20 dBA, Table 3-31).

Mechanical Thinning Noise Methodology Soundscape

Equipment associated with mechanical thinning activities includes feller/haulers (also called feller bunchers) which both cut and transport trees and shrubs, and chippers/shredders used to reduce volume of cut branches and other materials used onsite as mulch or transported offsite. These machines require operator hearing protection, and can have sustained levels in excess of 90 dBA, as shown in Table 4-61.

Manual Thinning Noise Methodology Soundscape

Manual treatment involves use of chainsaws and hand tools (e.g., axes, hand saws) to cut trees and shrubs, shovels, rakes, leaf blowers, and pulaskis to clear and maintain fuel breaks and fire lines. Chippers/ shredders may also be used.

Motor Vehicle Noise Methodology Soundscape

Fire management vehicles include pickup trucks, crew transport vehicles, fire engines, ATVs, vehicles associated with field camps (catering trucks, emergency vehicles, etc.), and industrial equipment such as bulldozers and dump trucks. Noise levels from smaller trucks and crew transport vehicles do not exceed those from common vehicles such as automobiles, buses, and trucks using the park road system (generally in the 40-50 dBA range at 100 feet). Larger diesel engines common on industrial equipment such as bulldozers, dump trucks, and some older fire engines can be louder.

Table 4-60 Sound Level Measurements of Fire-Related Equipment at GRCA

Noise-Producing Equipment Type	Operation	Max Sound Level (dBA) at 100 feet	Max Sound Level (dBA) at 400 feet	Relative Loudness at 100 feet (Relative to 20 dBA)
Helicopter Model				
MD-900	Takeoff	97.2	74.8	More than 128 times louder
	Landing	94.5	80.3	More than 128 times louder
	Overflight @ 400 ft AGL*	N/A	73.1	
Bell 407	Takeoff	97.2	80.2	More than 128 times louder
	Landing	98.1	81.1	More than 128 times louder
	Hovering	95.9	82.0	More than 128 times louder
	Overflight @ 400 ft AGL*	N/A	77.5	
Chainsaw Model				
Stihl 044 28" bar	Cutting Through Wood	69.3	47.0	Approx. 32 times louder
	Full Throttle	73.4	49.6	Approx. 32 times louder
	Idle	55.3	37.4	More than 8 times louder
Stihl 036 24" bar	Cutting Through Wood	63.3	43.4	More than 16 times louder
	Full Throttle	76.1	52.0	More than 32 times louder
	Idle	55.1	38.8	More than 8 times louder
Stihl 440 28" bar	Cutting Through Wood	71.1	46.7	Approx. 32 times louder
	Full Throttle	74.5	51.4	More than 32 times louder
	Idle	55.8	40.2	More than 8 times louder
Leaf Blower				
Stihl BR550	Full Throttle	65.2	45.4	More than 16 times louder
	Idle	49.6	36.0	Approx. 8 times louder
Water Pumps				
Waterous E-50 on Truck (truck idling)	150 psi @ 2400 rpm	59.3	41.5	Approx. 16 times louder
	100 psi @ 1900 rpm	56.9	35.9	More than 8 times louder
	Idle @ 1000 rpm	54.4	35.6	More than 8 times louder
Honda GXH50 4-stroke	Full Throttle	56.9	36.6	More than 8 times louder
	Idle	36.9	35.6	More than 2 times louder
Vehicles				
2004 Honda Foreman ES ATV 450cc	Drive-By (~20mph)	49.6	44.9	Approx. 8 times louder
	Idle	45.1	43.3	More than 4 times louder
2002 Ford F450 7.3L Powerstroke Turbodiesel	Drive-By (~15mph)	44.2	39.9	More than 4 times louder
	Idle with Safety Beep	44.9	38.0	More than 4 times louder
	Idle	45.7	39.2	More than 4 times louder
2001 Ford F250 XL SuperDuty	Drive-By (~15mph)	44.4	40.6	More than 4 times louder
	Idle	42.2	44.4	More than 4 times louder

*AGL = Above Ground Level. At its closest point, the helicopter was approximately 400 feet above the microphone.
Source: NPS 2007a and 2007b

Table 4-61 Noise Exposure Levels in the Wood Industry

Wood Industry Operation	Job	Eight-hour Time-weighted Average Range
Trucking	Driver- flatbeds, chip-trucks, loads/unloads trucks	76.95 – 96.12 dBA
Logging	Feller Buncher Operator	88.00 – 90.70 dBa
Logging	Chainsaw Operator	90.40 – 96.58 dBA
Logging	Chipper Operator	90.17 – 96.63 dBA

Source: Michigan 2005

Suppression Noise Methodology Soundscape

Suppression activities can include all appropriate management actions which can involve noise from all other sources and activities. Some suppression actions may be associated with large, complex fires, which could involve a large fire organization, large numbers of personnel and equipment, and fire camp(s). Suppression noise impacts may occur over a very large area and be applied in an all-out effort to contain fire as quickly as possible with little regard for mitigating noise and other impacts. As such, suppression would generally be the noisiest treatment type per unit time. Helicopters and chainsaws in close proximity would generally be the loudest typical equipment in a suppression action.

Other Fire-Related Noise Methodology Soundscape

Camp-related machinery (generators, pumps, other vehicles) and electronics (communication devices, music) is usually used in previously impacted areas. Noise levels would usually be greatest at or near the highest concentrations of people and vehicles (field camp settings or concentrated treatment areas). Although safety and comfort of field personnel are primary concerns for a field camp, thoughtful field camp locations and use of quiet machinery (mufflers and exhaust deflection technology, four-stroke motors for generators, etc.) may considerably reduce noise levels and audibility areas.

Noise produced by fire personnel talking (especially shouting), working, and hiking can sometimes be considerable in local areas.

4.4.3.4 Assumptions Soundscape

For indirect effects, soundscape impacts depend on vegetation impacts to the extent an alternative contributes to moving vegetation either toward or away from natural ecological conditions and natural fire regimes. Restoring natural ecological conditions contributes greatly to restoring natural soundscapes. Thus, sections on Vegetation, especially Effects Common to All Alternatives (Chapter 4) and sections on impacts to vegetation for each alternative, were relied on for effects to vegetation which would indirectly affect natural soundscapes. Acreages reported in the analysis for beneficial vegetation effects are calculated by adding acreages for prescribed and wildland fire-use fires, and manual/mechanical thinning, because a main objective of each of those treatment types is to move vegetation toward more natural ecological and fire regime conditions.

For the purposes of this EIS, the sound of fire burning is considered part of the natural soundscape, regardless of whether the fire was started naturally or by humans.

For safety and visitor experience reasons, non-fire management personnel (visitors and other park employees) will likely be kept a minimum distance from fires and fire management activities which would reduce noise impacts on those people. In addition, it is likely that any visitor physically close enough to a fire to hear noise from equipment such as chainsaws would perceive such noise as necessary or even welcome (Gramann 1999). However, chainsaw use associated with manual fuels reduction may not be understood or well received by visitors. This noise could affect wildlife as well as visitors, residents, and natural soundscape.

Noise-producing activities will be mostly limited to daylight hours for mechanical/manual thinning, and prescribed and wildland fire-use treatments. As a simplifying assumption, daylight hours will be assumed at 12 hours per day (nominally 7 a.m. to 7 p.m.), hours when most fire activities occur. Normally, prescribed and wildland fire-use activities during night are limited to observing fire, creating little noise.

For suppression, noise-producing activities may take place 24 hours/day, as fire personnel react to safety, fire management, and resource needs whenever they occur.

Flight time associated with all treatment types is usually restricted to daylight hours due to safety considerations (assumed 12 hours per day). Helicopters will normally keep moving and fly long distances, but sometimes may hover (heli-rappel) or concentrate flying in a small area. Helicopter behavior will be mission-specific related to treatment type employed, thus highly variable, so time over a specific site cannot be estimated with reasonable accuracy. Thus, flight time will be assessed over the entire park rather than over a specific site. Flight time is all helicopter flight time. Fixed-wing aircraft use for fire activities is rare at GRCA.

There will be years when annual acres treated by prescribed, wildland fire-use and/or suppression fires will be much less, or greater, than average.

It is assumed mitigation measures listed in this FEIS/AEF will be applied and effective. However, unforeseen events could possibly cause a specific fire to exceed acceptable impacts.

4.4.3.5 Impact Thresholds — Soundscape

Effects specific to natural soundscape are characterized for each alternative based on impact thresholds presented below.

Adverse — Impacts would result from increased human-generated noise from fire management activities or equipment or from effects that reduce amount of time or area in which natural sounds predominate

Beneficial — Impacts would result from reduced noise from fire management activities or equipment, or from effects that increase amount of time or area in which natural sounds predominate

Direct — Human-generated noise from fire management activities (helicopters, chainsaws, vehicles) directly impacts natural soundscape by introducing unnatural sounds into the natural environment, and is usually an adverse impact on soundscape

Indirect — Fire management treatments would usually change vegetation available in an area to transmit or mask sound, causing an indirect impact on soundscape. These changes would be beneficial impacts if they move vegetation toward natural ecological conditions and natural fire regime, but adverse if they move vegetation away from natural ecological conditions and natural fire regime (unnatural vegetation changes). An extreme example of an adverse indirect impact would be a catastrophic wildfire that denudes the landscape that might result in an ambient level lower than before but which would not be as natural. Wildlife sounds (including mammals, birds, insects, etc.) and running water are also largely dependent on vegetation, also indirectly affected by fire management activities

Context

Regional Impacts would affect a widespread area. Impacts would often occur to several fire management units

Local Impacts would occur over a small area and usually restricted to a single FMU unless close to the edge of a unit

Noise from most fire management activities would usually be local. The primary exception would be more wide-ranging effects from aircraft use in support of fire management activities.

Management zones described in the park's 1995 GMP are very important for providing context for natural soundscapes.

Timing Some sound effects depend on timing. Does the sound occur during a sensitive time? How frequently does it occur? Does it occur in a regular pattern or randomly? Does it occur during certain hours, days, months, or seasons? For example, noise intrusion effects will generally be greater close to sunrise/sunset and at night, than mid-day.

Duration

Short term Impacts would occur during the fire management activity and would end when the specific activity is complete. Short-term impacts would also normally not result in a lasting indirect change in natural soundscape through unnatural vegetation changes

Long term Impacts would occur or continue after the fire management activity or project is complete. Long-term impacts could result in a lasting indirect change in natural soundscape through unnatural vegetation changes (high severity wildfire), or a lasting direct change through changes in presence of noise sources in the environment

Duration can also include how long an individual noise intrusion event occurs, and how many hours during the day noise occurs from fire management activities

Intensity

Thresholds for impact intensity on soundscapes are defined below. All fire management activities will create noise, a direct adverse effect at some intensity level. However, indirect effects of vegetation changes may be either beneficial or adverse, as reflected in threshold definitions below.

Negligible Natural soundscape would predominate. Direct noise effects would be at lowest levels of detection and barely perceptible, with neither adverse nor beneficial consequences. There would be little or no vegetation change indirectly affecting natural soundscape

Minor *Adverse* Natural soundscape would predominate. Direct noise effects would increase a small amount, and/or would be measurable and perceptible but at low levels. Noise from fire management activities would infrequently be audible at low levels above the natural ambient, and then only for short durations and over a small area. There could be minor vegetation changes over small areas that move vegetation away from natural fire regimes and ecological conditions

Beneficial Natural soundscape would predominate. Direct noise effects would be reduced a small amount, and would be measurable and perceptible but at low levels. There could be minor vegetation changes over small areas that would move vegetation toward natural fire regimes and ecological conditions

Moderate	*Adverse* Natural soundscape would be affected by human noise intrusions some (less than 25%) of the time. Direct noise effects would increase by an intermediate amount, and/or would be easily perceived and measurable at intermediate levels. Noise from fire management activities would be audible at low levels above natural ambient for intermediate durations, or at intermediate levels for short durations, over a small to medium area. Noise may sometimes be regular and/or frequent. There could be intermediate vegetation changes over intermediate areas that would move vegetation away from natural fire regimes and ecological conditions *Beneficial* Direct noise effects would be reduced by an intermediate amount. There could be minor to intermediate vegetation changes over intermediate areas that would move vegetation toward natural fire regimes and ecological conditions
Major	*Adverse* Natural soundscape would be affected by human noise intrusions much (25% or more) of the time. Direct noise effects would increase by a substantial amount, and/or would be easily perceived and measurable at substantial levels. Noise from fire management activities would tend to dominate the area for much of the time period, audible above natural ambient at moderate or greater levels for moderate or greater durations over medium to large areas. Noise may often be regular and frequent. There could be major vegetation changes over large areas that would move vegetation away from natural fire regimes and ecological conditions *Beneficial* Direct noise effects would be reduced by a substantial amount, There could be moderate to major vegetation changes over large areas that would move vegetation toward natural fire regimes and ecological conditions

4.4.3.6 Mitigation of Effects — Soundscape

Reasonable mitigation measures for impacts to natural soundscapes include
- Incorporate best available noise abatement technology in fire-related equipment acquisition
- Implement best management practices to reduce noise from fire management activities and equipment

4.4.3.7 Impacts Common to All Alternatives — Soundscape

Noise-producing activities vary greatly with each situation, depending on highly variable factors such as personnel and equipment availability, weather conditions, terrain, and vegetation conditions at the time in a specific location. For example, a specific manual thinning treatment may be performed by two people with chainsaws over a month, or by 30 people with chainsaws over two-days. A wildland fire-use fire may burn slowly for months with very little human intervention and resulting noise, or considerable effort with attendant noise may be required to keep the fire in desired parameters. A prescribed fire may be ignited by helicopter with considerable noise over a short time, or by ground personnel with drip torches and less noise overall but over a longer time.

Although noise from individual situations varies greatly, noise produced by a given treatment type can be estimated within a reasonable range of time and area. Noise will vary by treatment type as shown in Table 4-62, which is based on experience and professional judgment of park fire personnel. While noise varies among different treatment types and individual situations, what varies among alternatives is treatment type acreage, not the nature of noise produced by treatment type. That is, noise produced per acre from prescribed fire treatments in Alternative 1 will be the same, when averaged over the life of the plan, as noise produced per acre from prescribed fire treatments in all other alternatives. The same is true, when averaged over the life of the plan, for all other treatment types.

For each sub-activity in each treatment type, Table 4-62 shows major noise-producing activities, typical equipment used, and estimated time and area of noise produced. Estimated times and areas are generally shown in ranges, reflecting wide variation in actual situations as discussed above. In Table 4-62, a small area is up to 10 acres, medium 10-40 acres, and large greater than 40 acres for a specific treatment; for example, one prescribed fire project or one manual thinning project.

Therefore, the primary analysis tool for evaluating direct soundscape impacts in this FEIS/AEF is to consider time and area estimates in Table 4-62 in relation to total acreages and helicopter flight hours for each treatment type in alternative descriptions. Although exact treatments will vary as described earlier, total treatment acreages and helicopter flight hours averaged over total plan duration provides a reasonable means for quantifying relative differences between soundscape impacts for alternatives in this analysis.

Equipment noise levels would be consistent with levels shown above in Tables 4-60 and 4-61 with decibel levels at 100 feet of helicopters and chippers/shredders in the 90 dBAs, chainsaws cutting through wood and leaf blowers in the 60 DBAs and 70 dBAs, pumps in the 50 dBAs, trucks in the 40 dBAs to 90 dBAs depending on weight of truck and cargo, and vehicles in the 40 dBAs. Noise sources in the 40 dBAs would be four times louder than average natural ambient levels shown in Table 3-31, noise levels in the 60 and 70 dBAs would be about 16 to 32 times louder, and noise sources in the 90 dBAs would be about 128 times louder than average natural ambient park sound levels.

Use of noise-producing equipment may also have direct adverse noise impacts on equipment operator hearing, often requiring hearing protection.

Sound levels vary greatly and frequently during operation in a random way for chainsaws, chippers/ shredders and mechanical thinning equipment, loudest at full throttle, a bit less when cutting wood, and much less at idle between cuts. Sound levels will be mostly constant during operation for pumps and leaf blowers as they are usually set to run at constant speed. Vehicles of all types vary in sound level with acceleration/deceleration and pulling loads, and helicopter sound levels vary with landing/ takeoff, hovering, and climbing/descending, but sound changes are more gradual and less frequent than chainsaws and chippers/shredders.

Sound levels are greatest close to equipment and decrease with distance. Decrease with distance varies with terrain, vegetation (composition, density, structure, etc.), wind direction, and ambient sounds. Although a 6 dBA decrease in sound level per doubling of distance is the usual rule of thumb, the measured data in Table 4-60 sometimes shows much more and sometimes much less than rule of thumb would predict. There is not enough data to model the decrease for different vegetation types, terrain, and other conditions throughout the park.

Noise Impacts by Location **Impacts Common to All Alternatives** **Soundscape**

Park airspace is generally divided into flight-free zones and flight corridors in the Grand Canyon National Park Special Flight Rules Area (SFRA). In the SFRA, most aircraft are required to fly on fixed routes at fixed altitudes, generally reducing noise from overflights in flight-free zones and increasing it under flight corridors. Map 4-5 shows the current SFRA configuration (configuration is subject to change due to a major interagency planning effort underway at the time of this FMP FEIS/AEF). To the extent that a fire management activity would occur in the vicinity of a flight corridor, aircraft noise from the corridor would already impact natural soundscape to some extent, and would tend to decrease soundscape impacts from fire management activities. To the extent that fire management activities would occur toward the middle of a flight-free zone, the area would tend to experience greater noise impacts from fire management activity, as the noise would tend to be less affected by aircraft noise from flight corridors.

Prescribed Fire

As shown in Table 4-62, preparation and pre-fire activities use vehicles, chainsaws, hand tools, and leaf blowers to prepare an area for burning by manual thinning, constructing or maintaining fire lines, transporting crews and equipment, and collecting fuel samples, creating minor to moderate adverse noise impacts for one to a few days over a small area. Equipment would be 2 to 4 times (for hand tools) to 16 to 32 times (for chainsaws/leaf blowers) louder than average park natural ambient sound levels at 100 feet.

Implementation would involve use of helicopters, chainsaws, hand tools, vehicles and pumps to implement the burn by igniting the fire (either aerial or ground ignition), aerial and/or ground observation /reconnaissance, crew and equipment transport, staging operations, limited suppression (for spot fires), and holding actions. This equipment would be 2 to 4 times (for hand tools) to about 8 times (for pumps) to 16 to 32 times (for chainsaws) to 128 times (for helicopters) louder than park average natural ambient levels at 100 feet. Aerial ignition, normally used in all burn units over 500 acres, usually occurs by quickly lighting strips over the entire burn unit, creating short-term adverse aircraft noise impacts over the entire unit for part of one day. Noise impacts usually decrease quickly after ignition, so overall implementation impacts would be minor to major adverse. Treatment is usually completed in one to four days.

Post-treatment monitoring would involve helicopters, vehicles, hand tools, and possibly fixed-wing aircraft to monitor burn effects with aerial and/or ground patrols for a few days over a small area. Aircraft use would be minimal. Impacts would be minor to moderate adverse.

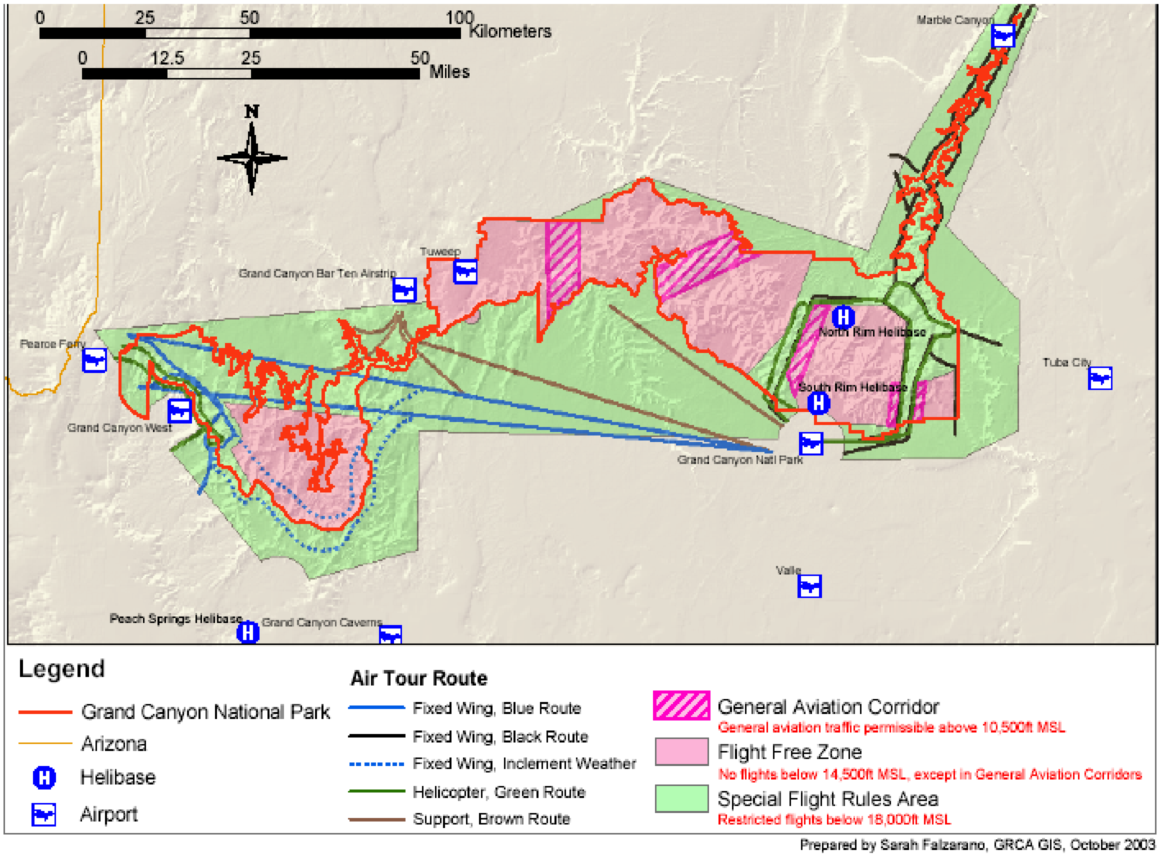
Other than aircraft used for aerial ignition and observation, prescribed fire treatment noise would tend to be concentrated on treatment area edges. Most sound impacts would be local to the treatment area, but aircraft noise would extend well beyond, as aircraft would travel to and from the treatment area over other park lands. Similarly, vehicles would create noise on roads to and from the treatment area.

Prescribed burn implementation would increase human-caused sounds in the treatment area due to fire crew activity, fire vehicles, and aircraft use to start and monitor the fire. These actions would be short term, lasting the burn duration (one to few days), and sporadic throughout the burn duration.
In general, prescribed fire activities usually create quite a bit of noise over a short time, a bit more per unit area than wildland fire use, but less noise overall per unit area than suppression or mechanical/manual treatment. There can be minor to moderate adverse direct noise impacts during preparation over a small area, and moderate to major adverse impacts over a large area on ignition day for implementation phase due to aerial ignition. But after ignition day, noise impacts usually drop to minor adverse over small areas, although observation/reconnaissance aircraft could have moderate short-term adverse impacts over a large area. Post-treatment monitoring would usually have minor to moderate adverse impacts depending on aircraft and vehicle use level. Most noise-producing activities would occur during daylight.

Wildland Fire Use

As shown in Table 4-62, pre-fire activities would create negligible to minor adverse direct impacts on soundscape for one to a few days over a small to medium area. Pre-fire activities would involve use of vehicles for fuel sample collection. Vehicles would create noise four times louder than average natural ambient sound levels at 100 feet.

Map 4-5 Special Flight Rules Area Grand Canyon National Park



Implementation would usually take a few days to many weeks, but would usually have negligible to minor adverse noise impacts except for reconnaissance flights which would spread moderate adverse noise impacts over a large area. This is because much implementation activity is watching the fire progress to insure it stays within acceptable parameters. Management actions like fireline construction with chainsaws and other tools could occur at any time to keep the fire away from fire sensitive areas, or keep the fire perimeter within a defined boundary, creating moderate to major short-term local adverse impacts. Wildland fire-use fires usually start in a small area and grow over time, but noise impacts would usually be in a small part of the treatment area on any given day, a part that would move over time as the fire spreads. When management actions occur, implementation could involve helicopters, vehicles, hand tools, chainsaws, pumps, and leaf blowers with sound levels 4 to 128 times louder than average natural ambient sound levels at 100 feet (moderate to major adverse short-term local impacts).

Post-treatment monitoring would create negligible to minor adverse direct noise impacts for a few days to many weeks over a small to medium area, with aircraft noise from aerial reconnaissance flights spreading moderate adverse noise impacts over a large area when they occur. Post-treatment rehabilitation would create negligible to moderate short-term adverse noise impacts for a few days to many weeks, but only over a small area as rehabilitation activities would generally be concentrated in specific small areas. These sub-activities could involve helicopters, chainsaws, vehicles, and hand tools which produce noise levels 4 to 128 times louder than average park natural ambient sound levels at 100 feet.

Overall, wildland fire use treatments generally create the least noise of all treatment types, but there is usually a small amount of noise on almost any given day over the life of the fire (which may be many weeks). Much activity is simply watching the fire progress, often using aircraft to do so, and taking minor management actions to keep the fire in the MMA or at management action points. Most treatment activities would have negligible to minor direct adverse effects, with the exception of aerial observation/ reconnaissance which could have moderate short-term adverse impacts over a large area. Treatment would be unplanned so could occur during a sensitive time, but almost all noise-producing activities would be during daylight hours. Occasionally, management actions could create moderate to major short-term adverse impacts depending on equipment used.

Suppression **Noise Impacts by Treatment Type** **Soundscape**

As shown in Table 4-62, pre-fire activities would usually affect a small area (for fuel collection activities) to a large area (for aerial reconnaissance) for one to a few days. Pre-fire activities would involve vehicles, helicopters, and possibly fixed-wing aircraft for ground and aerial patrols and fuel sample collection. While helicopters would create noise 128 times louder than average natural ambient sound levels at 100 feet, vehicles would be 4 times louder. Overall pre-fire impacts would be in minor to moderate adverse.

Suppression is an unplanned treatment type, so during containment sub-activity (from initial attack through actual containment), equipment used and suppression effort intensity (which directly influence noise produced) will vary greatly depending on resources immediately available, fire location, and risk level. Sound levels can create moderate to major adverse short-term impacts for a few days over a small area at the beginning of suppression effort, as initial suppression may involve an all-out effort to quickly build containment lines, transport people and equipment, and drop retardant and water. If the fire grows to a large size, suppression may involve major adverse noise impacts over large areas for many weeks.

Containment may involve any and all tools listed above in Tables 4-61 and 4-62, and noise levels anywhere from 4 to 128 times louder than average natural ambient sound levels at 100 feet.

Mop-up would create minor to moderate short-term adverse noise impacts for a few to many days over a small to large area, depending on fire size and nature, and include aerial and ground observation/ reconnaissance, crew and equipment transport, snag cutting, smoldering fire extinguishing, and containment lines reinforcing. Post-fire rehabilitation would create minor to moderate adverse noise impacts for a few to many days over a small to medium area, and could include aerial and ground observation/reconnaissance, aerial reseeding, crew and equipment transport, contour felling, and waterbar installation. These sub-activities could involve use of helicopters, fixed-wing aircraft, chainsaws, vehicles, and hand tools that produce noise levels 4 to 128 times louder than average park natural ambient sound levels at 100 feet.

With all sub-activities, aircraft noise could occur over large areas both in and outside the treatment area as aircraft used for reconnaissance, transport, and/or water/retardant drops fly over other park areas traveling to and from the suppression area. Vehicles are usually not used in the treatment area due to remoteness of most suppression fires, but vehicle noise impacts will often occur in staging areas, fire camps, and on roads to and from those areas. Fire camp impacts could also include sounds from generators, electronic devices, and staging area activities.

Table 4-62 Soundscape Impacts by Treatment Type and Sub-Activity

Treatment Type	Sub-Activity	Noise-Producing Activities	Noise-Producing Equipment	Estimated Time	Estimated Area	Impact Intensity Level
Prescribed Fire	Preparation/ Pre-Fire Activities	Manual Thinning, Fire Line Construction, Crew and Equipment Transport, Fuel Sample Collection	Vehicles, Major Chainsaw Use, Hand Tools, Leaf Blowers	One Day to Few Days	Small	Minor to moderate adverse
	Implementation	Aerial and Ground Ignition, Aerial and Ground Observation/ Reconnaissance, Crew and Equipment Transport (ground), Staging operations, Limited Suppression, Holding Actions	Helicopters, Hand Tools, Vehicles, Pumps, Chainsaws	Intense helicopter use for aerial ignition through burn area for one day. Usually one to four days for most other implementation activities	Large (often over 1,000 acres)	Minor to major adverse
	Post-Treatment Monitoring	Aerial and Ground Patrols	Vehicles, Hand Tools, Helicopters, Fixed-Wing Aircraft	Few Days	Small	Minor to moderate adverse
Wildland Fire Use	Pre-Fire Activities	Fuel Sample Collection	Vehicles	One Day to Few Days	Small (sample collection sites)	Negligible to minor adverse
	Implementation	Management Actions (Fire Lines, etc.), Aerial and Ground Observation/Reconnaissance, Crew and Equipment Transport, Aerial and Ground Ignition, Staging Operations	Helicopters, Hand Tools, Vehicles, Pumps (both large pumps on engines and small portable pumps), Chainsaws, Leaf Blowers	Few Days to Many Weeks, Helicopter Use Spread Out	Start Small, May Grow to Medium or Large Over Time	Negligible to major adverse
	Post-Treatment Monitoring	Aerial and Ground Observation Reconnaissance	Vehicles, Hand Tools, Helicopters	Few Days	Small to Medium	Negligible to moderate adverse
	Post-Treatment Rehabilitation	Aerial Reseeding, Crew and Equipment Transport, Contour Felling, Install Waterbars	Helicopters, Vehicles, Hand Tools, Minor Chainsaw Use	Few Days to Many Weeks	Small	Negligible to moderate adverse

Treatment Type	Sub-Activity	Noise-Producing Activities	Noise-Producing Equipment	Estimated Time	Estimated Area	Impact Intensity Level
Suppression	Pre-Fire Activities	Aerial and Ground Patrols, Fuel Sample Collection	Helicopters, Fixed-Wing Aircraft, Vehicles	One Day to a Few Days	Small (fuel collection) to Large (reconnaissance)	Minor to moderate adverse
	Containment	Construct Containment (Fire Lines, etc.), Extensive Aerial and Ground Observation/ Reconnaissance, Crew and Equipment Transport, Aerial Retardant Drops, Aerial and Ground Ignition, Staging Operations (Fire Camps)	Helicopters, Fixed-Wing Aircraft (Aerial Tankers, etc.), Hand Tools, Few Vehicles (due usually to remoteness of fire location), Pumps, Extensive Chainsaw Use, Leaf Blowers	Intense for Few Days to Many Weeks	Small to Large	Moderate to major adverse
	Mop-up	Aerial and Ground Observation/Reconnaissance, Crew and Equipment Transport, Cut Snags, Extinguish Smoldering Fire, Reinforce Containment Lines	Helicopters, Fixed-Wing Aircraft, Vehicles, Hand Tools, Chainsaws, Pumps	Few Days to Many Days	Small to Large	Moderate adverse
	Post-Fire Rehabilitation	Aerial and Ground Observation/Reconnaissance, Aerial Reseeding, Crew and Equipment Transport, Contour Felling, Install Waterbars	Helicopters, Fixed-Wing Aircraft, Vehicles, Hand Tools, Chainsaws	Few Days to Many Days	Small to Medium	Minor to moderate adverse
Manual Thinning		Crew and Equipment Transport, Cut and Transport Material (usually hand-hauling), Chip/Shred, Staging Operations	Hand Tools, Vehicles, Extensive Chainsaw Use, Leaf Blowers, Chippers	Few Days to Many Days	Small (1-3 acres per day) But May Grow to Medium Over Time	Moderate to major adverse
Mechanical Thinning		Crew and Equipment Transport, Cut and Transport Material (usually mechanical hauling), Chip/Shred	Cutting Machines, Chippers, Vehicles, Chainsaws	Few Days to Many Days	Small (1-5 acres per day) But May Grow to Medium Over Time	Major adverse

Overall, suppression treatments can create the greatest noise impacts of all treatment types. Direct impacts to soundscape would tend to be minor to major adverse short-term over a small to large area with no control over timing. Suppression activities may take place 24 hours per day, although aircraft use would usually be limited to daylight hours for safety reasons.

Manual Thinning **Noise Impacts by Treatment Type** **Soundscape**

As shown in Table 4-62, manual thinning would usually create moderate to major short-term local noise impacts for a few to many days, over a small area (one to five acres) on any given day, as chainsaws, hand tools, and vehicles thin and pile vegetation. In some cases, chippers/shredders may be used onsite to reduce cut vegetation volume in the treatment area, which would create major short-term local adverse noise impacts. Such equipment can produce noise 4 times (for vehicles) to 16 to 32 times (for chainsaws) to 128 times (for chippers/shredders) louder than average natural ambient sound levels at 100 feet.

Noise from manual thinning chainsaw use can be highly variable, depending on if a few people with chainsaws work over many days, or whether many people complete work in a few days. Also, if chipping /shredding is done onsite, noise impacts will be much greater. Most manual thinning will occur in WUI areas, but pre-treatment for prescribed burns may include some manual thinning in more remote areas. During treatment days, noise may be quite variable, irregular and random, as several to many pieces of equipment may be operating at the same time; noise may be present during most daylight hours during intense treatment. Chainsaws frequently change noise levels when turned off during piling of cut material, turned on at idle as the operator gets ready to make new cuts, increased to full throttle as the operator prepares to make the cut, and then changes as the chainsaw cuts through wood. Chippers/shredders also change sound level and quality between times when equipment is idling and times when wood is cut.

Overall, manual thinning tends to be in the middle of noise impacts: generally less than suppression and mechanical treatments, but more than prescribed fire and wildland fire-use treatments. Direct impacts to soundscapes would tend to be moderate to major local short-term adverse limited to daylight hours.

Mechanical Thinning **Noise Impacts by Treatment Type** **Soundscape**

Mechanical thinning would be conducted solely in the Primary WUI area (some of the park's least noise-sensitive areas), primarily in the piñon-juniper vegetation type. As shown in Table 4-62, mechanical thinning would usually create major short-term adverse local noise impacts for a few to many days over a small to medium area, as mechanical feller/haulers (also called feller bunchers), chipper/shredders, chainsaws, and vehicles are used to thin and pile vegetation. Feller/haulers and chipper/shredders are usually some of the noisiest equipment used in fire management, with sound levels in the 90s dBA at 100 feet, requiring operator hearing protection. Such equipment can produce noise on the order of 128 times louder than average natural ambient sound levels at 100 feet.

Noise from mechanical thinning is usually less variable than manual thinning, since one machine will usually be used rather than multiple chainsaws, but the machine will vary greatly in sound level and quality as the user cuts a tree, hauls it to a pile, then moves to another tree. If chipping/ shredding is performed onsite, noise impacts will be much greater than if it is done in a less-sensitive area. Overall, mechanical thinning tends to create some of the greatest noise impacts per acre and unit time, generally less than suppression, but more than prescribed and wildland fire-use fires and manual thinning. Direct impacts to soundscapes would tend to be major local short-term adverse, but limited to daylight hours. Table 4-63 summarizes how fire treatments generally affect natural soundscapes.

4.4.3.8 Cumulative Impacts **Soundscape**

Cumulative impacts on natural soundscapes were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions.

Aircraft Overflights **Cumulative Impacts** **Soundscape**

Primary activities with potential to cumulatively affect natural soundscape and related values are impacts from aircraft overflights not associated with fire management activities. Such flights are numerous over parts of the park, but occur independently of alternatives in this document. Overflights include commercial air tours and support operations, high altitude commercial jet traffic, non-fire-related park administrative flights and, to a lesser extent, military and general aviation aircraft use over and adjacent to the park. Several laws require the Federal Aviation Administration and the NPS to address the aircraft noise issue and work together to “substantially restore natural quiet” to Grand Canyon National Park (Public Laws 93-620 and 100-91). A continuing effort exists to determine whether “substantial restoration of natural quiet” has been achieved. However, cumulative aircraft use is causing a “significant adverse effect” (as used in Public Law 100-91) and an adverse, long-term, major impact on natural soundscape. Although alternatives in this plan add only a negligible regional increment to this major adverse cumulative effect, local effects of aircraft use in plan alternatives can be major adverse in some cases.

GRCA fire-related aircraft can impact other aviation in the vicinity if temporary flight restrictions (TFR) are instituted for aviation safety reasons. Normally, TFR are rarely used except in large suppression fires, but may be considered for fire management activities in areas of air-tour flight corridors (Map 4-5).

Aircraft noise impacts also occur due to high altitude commercial jet traffic, military aircraft, general aviation aircraft, and park administrative aircraft use.

Given Grand Canyon’s history of aircraft overflights, mitigation that would reduce cumulative impacts on natural soundscape to a minor or lower intensity level is unlikely.

Other Cumulative Noise Sources **Cumulative Impacts** **Soundscape**

Areas near the park’s developed areas with paved road access (Grand Canyon Village, Desert View, North Rim, Hermits Rest) experience noise from sources associated with visitors, residents, and concession operations including automobiles, buses, and trucks in all three areas, trains in Grand Canyon Village, and air conditioners and other noise related to lodging, services, and housing. These areas are classified in this FEIS/AEF as WUI. Of the park’s two other developed areas, Tuweep is located on a rugged unpaved road and has a ranger station, remote overlooks, and primitive campground, with noise primarily from vehicles on the dirt road and a generator at the ranger station. Phantom Ranch, located at the bottom of the canyon, is accessed only by foot or mules on trails, or by boats on the Colorado River (no vehicle access).

The only other major noise source in most rim areas (where the majority of fire management activities would take place) are vehicles on the few unpaved roads designated open for vehicle travel. Vehicle use may include visitors accessing remote park areas, or administrative use. Noise levels would be comparable with vehicle measurements shown in Table 4-60. For purposes of this FEIS/AEF, such vehicle use for fire management activities would be considered a direct impact; only administrative vehicle use for non-fire purposes (law enforcement, resource management, research) would be considered a cumulative impact.

4.4.3.9 Alternative 1 No Action, Existing Program Soundscape

Alternative 1 is a continuation of current fire management strategies, and is the alternative against which others are compared. This alternative continues the existing program of suppression, wildland fire-use, and prescribed fires, and limited manual thinning treatments. Alternative 1 is the only alternative with no mechanical thinning treatments. Approximately 12,700 total acres are to be treated annually.

As explained in Impacts Common to All Alternatives, direct noise impacts among alternatives differ primarily by treatment acreage and helicopter hours which vary for each treatment type and alternative. Indirect noise impacts caused by the alternative's vegetation effects are described separately below.

There will be years when annual acres treated by prescribed, wildland fire-use, and/or suppression fire will be much less, or greater, than average.

Prescribed Fire Alternative 1 Soundscape

Alternative 1 proposes to treat an annual average 5,840 acres with prescribed fire. As shown in Table 4-62, usually one to a few days of minor to moderate adverse short term local noise impact would occur for preparation/pre-fire mostly near burn unit edges limited to daylight hours. Minor to major short-term, local adverse noise impacts may occur during implementation.

Annual helicopter flight time associated with prescribed fire treatments is 14 hours, tied for second most for prescribed fire among alternatives. Helicopter noise impacts would be moderate to major short-term local adverse often for a day or less during aerial ignition activity, or, at most, a few days.

Direct noise effects from non-aircraft prescribed fire activities will normally be minor to moderate short-term adverse impacts local to burn area edges.

Burn results would normally be a major beneficial long-term local to regional indirect impact over a moderate area, as ponderosa pine and mixed-conifer vegetation move toward more natural conditions.

Wildland Fire Use Alternative 1 Soundscape

Alternative 1 proposes to treat an average 5,000 acres annually with wildland fire use, possibly in some of the most remote and thus, some of the most noise-sensitive, park areas.

Helicopter flight time associated with wildland fire use is 32 annual hours, tied for second most for wildland fire use among alternatives.

Direct noise effects from non-aircraft wildland fire-use activities will normally be negligible to moderate adverse local short-term impacts over a small area during daylight hours, but the area will usually move as the fire spreads so would end up affecting most of the acreage shown, but only a small amount at any given time over the life of the fire. There may also be local short-term moderate to major adverse impacts in small areas where active management activities occur, but effects would usually be for a day or less or, at most, a few days. Wildland fire use is an unplanned activity, occurring whenever a fire starts naturally, so noise impacts may occur during sensitive times.

Fire results would normally be a major beneficial long-term local to regional indirect impact over a moderate area, as ponderosa and mixed-conifer vegetation types move toward more natural conditions.

Suppression Alternative 1 Soundscape

Alternative 1 anticipates an average 1,800 acres of suppression fires annually. Helicopter flight time associated with Alternative 1 suppression treatments is 110 annual hours, in the middle of suppression flight hours in all alternatives.

Direct noise effects from non-aircraft suppression activities may occur over a small to large area; effects may be local to regional and affect almost all acreage shown 24 hours/day. Noise impacts from all fire fighting equipment will be minor to major adverse local short term in areas where suppression activities occur, and impacts may occur for the activity's duration, a few days to many weeks. Suppression is an unplanned activity, occurring whenever a fire starts for any reason, so noise impacts may occur during sensitive times.

Table 4-63 Beneficial and Detrimental Effects of Fire Management Practices on Natural Soundscapes

Management Type	Benefit to Natural Soundscapes	Detriment to Natural Soundscapes
Prescribed Fire	• A primary treatment objective is to move vegetation toward natural ecological and fire regime conditions, indirectly benefiting natural soundscape • Relative control over fire intensity, helping achieve objectives for moving vegetation toward natural ecological conditions • Fire sounds are considered natural, so not an impact • Because most treatments would be in remote areas, most noise impacts occur away from most visitors and residents	• Direct adverse noise effects from prescribed fire activities and equipment (helicopters, vehicles, engines and pumps) but usually only at management action points • Temporary wildlife displacement due to noise and treatment personnel presence
Wildland Fire Use	• Fire sounds are considered natural, so not an impact • Generally the least noise impact of all treatment types, with the exception that considerable fire management activity may create noise at management action points under some circumstances. However, fire will often be allowed to burn with observation the primary management activity • A primary treatment objective is to move vegetation toward natural ecological and fire regime conditions, indirectly benefiting natural soundscape • Because most fires would be in remote areas, most noise impacts occur away from most visitors and residents	• Direct adverse noise effects from helicopters, vehicles, engines and pumps, but usually only at management action points • Less control over fire intensity than prescribed fire, so some treatment may not move vegetation toward natural conditions • Temporary wildlife displacement due to noise and treatment personnel presence
Suppression	• Fire sounds are considered natural, so not an impact	• Generally the greatest direct adverse noise effects of all treatment types from fire management activities and equipment (aircraft, vehicles, chainsaws, etc.) • Least control over fire intensity, so potential for greatest adverse impacts to vegetation, thus greatest adverse indirect impacts to soundscape • No opportunity to control timing to avoid sensitive times • Temporary wildlife displacement due to noise and treatment personnel presence
Manual Thinning	• Although primary treatment objective is safety-related in protecting WUI, treatment would be designed to help move vegetation toward natural ecological and fire regime conditions, indirectly benefiting natural soundscape • Some ability to time treatments to avoid sensitive times	• Direct adverse noise effects from manual thinning activities and equipment (chainsaws, etc.) • Temporary wildlife displacement due to noise and treatment personnel presence • Direct noise impacts on visitors and residents in and adjacent to WUI
Mechanical Thinning	• Although primary treatment objective is safety-related in protecting WUI, treatment designed to help move vegetation toward natural ecological and fire regime conditions, indirectly benefiting natural soundscape • Some ability to time treatments to avoid sensitive times	• Direct adverse noise effects from mechanical thinning equipment • Temporary wildlife displacement due to noise and treatment equipment and personnel presence • Direct noise impacts on visitors and residents in and adjacent to WUI

Fire results would often not contribute to moving vegetation to a more natural condition, so moderate to major adverse long-term indirect impacts to soundscapes could occur in any or all vegetation types, but expected acreage would be small to medium, resulting in mostly local impacts.

Manual Thinning **Alternative 1** **Soundscape**

Alternative 1 proposes to treat an annual average 40 acres with manual thinning in WUI areas along highways and adjacent to developed areas, some of the least noise-sensitive areas. Direct noise impacts would normally be local short-term (a few to many days), moderate to major adverse, and would affect almost all acreage shown. Aircraft would not be used, thus no aircraft impacts.

Thinning results would be a moderate beneficial long-term local indirect impact, only over a small area.

Mechanical Thinning **Alternative 1** **Soundscape**

There would be no mechanical thinning under Alternative 1, thus no impacts on natural soundscape.

Indirect Impacts **Alternative 1** **Soundscape**

Alternative 1 would move 119,600 acres toward desired vegetative conditions, the third-highest acreage among the alternatives, which would be a moderate to major regional long-term beneficial indirect soundscape impact. Alternative 1 also has the second lowest suppression acreage (20,050), which would move vegetation away from natural vegetative conditions, a moderate to major regional long-term adverse indirect impact on soundscape.

Cumulative Effects **Alternative 1** **Soundscape**

Alternative 1's cumulative impacts, when combined with past and reasonably foreseeable future actions, would result in major adverse long-term regional impacts to natural soundscape, primarily due to aircraft overflights not related to fire management activities which only add a negligible contribution to cumulative impacts. However, even if all noise-producing fire management activities were eliminated, there would still be major adverse cumulative effects from non-related overflights. Because overflight effects on soundscape are so much greater than effects of any alternative, all plan alternatives would have major adverse cumulative impacts on park natural soundscape.

Conclusion **Alternative 1** **Soundscape**

Alternative 1 represents a continuation of current fire management strategies, and is the alternative against which others are compared. This alternative continues the existing program including suppression, wildland fire-use, and prescribed fires, and limited manual thinning treatments. Alternative 1 is the only alternative with no mechanical thinning treatments.

Impacts to soundscape from prescribed fire operations (5,840 acres/year) are minor to major short-term local to regional adverse. Result of prescribed burns to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland fire use operations (5,000 acres/year) would be negligible to major, short-term local adverse. Results of wildland fire-use fires to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland suppression operations (1,800 acres/year) would be minor to major short term local to regional adverse. Suppressed fire results to vegetation and thus natural soundscape would be moderate to major long-term local adverse.

Impacts to soundscape from manual thinning operations (40 acres/year) would be moderate to major short term local adverse. Result of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial. Since there are no mechanical thinning operations in this alternative, there would be no impacts.

Overall indirect impacts to natural soundscape associated with vegetation would be moderate to major long term regional beneficial as 119,600 acres (10,870 acres/year, excluding suppression fires) would move toward desired vegetative conditions. Indirect impacts from suppression fires would tend to move natural soundscape away from desired conditions and would be moderate to major long term regional adverse.

Overall cumulative impacts would be major adverse long term regional due to aircraft overflights not related to fire management activities.

Impairment **Alternative 1** **Soundscape**

Although there are short- to long-term local and regional major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair soundscape during Alternative 1 implementation.

Unacceptable Impacts **Alternative 1** **Soundscape**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soundscape as a result of implementation of this Alterative.

4.4.3.10 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Soundscape

Alternative 2 would continue the existing direction of GRCA's Fire Management Program with limited changes. Changes include use of new Fire Management Units (Map 2-2) and development of a Wildland-Urban Interface treatment program involving manual/mechanical fuel reduction methods. Alternative 2 would continue use of suppression, wildland fire-use, and prescribed fires, and manual fuel reduction treatments. With the exception of mechanical treatments, Alternative 2 has the same treatment acreages as Alternative 1. Mechanical thinning treatments will total approximately 200 acres annually. Alternative 2 would treat an average 12,900 acres per year, a small increase compared to Alternative 1.

As explained in Impacts Common to All Alternatives, direct noise impacts among alternatives differ by treatment acreage and helicopter flight hours which vary for each treatment type and alternative. Indirect noise impacts caused by effects of alternatives on vegetation are described separately below.

There will be years when annual acres treated by prescribed, wildland fire-use, and/or suppression fires will be much less, or greater, than average.

Prescribed Fire **Alternative 2** **Soundscape**

Alternative 2 proposes to treat an annual average 5,840 acres with prescribed fire. As shown in Table 4-62, usually one to a few days of minor to moderate short-term local adverse noise impact would occur for

preparation/pre-fire mostly near burn unit edges limited to daylight hours. However, minor to major short-term local adverse noise impacts may occur during the implementation phase.
Annual helicopter flight time associated with prescribed fire treatments is 14 annual hours, tied for second most for prescribed fire among alternatives. Helicopter noise would have moderate to major short-term local adverse impacts often for a day or less during aerial ignition activity, or at most for a few days.

Direct noise effects from non-aircraft prescribed fire activities will normally be minor to moderate short-term adverse impacts local to burn area edges.

Burn results would normally be a major beneficial long-term local to regional indirect impact over a moderate area as ponderosa pine and mixed-conifer vegetation move toward more natural conditions.

Wildland Fire Use **Alternative 2** **Soundscape**

Alternative 2 proposes to treat an average 5,000 acres annually with wildland fire use, possibly in some of the most remote and thus, most noise-sensitive, park areas.

Helicopter flight time associated with wildland fire use is 32 hours annually, tied for second most for wildland fire use among alternatives.

Direct noise effects from non-aircraft wildland fire-use activities will normally be negligible to moderate adverse local short-term impacts over a small area during daylight, but the area will usually move as the fire spreads so would end up affecting most of the acreage shown, but only a small amount at any given time over the fire's life. There may also be local short-term moderate to major adverse impacts in small areas where active management activities occur, but effects would usually be a day or less, or at most a few days. Wildland fire use is an unplanned activity, occurring whenever a fire starts naturally, so noise impacts may occur during sensitive times.

Fire results would normally be a major beneficial long-term local to regional indirect impact over a moderate area as ponderosa and mixed-conifer vegetation types move toward more natural conditions.

Suppression **Alternative 2** **Soundscape**

Alternative 2 anticipates an annual average 1,800 acres of suppression fire. Helicopter flight time associated with suppression treatments is 110 hours annually, in the middle of flight hours for suppression in all alternatives.

Direct noise effects from non-aircraft suppression activities may occur over a small to large area, so effects may be minor to moderate local to regional short term, and may affect almost all acreage shown 24 hours per day. Noise impacts from all firefighting equipment will be minor to major adverse short term local to regional. Suppression is an unplanned activity, occurring whenever a fire starts for any reason, so noise impacts may occur during sensitive times.

Fire results would often not contribute to moving vegetation to a more natural condition, so moderate to major adverse long-term indirect impacts to soundscapes could occur in any or all vegetation types; expected acreage would be small to medium resulting in mostly local impacts.

Manual Thinning **Alternative 2** **Soundscape**

Alternative 2 proposes to treat an average 40 acres annually with manual thinning in WUI areas along highways and adjacent to developed areas, some of the least noise-sensitive park areas. Direct noise impacts would normally be local and short-term (a few to many days), moderate to major adverse, and would affect almost all acreage shown. Aircraft would not be used, so there would be no aircraft impacts.

Thinning results would be a moderate beneficial long-term local indirect impact, but over a small area.

Mechanical Thinning Alternative 2 Soundscape

Mechanical thinning treatments are the primary difference between Alternatives 1 and 2, with the annual addition of an average 200 acres. Mechanical thinning would create a major short-term local direct adverse impact to soundscapes from equipment noise. There would be a moderate long-term local indirect beneficial impact to soundscape because vegetation is closer to desired vegetative conditions.

Indirect Impacts Alternative 2 Soundscape

Additional mechanical WUI treatment would lessen potential for fire ignition and spread in the WUI, especially around Grand Canyon Village. Fuels reduction treatments would result in decreased likelihood of fire ignition and/or spread in or into the WUI compared to Alternative 1.

Alternative 2 would move 121,700 acres toward desired vegetative conditions, the second-highest acreage among alternatives, a moderate to major regional long-term beneficial indirect soundscape impact. It also has the second lowest suppression acreage (20,050), which would move vegetation away from natural vegetative conditions, a moderate to major regional long-term adverse indirect impact on soundscape.

Cumulative Effects Alternative 2 Soundscape

Cumulative impacts of Alternative 2, when combined with past and reasonably foreseeable future actions, would result in major adverse long-term regional impacts to natural soundscape, primarily due to aircraft overflights unrelated to fire management activities which only add a negligible contribution to cumulative impacts. However, even if all noise-producing fire management activities were eliminated, there would still be major adverse cumulative effects from non-related overflights. Because overflight effects on soundscape are so much greater than effects of alternatives, all plan alternatives would have major adverse cumulative impacts on park natural soundscape.

Conclusion Alternative 2 Soundscape

Alternative 2 would continue the existing direction of GRCA's Fire Management Program with limited changes. Changes include new Fire Management Units (Map 2-2) and development of a Wildland-Urban Interface treatment program involving manual/mechanical fuel reduction methods. Alternative 2 would continue suppression, wildland fire-use, and prescribed fires, and manual fuel-reduction treatments.

Impacts to soundscape from prescribed fire operations (5,840 acres/year) include minor to major short-term local adverse. Prescribed burn results to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland fire use operations (5,000 acres/year) would be negligible to major short term local adverse. Result of wildland fire-use fires to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland suppression operations (1,800 acres/year) would be minor to major short term local to regional adverse. Results of suppressed fires to vegetation and thus natural soundscape would be moderate to major long term local adverse.

Impacts to soundscape from manual thinning operations (40 acres/year) would be moderate to major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Impacts to soundscape from mechanical thinning operations (200 acres/year) would be major short term local adverse. Result of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Overall indirect impacts to soundscape would be moderate to major long term regional beneficial as 121,700 acres (11,000 acres/year [excluding suppression fires]) would move toward desired vegetative conditions. Indirect impacts to soundscape from suppression fires would be moderate to major long term regional adverse.

Overall cumulative impacts would be major adverse long term regional due to aircraft overflights unrelated to fire management activities.

Impairment Alternative 2 Soundscape

Although there are short- to long-term local and regional major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair soundscape during Alternative 2 implementation.

Unacceptable Impacts Alternative 2 Soundscape

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soundscape as a result of implementation of this Alterative.

4.4.3.11 Alternative 3 Non-Fire Treatment Program Soundscape

Alternative 3 combines suppression, wildland fire-use, and prescribed fires with mechanical/manual fuel reduction techniques, but focuses fire management efforts on manual/mechanical treatments in the WUI. This alternative treats the fewest acres with prescribed fire and wildland fire-use as compared to all alternatives. Alternative 3 would treat an estimated average 5,840 acres/year.

The speed at which thinning would occur and number of acres treated with non-fire treatments in primary WUI will be faster and larger than for any other alternative.

As explained in Impacts Common to All Alternatives, direct noise impacts among alternatives differ primarily by treatment acreage and helicopter hours which vary for each treatment type and alternative. Indirect noise impacts caused by alternative effects on vegetation are described separately below.

There will be years when annual acres treated by prescribed fire, wildland fire use, and/or suppression will be much less, or greater, than average.

Prescribed Fire Alternative 3 Soundscape

Prescribed fire would be used to treat an average 2,310 acres annually, lowest of alternatives. Helicopter flight time associated with prescribed fire treatments would be six hours annually, lowest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 5,320 acres and has 13 flight hours with prescribed fire. Helicopter noise impacts would still be moderate to major short term adverse, often for a day or less during aerial ignition activity, or at most a few days. Direct noise effects from non-aircraft prescribed fire activities will normally be minor to moderate short-term adverse impacts local on burn area edges. Overall, prescribed fire impacts would be minor to major short term local adverse.

Burn results would normally be a major beneficial long-term local to regional indirect impact over a small area as portions of ponderosa pine and mixed-conifer move toward more natural conditions.

Wildland Fire Use **Alternative 3** **Soundscape**

Alternative 3 proposes to treat an average 800 acres annually with wildland fire use, second lowest total for this treatment among alternatives.

Helicopter flight time associated with wildland fire-use treatments would be five hours annually, second lowest for this treatment among alternatives. For comparison, Alternative 1 treats 5,000 acres and has 32 flight hours with wildland fire use.

Direct noise effects from non-aircraft wildland fire-use activities will normally be negligible to minor adverse local short-term impacts over a small area during daylight hours, but the area will usually move as fire spreads so would end up affecting most of the acreage shown, but only a small amount at any given time over the fire's life. There may also be local short-term moderate to major adverse impacts in small areas where active management activities occur, but effects would usually be for a day or less, or at most a few days. Wildland fire use is an unplanned activity, occurring whenever a fire starts naturally, so noise impacts may occur during sensitive times.

Fire results would normally be a major beneficial long-term local to regional indirect impact over a small area, as ponderosa and mixed-conifer move toward more natural conditions.

Suppression **Alternative 3** **Soundscape**

Suppression treatments would increase to an average 2,370 acres annually, greatest suppression acreage of all alternatives. Helicopter flight time associated with suppression treatments would be 144 hours, greatest number of flight hours per year for suppression among alternatives. For comparison, Alternative 1 estimates 1,800 acres with 110 flight hours each year. Fuel loading outside the WUI would continue to increase, thus increasing risk of large wildfires. As fuel loads increase, fires will grow more quickly and with greater intensity, reducing effectiveness of firefighters and suppression equipment.

Direct noise effects from non-aircraft suppression activities may occur over a small to large area, so effects may be local to regional minor to moderate short term and may affect almost all acreage shown 24 hours per day. Noise impacts from all firefighting equipment will be minor to major adverse short term local to regional. Suppression is an unplanned activity, occurring whenever a fire starts for any reason, so noise impacts may occur during sensitive times.

Fire results would often not contribute to moving vegetation to a more natural condition, so moderate to major adverse long-term indirect impacts to soundscapes could occur in any or all vegetation types, resulting in mostly local impacts.

Manual Thinning **Alternative 3** **Soundscape**

Manual thinning treatments will average 55 acres each year, largest total for this treatment type among alternatives (compared to 40 acres manual thinning in Alternative 1). Direct noise impacts would normally be local and short term (a few to many days), moderate to major adverse, and would affect almost all acreage shown. Aircraft would not be used, so there would be no aircraft impacts.

Thinning results would normally be a moderate beneficial long-term local indirect impact, but only over a small area under Alternative 3.

Mechanical Thinning **Alternative 3** **Soundscape**

Mechanical thinning treatments will average 305 acres annually, largest total for this treatment type among alternatives (compared to zero mechanical-thinning acres in Alternative 1). Mechanical thinning would normally create a major short-term local direct adverse impact to soundscapes from equipment noise. There would be a moderate long-term local indirect beneficial impact to soundscape because vegetation is closer to desired vegetative conditions.

Indirect Impacts **Alternative 3** **Soundscape**

Alternative 3 would move 38,525 acres toward desired vegetative conditions, lowest acreage among alternatives, a minor regional long-term beneficial indirect soundscape impact. Alternative 3 has the highest suppression acreage (26,070), which would move vegetation away from natural vegetative conditions, a moderate to major regional long-term adverse indirect effect on soundscape.

Cumulative Effects **Alternative 3** **Soundscape**

Cumulative impacts of Alternative 3, when combined with past and reasonably foreseeable future actions, would result in major adverse long-term regional impacts to natural soundscape, primarily due to aircraft overflights unrelated to fire management activities which only add a negligible contribution to cumulative impacts. However, even if all noise-producing fire management activities were eliminated, there would still be major adverse cumulative effects from non-related overflights. Because effects of overflights on soundscape are so much greater than effects of alternatives, all alternatives in this plan would have major adverse cumulative impacts on park natural soundscape.

Conclusion **Alternative 3** **Soundscape**

Alternative 3 combines suppression, wildland fire-use, and prescribed fires with mechanical/manual fuel reduction techniques, focusing fire management efforts on WUI manual/mechanical treatments. This alternative treats the fewest acres with prescribed and wildland fire-use fire compared to all alternatives.

Impacts to soundscape from prescribed fire operations (2,310 acres/year) include minor to major short term local adverse. Results of prescribed burns to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland fire use operations (800 acres/year) would be negligible to major short term local adverse. Results of wildland fire-use fires to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland suppression operations (2,370 acres/year) would be minor to major short term local to regional adverse. Results of suppressed fires to vegetation and thus natural soundscape would be moderate to major long term local adverse.

Impacts to soundscape from manual thinning operations (55 acres/year) would be moderate to major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Impacts to soundscape from mechanical thinning operations (305 acres/year) would be major short term local adverse. Result of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Overall indirect impacts to soundscape would be moderate to minor long term regional beneficial as 38,525 acres (3,505 acres/year [excluding suppression fires]) would move toward desired vegetative conditions. Indirect impacts to soundscape from suppression fires would be moderate to major long term regional adverse.

Overall cumulative impacts would be major adverse long term regional due to aircraft overflights unrelated to fire management activities.

Impairment Alternative 3 Soundscape

Although there are short term and long term, local and regional, major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair soundscape during Alternative 3 implementation.

Unacceptable Impacts Alternative 3 Soundscape

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessionaire or contractor operations, there would not be unacceptable impacts on soundscapes as a result of implementation of this Alterative.

4.4.3.12 Alternative 4 Prescribed Fire Emphasis Soundscape

Alternative 4 combines suppression, wildland fire-use, and prescribed fires with mechanical/manual hazard-fuel reduction techniques treating an estimated 12,700 acres. Alternative 4 relies on prescribed fire as the preferred (not exclusive) method to restore vegetative communities to desired conditions prior to managing fire in those areas with wildland fire use. Wildland fire use would only occur in areas that meet desired-condition criteria. Non-fire treatments and prescribed fire would occur in WUI.

As explained in Impacts Common to All Alternatives, direct noise impacts among alternatives differ primarily by treatment acreage and helicopter hours which vary for each treatment type and alternative. Indirect noise impacts caused by effects of the alternative on vegetation are described separately below.

There will be years when annual acres treated by prescribed, wildland fire-use and/or suppression fires will be much less, or greater, than average.

Prescribed Fire Alternative 4 Soundscape

Prescribed fire would treat an annual average 9,940 acres, by far the greatest acreage for this treatment among alternatives. Helicopter flight time associated with prescribed fire treatments in Alternative 4 would be 25 hours/year, greatest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 5,840 acres and has 14 flight hours with prescribed fire.

Helicopter noise impacts will be moderate to major short term adverse, often for a day or less during aerial ignition activity, or at most for a few days. Direct noise effects from non-aircraft prescribed fire activities will normally be moderate to major short-term adverse impacts local on burn area edges. Overall, prescribed fire impacts would be moderate to major short term local adverse.

Burn results would normally be a major beneficial long-term local to regional indirect soundscape impact over a moderate to large area as vegetation moves toward more natural conditions.

Wildland Fire Use **Alternative 4** **Soundscape**

Wildland fire use would treat an average 500 acres annually under this alternative, lowest total for this treatment type among alternatives. Helicopter flight time associated with wildland fire use treatments in Alternative 4 would be three hours/year, by far the lowest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 5,000 acres and has 32 flight hours wildland fire use.

Direct noise effects from non-aircraft wildland fire use activities will normally be negligible to minor adverse local short-term impacts over a small area during daylight hours, but the area will usually move as fire spreads so would end up affecting most acreage shown, but only a small amount at any given time over the life of the fire. There may also be local short-term moderate to major adverse impacts in small areas where active management activities occur, but effects would usually be for a day or less, or at most a few days. Wildland fire use is an unplanned activity, occurring whenever a fire starts naturally, so noise impacts may occur during sensitive times.

Fire results would normally be a major beneficial long-term local to regional indirect impact over a small area as vegetation moves toward more natural conditions.

Suppression **Alternative 4** **Soundscape**

Alternative 4 anticipates an annual average 2,200 acres, second greatest total among alternatives. Helicopter time associated with suppression in Alternative 4 would be 133 hours annually, second greatest flight hours for suppression among alternatives. For comparison, Alternative 1 treats 1,800 acres and has 110 flight hours with suppression.

Direct noise effects from non-aircraft suppression activities may occur over a small to large area; effects may be minor to moderate local to regional short term and may affect almost all acreage shown 24 hours per day. Noise impacts from all firefighting equipment will be minor to major adverse short term local to regional. Suppression is an unplanned activity, occurring whenever a fire starts for any reason, so noise impacts may occur during sensitive times.

Fire results would often not contribute to moving vegetation to a more natural condition, so moderate to major adverse long-term indirect impacts to soundscapes could occur in any or all vegetation types, but expected acreage would be small resulting in mostly local impacts.

Manual Thinning **Alternative 4** **Soundscape**

Manual thinning treatments will occur on an annual average 12 acres, by far the lowest total for this treatment type among alternatives (compared to 40 acres manual thinning in Alternative 1). Direct noise impacts would normally be local short-term (a few to many days), moderate to major adverse, and would affect almost all acreage shown. Aircraft would not be used, thus no aircraft impacts.

Thinning results would normally be a moderate beneficial long-term local indirect impact, but only over a very small area under Alternative 4.

Mechanical Thinning **Alternative 4** **Soundscape**

Mechanical thinning treatments will occur on an annual average 60 acres, second lowest total for this treatment type among alternatives (but an increase compared to zero mechanical-thinning acres in Alternative 1). Mechanical thinning would create a major short-term local direct adverse impact to soundscape from equipment noise. There would be a moderate long-term local indirect beneficial impact to soundscape because vegetation is closer to desired vegetative conditions.

Indirect Impacts **Alternative 4** **Soundscape**

Alternative 4 would move 115,600 acres toward desired vegetative conditions, fourth-highest acreage among alternatives, and a moderate to major regional long-term beneficial indirect soundscape impact. It has the second highest acreage for suppression (24,070), which would move vegetation away from natural vegetative conditions, a moderate to major regional long-term adverse indirect affect on soundscape.

Cumulative Effects **Alternative 4** **Soundscape**

Cumulative impacts of Alternative 4, when combined with past and reasonably foreseeable future actions, would result in major adverse long-term regional impacts to natural soundscape, primarily due to aircraft overflights unrelated to fire management activities which only add a negligible contribution to cumulative impacts. However, even if all noise-producing fire management activities were eliminated, there would still be major adverse cumulative effects from non-related overflights. Because effects of overflights on soundscape are so much greater than effects of alternatives, all plan alternatives would have major adverse cumulative impacts on park natural soundscape.

Conclusion **Alternative 4** **Soundscape**

Alternative 4 combines suppression, wildland fire-use, and prescribed fires with mechanical/manual hazard-fuel reduction techniques. Alternative 4 relies on prescribed fire as the preferred (not exclusive) method to restore vegetative communities to desired conditions prior to managing fire in those areas with wildland fire use. Wildland fire use would only occur in areas that meet desired-condition criteria. Non-fire treatments and prescribed fire would occur in the WUI.

Impacts to soundscape from prescribed fire operations (9,940 acres/year) include moderate to major short term local adverse. Prescribed burn results to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland fire use operations (500 acres/year) would be negligible to major short term local adverse. Results of wildland fire-use fires to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland suppression operations (2,200 acres/year) would be minor to major short term local to regional adverse. Results of suppressed fires to vegetation and thus natural soundscape would be moderate to major long term local adverse.

Impacts to soundscape from manual thinning operations (12 acres/year) would be moderate to major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Impacts to soundscape from mechanical thinning operations (60 acres/year) would be major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Overall indirect impacts to vegetation would be moderate to major long term regional beneficial as 115,600 acres (10,500 acres/year [excluding suppression fires]) would move toward desired vegetative conditions. Indirect impacts to vegetation from suppression fires would be moderate to major long term regional adverse.

Overall cumulative impacts would be major adverse long term regional due to aircraft overflights not related to fire management activities.

Impairment **Alternative 4** **Soundscape**

Although there are short term and long term, local and regional, major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair soundscape during Alternative 4 implementation.

Unacceptable Impacts **Alternative 4** **Soundscape**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soundscapes as a result of implementation of this Alterative.

4.4.3.13 Alternative 5 Fire Use Emphasis Soundscape

This alternative combines suppression, wildland fire-use, and prescribed fires with mechanical/manual hazard-fuel reduction techniques. Protection of the WUI and values at risk would occur through prescribed fire and thinning operations. Alternative 5 relies on wildland fire use as the preferred (not exclusive) method to restore GRCA vegetative communities.

Managing wildfire under a fire-use strategy would be considered in all park areas except WUI. Prescribed fire program focus would be limited to protection of values at risk, developing defendable management action points or MMA, and reducing wildfire risk in WUI. Prescribed fire treatments would be phased out of the proposed wilderness area, but would occur in and around park boundaries and WUI. Non-fire treatments would only occur in WUI. Alternative 5 would treat an estimated 12,600 acres per year.

As explained in Impacts Common to All Alternatives direct noise impacts among alternatives differ primarily by treatment acreage and helicopter hours which vary for each treatment type and alternative. Indirect noise impacts caused by effects of the alternative on vegetation are described separately below.

There will be years when the annual acres treated by prescribed fire, wildland fire use and/or suppression will be much less, or greater, than average.

Prescribed Fire **Alternative 5** **Soundscape**

Prescribed fire would treat an annual average 2,700 acres, second lowest acreage for this treatment among alternatives. Helicopter flight time associated with prescribed fire treatments would be seven hours/year, second lowest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 5,840 acres and has 14 flight hours with prescribed fire.

Helicopter noise impacts will be moderate to major short term adverse, often for a day or less during aerial ignition activity, or at most a few days. Direct noise effects from non-aircraft prescribed fire activities will normally be minor to moderate short-term adverse impacts local on burn area edges. Overall, prescribed fire impacts would be minor to major short term local adverse.

Burn results would normally be a major beneficial long-term local to regional indirect impact over a small area as vegetation moves toward more natural conditions.

Wildland Fire Use **Alternative 5** **Soundscape**

Wildland fire use would treat an annual average 8,000 acres, by far the largest for this treatment type among alternatives. Helicopter flight time associated with wildland fire use treatments would be 52 hours per year, by far the greatest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 5,000 acres and has 32 flight hours with wildland fire use.

Direct noise effects from non-aircraft wildland fire use activities will normally be minor to moderate adverse local short-term impacts over a small area during daylight hours, but the area will usually move as fire spreads so would end up affecting most acreage shown, but only a small amount at any given time over the fire's life. There may also be local short-term moderate to major adverse impacts in small areas where active management activities occur, but effects would usually be for a day or less, or at most a few days. Wildland fire use is an unplanned activity, occurring whenever a fire starts naturally, so noise impacts may occur during sensitive times.

Fire effects would normally be a major beneficial long-term local to regional indirect impact over a large area as vegetation moves toward more natural conditions.

Suppression **Alternative 5** **Soundscape**

Suppression is expected on an annual average 1,640 acres, lowest suppression acreage of alternatives. Helicopter flight time associated with suppression treatments would be 100 hours per year, lowest flight hours for this treatment among alternatives. For comparison, Alternative 1 treats 1,800 acres and has 32 flight hours with suppression.

Direct noise effects from non-aircraft suppression activities may occur over a small to large area, so effects will be minor to moderate local to regional short term and may affect almost all acreage shown 24 hours per day. Noise impacts from all firefighting equipment will be moderate to major adverse short term local to regional. Suppression is an unplanned activity, occurring whenever a fire starts for any reason, so noise impacts may occur during sensitive times.

Fire results would often not contribute to moving vegetation to a more natural condition, so moderate to major adverse long-term indirect impacts to soundscapes could occur in any or all vegetation types, but expected acreage would be small (18,050 acres) resulting in mostly local impacts.

Manual Thinning **Alternative 5** **Soundscape**

Manual thinning treatments will occur on an annual average 40 acres. Direct noise impacts would normally be local short-term (a few to many days), moderate to major adverse, and would affect almost all acreage shown. Aircraft would not be used, so there would be no aircraft impacts.

Thinning results would normally be a moderate beneficial long-term local indirect impact, but only over a very small area under Alternative 5.

Mechanical Thinning **Alternative 5** **Soundscape**

Mechanical thinning treatments will occur on an annual average 205 acres, second greatest total for this treatment type among alternatives (compared to zero mechanical-thinning acres in Alternative 1). Mechanical thinning would create a major short-term local direct adverse impact to soundscape due to equipment noise, and a moderate long-term local indirect beneficial impact to soundscape because vegetation is closer to desired vegetative conditions.

Indirect Impacts **Alternative 5** **Soundscape**

Alternative 5 would move 120,570 acres toward desired vegetative conditions, highest acreage among the alternatives, a moderate to major regional long-term beneficial indirect impact. It has lowest acreage for suppression (18,050), which would move vegetation away from natural vegetative conditions, a moderate to major regional long-term adverse indirect affect to soundscape.

Cumulative Effects **Alternative 5** **Soundscape**

Cumulative impacts of Alternative 5, when combined with past and reasonably foreseeable future actions, would result in major adverse long-term regional impacts to natural soundscape, primarily due to aircraft overflights unrelated to fire management activities which only add a negligible contribution to cumulative impacts. However, even if all noise-producing fire management activities were eliminated, there would still be major adverse cumulative effects from the non-related overflights. Because effects of overflights on soundscape are so much greater than effects of alternatives, all alternatives in this plan would have major adverse cumulative impacts on park natural soundscape.

Conclusion **Alternative 5** **Soundscape**

This alternative combines suppression, wildland fire-use, and prescribed fires with mechanical/manual hazard-fuel reduction techniques. Protection of WUI and values at risk would occur through prescribed fire and thinning operations. Alternative 5 relies on wildland fire use as the preferred (although not exclusive) method to restore GRCA vegetative communities.

Impacts to soundscape from prescribed fire operations (2,700 acres/year) include minor to major short term local adverse. Results of prescribed burns to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland fire use operations (8,000 acres/year) would be minor to major short term local adverse. Results of wildland fire-use fires to vegetation and thus natural soundscape would be major long term local to regional beneficial.

Impacts to soundscape from wildland suppression operations (1,640 acres/year) would be minor to major short term local to regional adverse. Results of suppressed fires to vegetation and thus natural soundscape would be moderate to major long term local adverse.

Impacts to soundscape from manual thinning operations (40 acres/year) would be moderate to major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Impacts to soundscape from mechanical thinning operations (205 acres/year) would be major short term local adverse. Results of thinning operations to vegetation and thus natural soundscape would be moderate long term local beneficial.

Overall indirect impacts to soundscape would be moderate to major long term regional beneficial as 120,570 (10,960 acres/year [excluding suppression fires]) acres would move toward desired vegetative conditions. Indirect impacts to soundscape from suppression fires would be moderate to major long term regional adverse.

The overall cumulative impacts would be major adverse long term regional due to aircraft overflights not related to fire management activities.

Impairment **Alternative 5** **Soundscape**

Although there are short- to long-term local and regional major adverse impacts to resources whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, these impacts would not impair soundscape during Alternative 5 implementation.

Unacceptable Impacts **Alternative 5** **Soundscape**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on soundscape as a result of implementation of this Alterative.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Soundscape**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternatives 1, 2, 3, and 5 would have adverse minor to major local short–term impacts from prescribed fire activities.
Alternative 4 would have adverse moderate to major impacts from prescribed fire activities.

Alternatives 1, 2, 3, and 4 would have adverse negligible to major local short-term impacts from wildland fire use activities.

Alternative 5 would have adverse minor to moderate impacts from wildland fire use activities.

Alternatives 1-5 would have adverse minor to major local to regional short-term impacts from suppression activities; adverse moderate to major local, short-term impacts from manual thinning.

Alternatives 2-5 would have adverse major local short-term impacts from mechanical thinning activities.

There will also be adverse major regional long-term cumulative impacts to soundscape from aircraft overflights not related to fire management activities.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Soundscape**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during the implementation of the plan and could not be reused or recovered during the lifespan of the plan.

There would be no irreversible or irretrievable commitments of resources.

4.5 Wilderness Character

4.5.1 Impacts on Wilderness Character

4.5.1.1 Guiding Regulations And Policies — Wilderness Character

Existing law and management direction for wilderness character in GRCA include
- National Environmental Policy Act
- National Park Service Organic Act of 1916
- Wilderness Act of 1964
- NPS Management Policies 2006 (6.3.5) Minimum Requirement and (6.3.9) Fire Management
- NPS Reference Manual 18 Wildland Fire Management
- NPS Reference Manual 77 Natural Resource Management
- Director's Order 41 Wilderness Preservation and Management

For more information, see Appendix A.

4.5.1.2 Management Objectives — Wilderness Character

The goal and objectives for the proposed FMP related to wilderness character is

Goal 3 Protect the park's natural, cultural, and social values
- Maintain critical habitat elements for listed Threatened, Endangered, and Sensitive Species
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and limit spread of invasive plant species
- Minimize impact of smoke on air quality related values including visibility

4.5.1.3 Methodology For Analyzing Impacts — Wilderness Character

Tools Used to Analyze Effects

Wilderness characteristics were derived from the Wilderness Act of 1964 which states, wilderness
- is an area where the earth and its community of life are untrammeled by man
- is an area of undeveloped land without permanent improvements or human habitation
- generally appears to have been affected primarily by the forces of nature where the imprint of man's work is substantially unnoticeable
- has outstanding opportunities for solitude or a primitive and unconfined type of recreation

Wilderness characteristics were evaluated and compared based on the alternatives. Analysis focuses on wilderness setting as a basis to compare impacts to wilderness character for each alternative. Wilderness setting is defined as 1) whether vegetation types are within their natural range of variability related to natural fire history regime, and 2) the physical impacts fire management activities would have on proposed wilderness lands. Predominance of effect to vegetation and effects from fire management activities does not imply there would be no effect to other wilderness characteristics. Impacts to other natural and cultural resources would also pertain to wilderness character, and impacts to these resources are described in applicable sections of this chapter. Impacts to wilderness (backcountry) visitors are addressed in Chapter 4, Visitor Experience.

Fire management affects the vegetation component of proposed wilderness. Vegetation is critical to the wilderness setting; therefore, effects to vegetation throughout various vegetation types are primary determinants of effects to wilderness character. The methods, assumptions, and results for departure of historic fire regime analysis used for this FMP FEIS/AEF are described in the vegetation section 4.2.

4.5.1.4 Impact Thresholds — Wilderness Character

Impacts of fire management activities and operations on wilderness character were analyzed by assessing their effect on wilderness setting (which included natural fire regime for each vegetation type and physical fire management activities on the land).

Type of Impact

Adverse	Actions impede preservation of wilderness character components (untrammeled, undeveloped, natural, outstanding opportunities for solitude or a primitive and unconfined type of recreation) or degrades the public purposes of wilderness (recreation, scenic, scientific, education, conservation, and historical use)
Beneficial	Actions contribute to preservation of wilderness character components (untrammeled, undeveloped, natural, outstanding opportunities for solitude or a primitive and unconfined type of recreation) or supports public purposes of wilderness (recreation, scenic, scientific, education, conservation, and historic use)

Intensity

Negligible	Impacts would have no discernible effect on wilderness character. Natural conditions would prevail. No permanent improvements or human occupation. The forces of nature would primarily affect the wilderness area. There would be outstanding opportunities for solitude or a primitive and unconfined type of recreation
Minor	Impacts would be slightly detectable within limited wilderness areas. Natural conditions would predominate. No permanent improvements or human occupation. The wilderness area would generally appear to have been affected primarily by the forces of nature. While there might be short-term impacts in wilderness, over the long term, outstanding opportunities for solitude or a primitive and unconfined type of recreation would prevail
Moderate	Impacts would be readily apparent in limited wilderness areas. Human alterations of natural conditions would be apparent within such areas. No permanent improvements or human occupation. Outstanding opportunities for solitude or a primitive and unconfined type of recreation would be restricted in limited areas and during limited times of the year
Major	Impacts would substantially alter the wilderness resource throughout thousands of wilderness area acres. Natural conditions would have been substantially altered by humans. Improvements made by humans, while not permanent, would be long term and part of the landscape. Outstanding opportunities for solitude or a primitive and unconfined type of recreation would be restricted through thousands of wilderness acres

Context

Regional	Regional impacts would affect the entire area of GRCA lands proposed for wilderness designation
Local	Local impacts would be confined to specific areas in proposed wilderness

Duration

Short term Occur in the period concurrent with implementation of individual actions or leaves evidence of human activity that lasts no more than five years after the action

Long term Continue after completion of individual actions and can be expected to persist longer than five years

Timing Impacts to wilderness character can occur year round, although relative to visitor experience and some wildlife and/or vegetation concerns, may be more seasonal

4.5.1.5 Mitigation of Effects — Wilderness Character

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description, address impacts to wilderness characteristics, and may be addressed in other sections of this Chapter.

- According to DO-18, Wildland Fire Management, all fire management activities in wilderness, including categories of designated, recommended, potential, proposed, and study area will be conducted in keeping with minimum requirement analysis protocols. The Branch of Fire and Aviation will submit for review and approval minimum requirement analysis documents regarding fire management activities including, but not limited to fuels sampling; fire effects monitoring; fire weather observation; air quality monitoring; cultural and natural resource surveys and monitoring; prescribed fire planning, preparation, and implementation; fire use; and resource rehabilitation. Use of vehicles, chainsaws, motorized pumps, aerial ignitions, and helicopter landings will be assessed on a programmatic basis under the minimum requirement decision process to reduce use to the extent possible. Programmatic documents will be reviewed annually and updated as needed
- Locate control lines, helispots, fire camps, and other soil-disturbing fire management activities to minimize damage to resources
- Protect aquatic habitat, riparian and wetland areas, meadows, and other sensitive resource areas by defining and avoiding these areas, especially with wheeled vehicles
- Rehabilitate affected sites (e.g., control lines, staging areas, and helispots) as soon as possible following disturbance. Develop BAER plans as appropriate.
- Inspect helispots, staging areas, incident command posts/base camps, etc., periodically to minimize exotic species introduction
- Use MIST to minimize disturbances to soil, vegetation, and wilderness character
- Clean, prior to returning from an out-of-park incident, fire vehicles, equipment, clothing in compliance with park policy
- Procure certified weed-seed-free mulching materials and native plant seed for use in fire rehabilitation
- Adhere to regulations of the Arizona Department of Environmental Quality (ADEQ) Final Forest and Range Management Burn Rule and any other provisions (if any) of permits issued for specific burns to minimize undesirable impacts to public health, public welfare, and visibility-related values
- Implement as many Emission Reduction Techniques as feasible, subject to the economic, technical, legal, and safety implications of the techniques, and burn management objectives to reduce smoke produced by prescribed fires
- Implement as many smoke management techniques (as prescribed by the state in AAC R18-2-1510) as practicable to manage smoke produced during any desired fire
- Explore new technologies and methods to reduce use of mechanized/motorized tools and transport for monitoring and other onsite fire management activities. These technologies will be included in the minimum requirement process.

4.5.1.6 Cumulative Impacts Wilderness Character

Fire management activities on adjacent Federal and tribal lands have potential to affect park proposed wilderness areas. Therefore, lands adjacent to these areas, both in and neighboring the park, mainly define the geographic scope of this cumulative impact analysis.

Cumulative impacts on wilderness character were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions. (See Appendix G).

4.5.1.7 Assumptions Wilderness Character

Section 4.2.1.8 describes assumptions for effects to wilderness character's vegetation component. Specifically, effects of alternatives include continued movement toward the natural range of variability where fire treatments are proposed, and away where no treatments occur.

In addition, assumptions used to complete the wilderness character analysis include

- According to NPS Management Policies 2006, all national park units must complete a minimum requirement analysis on administrative practices and equipment uses that have potential to impact wilderness resources or values. The minimum requirement concept is a two-step, documented process used to determine whether specific administrative activities affecting wilderness resources or visitor experience are necessary, and what techniques and equipment are needed to ensure impact to wilderness resources and character is minimized
- Administrative use of motorized/ mechanical equipment or transport will be authorized only
    - If determined by the Superintendent to be the minimum requirement needed by management to achieve the purposes of the area as wilderness, including preservation of wilderness character and values; or
    - In emergency situations (search and rescue) involving health or safety of persons actually in the area. Such management activities will be conducted in accordance with all applicable regulations, policies, and guidelines, including minimum requirement protocols as practicable
- For analysis purposes, some level of aircraft use is assumed.
- Wildland fire-use fires cause a major, beneficial trend toward restoration of historic spatial complexity in vegetation structure and composition. Prescribed fires would cause a moderate beneficial trend toward restoration of historic spatial complexity in vegetation structure and composition. Suppression fires tend to have lower spatial complexity.

4.5.1.8 Incomplete and/or Unavailable Information Wilderness Character

It is not possible to predict exact locations where wildland fire-use and suppression fires will occur in proposed or potential wilderness. Spread and effects are dependent on fuels and topography, where ignition occurs, and weather conditions under which fire burns. Effects to proposed wilderness, from wildland fire-use and suppression fires are necessarily general and not specific to any location.

4.5.1.9 Impact Analysis Wilderness Character
Effects Common To All Alternatives Direct And Indirect Effects

Fire's role in an ecosystem is extremely complex, and varies between vegetation species. Historic evidence indicates major stand-replacing fires are not necessarily unnatural or catastrophic. Nature begins repopulating an area with wildlife soon after a fire of any size. Fire in wilderness is no less a complex issue; a number of factors can be involved with any particular fire situation, such as presence of endangered species, fire size, recreation facilities, cultural properties and other structures, or fire conditions, time of year, etc. GRCA landscape evolved with fire as a major influence shaping vegetative type, ecosystem health, and species abundance. Decades of fire suppression in some vegetation types have altered this landscape, resulting in unnatural woody fuel accumulations and dense vegetation stands. General recommendations for wilderness fire management include allowing naturally-ignited fires to burn while protecting human life and property in or near wilderness.

Effects Common To All Alternatives **Direct And Indirect Effects**
Natural Fire Regime for Vegetation Types **Wilderness Character**

Effects to wilderness character parallel descriptions in vegetation (4.2.1). Depending on fire ignition location or fire management tool, effects to wilderness character would follow vegetation composition structure and fuels as described. All vegetation types are found in proposed wilderness. Below is a summary from 4.2.1.10 on general effects to each vegetation type common to all alternatives.

- Fire treatments in ponderosa pine vegetation result in trends toward desired condition and natural range of variability for the first ten years; after ten years trend is toward fuel accumulation. Fires that ignite in ponderosa pine would have a low probability of burning at high intensities or with much crown fire
- An estimated 42% of mixed-conifer vegetation is currently at a high level of departure from historic fire regimes. Recent wildland fire-use fires in this type are either within or at the high end of the natural range of variability for a mixed severity regime in area proportion burned at different severity levels
- Overall, it is assumed that effects of fires under most weather conditions would result in a patchy or complex spatial pattern of effects in spruce-fir vegetation type. This would be within the natural range of variability. It is likely that historically some fires did burn under extreme weather conditions in spruce-fir and that the patchier nature of most fires and relatively longer fire-free intervals would lead to large patches of stand-replacement fire.
- Treated piñon-juniper areas trend toward the natural range of variability and desired conditions for surface fuels, but areas outside treated areas are assumed to be trending away from the natural range of variability. How much is uncertain, given uncertainty about historic fire regimes. Treatment areas are outside proposed wilderness, and fire staff estimate approximately 1% of piñon-juniper vegetation would burn under suppression fires for all alternatives; therefore, there would be negligible to no direct effect to wilderness character in this vegetation type
- There are no planned treatments in montane-subalpine grasslands but it is likely that this vegetation type would burn during adjacent fire treatments. It is assumed the effect would be local, concentrated in the grassland-forest boundary and beneficial
- Overall effects of fire to vegetation below the rim maintain the natural range of variability

Effects Common To All Alternatives **Direct And Indirect Effects**
Physical Fire Management Activities **Wilderness Character**

Minimum requirement analysis is required by policy for fire activities in areas proposed as wilderness, but long-term, minor impacts would result from alternatives with prescribed, wildland fire use, or suppression fires in proposed wilderness areas. Prescribed fire and suppression activities have potential to trammel wilderness resources; in addition, wildland fire-use management actions also have potential, although not as high. Included would be handline construction resulting in felled trees and trenching, and helispot construction with tree and brush removal. Burned area emergency rehabilitation may follow significant fire suppression actions. Recovery actions would be submitted to recommend and enforce the appropriate environmental compliance level. Trail or area closures may be required to safely manage wilderness fire management. These fire management activities would have local, direct, adverse impacts on fire-area wilderness character components during and after the fire event. Long-term, direct impacts would be minimized through activity plans (i.e., Burned Area Emergency Rehabilitation Plans, Wildland Fire Implementation Plans) and mitigation measures (4.5.1.5).

4.5.1.10 Cumulative Effects | Effects Common To All Alternatives | Wilderness Character

Fire management activities on the Kaibab National Forest adjacent to GRCA potentially impact park wilderness character because fires originating in the KNF may cross boundaries into proposed wilderness areas. Regardless of the alternative implemented, risk would be expected to decrease with proposed vegetation treatments in the park and those proposed on adjacent lands. Past actions with incremental indirect and direct effects on GRCA's wilderness resource over the last decade include fire and park fire management activities and some trailhead and road work. Since 1993, 18 fires (22,942 acres) were suppressed, 34 (46,434 acres) were wildland fire-use fires, and 41 (46,463 acres) were prescribed fires, some of which were in proposed wilderness areas.

Projects recently completed, currently being conducted, or planned that could have indirect impacts to wilderness character include trailhead and access road work, and Invasive Species and Aviation Plans development. Many GRCA actions are outside proposed wilderness areas, but could indirectly affect wilderness character. In addition, regular trail maintenance in proposed wilderness could have direct affects on wilderness character. Actions had or have potential to adversely affect wilderness character; however, due to NEPA compliance requirements and mitigation measures built into each project, adverse impacts did not occur or are unlikely. Present plans for fire management and limited manual fuels-reduction treatments are written to ensure any impacts to wilderness character would be limited during prescribed fire, wildland fire use, and wildland fire suppression activities.

4.5.1.11 Alternative 1 | No Action Existing Program | Wilderness Character

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same level of suppression of approximately 20,050 acres; 58,500 acres will be treated through prescribed fire (primarily in the ponderosa pine and mixed-conifer FMUs); 55,000 acres will be treated through wildland fire use; and, 400 acres will be manually treated (primarily in piñon-juniper habitat). Manual treatment description includes chainsaw use with cut vegetation chipped, piled, or otherwise disposed of offsite. For a full description of Alternative 1, see Chapter 2.

Direct and Indirect Effects | Alternative 1 | Wilderness Character
Natural Fire Regime for Vegetation Types

There is a high probability that most if not all (greater than 70%) ponderosa pine areas would receive some treatment given the number of acres proposed for treatment through prescribed fire or wildland fire use. Suppression fires in this type would be readily contained in most locations and conditions due to the high level of past treatment and planned treatments proposed in Alternative 1. Departure from historic fire would trend toward the natural range of variability with at least 78% reaching a low level and an additional 12% reaching low to moderate levels at the end of ten years. Impacts to vegetation composition and structure in ponderosa pine are beneficial, moderate, long-term and regional; therefore, impacts to wilderness character would be beneficial, moderate, long-term, and regional.

More than half the mixed-conifer type is proposed for prescribed fire treatment in Alternative 1. Wildland fire-use fires could occur on an additional 7% of the same treated, or different untreated, mixed-conifer areas. Even though a low severity fire constraint exists with this alternative (see Chapter 2), areas treated in the mixed-conifer type would likely result in smaller suppression fires since fuels and potential fire behavior would be reduced. In addition, approximately 18% of mixed-conifer vegetation is anticipated to burn through fire suppression. 40% of these suppression fires would be expected to burn much hotter with moderate/high to high severity fire. Full alternative implementation would result in a moderate, beneficial, regional and long-term trend toward range of natural variability in mixed conifer; therefore, beneficial, moderate, regional, and long-term impacts would also apply to wilderness character.

Prescribed fire treatments proposed in 19% of the spruce-fir type would produce a trend toward the natural range of variability, beneficial to wilderness character, while effects in untreated areas would be adverse with short-term, moderate impact at a regional scale. As noted earlier, prescribed fire would be at a low fire intensity which may not be within the natural fire regime for this vegetation type. In addition, GRCA anticipates approximately 36% of spruce-fir vegetation type would burn as suppression-fire acres, increasing adverse impacts in this vegetation type. Based on analysis throughout 4.2.1, moderate/high to high fire severity would occur in approximately 70% of these areas, affecting thousands of acres. There is a relatively high level of uncertainty about whether effects would be adverse or beneficial to both natural fire regime and wilderness character. Overall, it is believed impacts would be long term, beneficial, minor and local to wilderness character.

The piñon-juniper vegetation type in proposed wilderness would have negligible to no affect from the proposed management plan.

Little is known about historic fire regime in the grassland type; therefore, there is a high uncertainty on the effect of Alternative 1 on departure from historic fire regime. Since fire occurred historically in adjacent forests, it is presumed that fire effects in these adjacent forests would have a beneficial, moderate, local, long-term effect on fire regimes, vegetation composition, and structure in grasslands, and on wilderness character.

Indirect impacts to wilderness character are beneficial and long term through return of a more natural fire frequency and reduced likelihood of large unwanted high severity wildfire that would require fire suppression activities. These effects would vary depending on vegetation type.

Direct and Indirect Effects — Alternative 1 — Wilderness Character
Physical Fire Management Activities

Fire suppression activities would likely cause the most physically adverse impacts to wilderness character due to helispots, handline construction, potential fire retardant drops, aircraft noise, overflights, etc. These activities may also be required with prescribed and wildland fire use, but to a lesser extent. Depending on handline location in relationship to public use, handlines could become unofficial hiking trails. Overall, these adverse impacts would be short term, minor, and local. Mitigation measures described in 4.5.1.5 will help reduce these impacts.

Mitigation of Effects — Alternative 1 — Wilderness Character

In addition to mitigation measures affecting wilderness character in 4.5.1.5, Alternative 1 includes the following mitigation measures that will also affect wilderness character

- Manage prescribed fire as low intensity fire to minimize negative effects on habitat and on primary constituent elements of MSO critical habitat
- Manage wildland fire-use fires as low intensity fires to minimize negative effects on habitat. The objective is to limit mortality of trees greater than 18 inches dbh to less than 5% across the project area
- Natural fire starts will not be allowed to burn if fire managers anticipate mortality greater than 5% in larger trees (greater than 18 inches dbh), but occasionally up to 10% mortality may occur in large trees

Cumulative Effects — Alternative 1 — Wilderness Character

As noted in 4.5.1.6, fire management activities in GRCA and on adjacent lands have potential to affect park proposed wilderness and special designation areas. Past, present, and reasonably foreseeable future actions taken by GRCA and other agencies and persons have potential to contribute to cumulative impacts to proposed wilderness and special designation areas.

Recent fire management practices with treatments to reduce fuel loads and stand densities have largely benefited treated areas, but areas not yet treated are at risk from adverse effects of uncontrolled high intensity fire. The Kaibab National Forest has completed and planned numerous treatments to reduce hazardous fuel loads and restore fire regimes; just south of the southern park boundary treatments reduce the likelihood of a large, severe wildfire burning from outside into the park. These treatments, in addition to those planned in the park, add cumulatively to a beneficial, moderate and greater impact to wilderness character. They contribute to restoring historic fire regimes and vegetation structure and composition in ponderosa pine. It is not known if this cumulative impact to wilderness character is local or regional.

Although prevailing southwest winds make it unlikely that most fires would spread from the northern Kaibab National Forest into the park on the Kaibab Plateau, projects here add to the beneficial, moderate or greater impact of Alternative 1 treatments toward restoration of historic fire regime, vegetation structure and composition, and wilderness character. This is particularly the case in the ponderosa pine type. Cumulatively, there is a beneficial effect across a regional scale in ponderosa pine when considering extent of the type and treatments on the entire Kaibab Plateau.

Past, present, and future projects that involve trailhead, trail, and road maintenance could directly and indirectly affect proposed wilderness areas. These impacts would mainly be through encouraging visitor use by maintaining improvements.

Additional aircraft noise and overflights related to other activities on KNF and tribal lands outside GRCA, when combined with flight activities—in particular helicopter use associated with the proposed FMP—would add to the adverse effect frequency to the wilderness character of providing outstanding opportunities for solitude or a primitive and unconfined type of recreation. Cumulative adverse impacts of actions inside and outside the park on wilderness character would be short term and negligible to minor, and local to areas where specific management activities occur. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long-term, minor to major, and regional.

Conclusion **Alternative 1** **Wilderness Character**

Fire management activities would affect wilderness character in generally beneficial ways through actions that maintain plant communities within the natural range of variability and thereby maintain wilderness values. Intensity and extent (or context) of effect varies by major vegetation type

- Ponderosa pine Beneficial, long term, moderate, regional impact
- Mixed-conifer Beneficial, long term, moderate, regional impact
- Spruce-fir Beneficial, long term, minor, local impact
- Piñon-juniper Negligible to no impact
- Grasslands Beneficial, long term, moderate, local impact

Impacts from physical fire management activities, including helicopter noise, would be short term, adverse, minor, local.

When analyzing wilderness character, other components such as natural resources (including soundscapes), cultural resources, and visitor experience need to be examined. As described throughout Chapter 4 (and summarized in Table 2-11), analysis for other resources includes a range of effects. The majority of these effects range from negligible to moderate, short to long term, local to regional, adverse as well as minor to major, short to long term, local to regional, beneficial.

Soundscape impacts would be negligible to major, short term, local to regional, adverse, but due to vegetation's potential for reaching natural fire regime, impacts are moderate to major, long term, regional, beneficial. Cultural resources impacts due to planned events are negligible to minor, short term, local, adverse. Due to unplanned events impacts could range from negligible to major, and long term, local, adverse.

Overall effects to wilderness character would be beneficial, negligible to major, local to regional and short to long term. Adverse impacts would range from negligible to major, local to regional, short to long term. Mitigation measures in Chapter 4 , Soundscapes and Cultural Resources intend to lower intensity to moderate or below.

Cumulative adverse impacts of actions inside and outside the park on wilderness character would be short term and negligible to minor, and local to areas where specific management activities occur. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long term, minor to major, and regional.

Impairment Alternative 1 Wilderness Character

Although there are major adverse impacts in Alternative 1, these impacts to this resource whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair Wilderness Character during the implementation of Alternative 1.

Unacceptable Impacts Alternative 1 Wilderness Character

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wilderness as a result of implementation of this Alterative.

4.5.1.12 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Wilderness Character

Alternative 2 proposes similar treatment as proposed in Alternative 1 with addition of allowing mixed fire severity with prescribed and wildland fire-use fires in all vegetation types, and proposing approximately 2,490 acres of manual and mechanical treatment in designated WUI. For a full description see Chapter 2.

Direct and Indirect Effects Alternative 2 Wilderness Character
Natural Fire Regime for Vegetation Types

Similarities in impacts for Alternatives 1 and 2 exist, but beneficial direct impacts from Alternative 2 are greater, particularly in the mixed-conifer vegetation type and indirectly in the South Rim WUI as they relate to wilderness character. Alternative 2 proposed a greater trend toward desired conditions for vegetation and natural range of variability for fire which has a direct relationship to effects on wilderness character. Beneficial impacts are greater than Alternative 1 and more often long- than short-term. The ability for prescribed fire and wildland fire-use fires to burn at greater intensities in mixed-conifer and ponderosa pine types would result in greater reductions in vegetation densities and fuel loadings, and thus a greater trend toward desired conditions. The ability for a wider array of fire severities and application of fire use would result in a greater trend toward the historic pattern of fire severity and spatial complexity. This would have a beneficial effect on wilderness character. Therefore impact to wilderness character would be beneficial, minor to major, local to regional long term.

Direct and Indirect Effects **Alternative 2** **Wilderness Character**
Physical Fire Management Activities

Amount of fire suppression activities would be the same as Alternative 1; therefore, impacts from these activities on wilderness character would be the same. Overall adverse impacts would be short term, minor, and local. Mitigation measures described in 4.5.1.5 would reduce adverse effects.

Because proposed mechanical and manual treatment is outside proposed wilderness there would be no direct effect on wilderness setting. An indirect beneficial effect from non-fire treatments would be a decrease in potential of a fire starting in the WUI and entering proposed wilderness areas.

Mitigation of Effects **Alternative 2** **Wilderness Character**

Mitigation measures will decrease adverse impacts to wilderness character. These mitigation measures mainly focus on decreasing adverse effects from fire suppression activities. See 4.5.1.5.

Cumulative Effects **Alternative 2** **Wilderness Character**

Cumulative effects would be similar to those for Alternative 1. The exception would be that fire severity in mixed-conifer and spruce-fir would be higher, and additional mechanical treatment would occur. These direct and indirect effects would not add to cumulative effects from all projects. Although prevailing southwest winds make it unlikely most fires would spread from the northern Kaibab National Forest into the park on the Kaibab Plateau, projects here add to the beneficial, moderate or greater impact of treatments in Alternative 2 toward restoration of historic fire regime, vegetation structure and composition, and wilderness character.

Additional aircraft noise and overflights related to other activities on KNF and tribal lands outside GRCA, when combined with flight activities—in particular helicopter use associated with the proposed FMP—would add to the adverse effect frequency to the wilderness character of providing outstanding opportunities for solitude or a primitive and unconfined type of recreation. Cumulative adverse impacts of actions inside and outside the park on wilderness character would be short term and negligible to minor, and local to areas where specific management activities occur. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long term, minor to major, and regional.

Conclusion **Alternative 2** **Wilderness Character**

Overall, similarities in impacts for Alternatives 1 and 2 exist, but beneficial direct impacts from Alternative 2 are greater, particularly in mixed-conifer, and indirectly from treatment in South Rim WUI. Therefore impact to wilderness character would be beneficial, minor to major, local to regional, and long term.

Amount of fire suppression activities would be the same as Alternative 1; therefore, impacts from these activities on wilderness character would be the same. Adverse impacts to the wilderness setting from human activities (e.g. fire suppression activities) would be minor, short term, and local.

When analyzing wilderness character, other components such as natural resources (including soundscapes), cultural resources, and visitor experience need to be examined. As described throughout Chapter 4 (and summarized in Table 2-11) analysis for other resources includes a range of effects. The majority of these effects range from minor to moderate, short to long term, local to regional, adverse as well as minor to major, short to long term, local to regional, beneficial. Soundscape impacts would be negligible to major, short term, local to regional, adverse, but due to vegetation's potential for reaching natural fire regime, impacts are moderate to major, long term, regional, beneficial. Cultural resources impacts due to planned events are negligible to minor, short term, local, adverse. Due to unplanned events impacts could range from negligible to major, long term, local, adverse.

Overall effects to wilderness character would be beneficial, minor to major, local to regional, long-term. Adverse impacts would range from minor to major, local to regional, short to long term. Mitigation measures listed in Chapter 4 for Soundscapes and Cultural Resources intend to lower intensity to moderate or below.

Cumulative adverse impacts of actions inside and outside the park on wilderness character would be short term and negligible to minor, and local to areas where specific management activities occur. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long term, minor to major, and regional.

Impairment — Alternative 2 — Wilderness Character

Although there are major adverse impacts in Alternative 2, impacts to this resource whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair Wilderness Character during Alternative 2 implementation.

Unacceptable Impacts — Alternative 2 — Wilderness Character

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wilderness as a result of implementation of this Alterative.

4.5.1.13 Alternative 3 — Non-Fire Treatment Emphasis — Wilderness Character

Alternative 3 emphases is non-fire, mechanical and manual treatments in the WUI. Alternative 3 proposes the highest amount of manual and mechanical treatment in the WUI and the least amount of prescribed and wildland fire use compared with other alternatives. Approximately 3,950 acres would be treated in the WUI through mechanical and manual means. This alternative treats the lowest number of total acres, with estimates of 25,400 for prescribed fire; 8,800 for wildland fire-use fire; and a projected 26,070 acres annually in fire suppression. The majority of additional suppression acres are assumed primarily in North Rim forests. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects — Alternative 3 — Wilderness Character
Natural Fire Regime for Vegetation Types

Reduction in wildland fire use and prescribed fire treatments would reduce improvement to fire-hazard danger and potentially result in additional high severity fire risk. However, intensity of impact would vary by vegetation type. In ponderosa pine, short-term adverse effect within ten years would be minor in much of the landscape. For mixed-conifer and spruce-fir, adverse effect would be moderate to major given continued trends of increased fuel accumulations and uniform spatial distribution. There is uncertainty about amount of high severity wildfire in these two vegetation types because of amount of fuel buildup; therefore, it is uncertain whether adverse effects of Alternative 3 on mixed-conifer and spruce-fir would be moderate or major. Effects to piñon-juniper and grasslands are similar to Alternative 1. Overall, based on natural range of variability in vegetation types, effects to wilderness setting and character from the vegetative perspective would be adverse, short to long term, negligible to major and local to regional.

Direct and Indirect Effects — Alternative 3 — Wilderness Character
Physical Fire Management Activities

Additional thinning treatments, including mechanical, proposed under Alternative 3 would not directly affect proposed wilderness areas since mechanical and manual thinning and fuel reduction would occur in the WUI. However, fuel reduction in this area would reduce likelihood of fire spreading to adjacent proposed wilderness areas; therefore, there would be a beneficial indirect impact.

Reduction of prescribed and wildland use fires would have a beneficial effect of reducing smoke and increasing visibility when compared with other alternatives. In addition, fire suppression activities would likely cause physically adverse impacts to wilderness character due to helispots, handline construction, potential fire retardant drops, aircraft noise, overflights, etc. Due to increased suppression activities, these effects would be slightly more than anticipated from other alternatives.

Overall, these adverse impacts would be short term, minor, and local. Mitigation measures in 4.5.1.5 would reduce several of these adverse effects.

Mitigation of Effects — Alternative 3 — Wilderness Character

Mitigation measures will decrease adverse impacts to wilderness character. Mitigation measures mainly focus on decreasing adverse effects from fire suppression activities. See 4.5.1.5.

Cumulative Effects — Alternative 3 — Wilderness Character

Cumulative effects would be similar to Alternatives 1 and 2 from past, present, and planned treatments in areas in and adjacent to the park. However, there would be an increased cumulative, adverse impact on vegetation types (and wilderness character) in this alternative. There would be an increase in amount of high severity fire, particularly in mixed-conifer and spruce-fir. This may lead to a higher probability of uncontained wildfire crossing from the park on North Rim onto the adjacent Kaibab National Forest. There is uncertainty regarding magnitude of increased wildfire probability and high severity fire, but certainty that this trend would occur.

Overall, anticipated cumulative adverse long-term, regional effects of implementing Alternative 3 with the projects discussed earlier, would be moderate in cumulative effects.

Conclusion — Alternative 3 — Wilderness Character

This alternative de-emphasizes ecosystem restoration outside WUI. Reduction in wildland fire use and prescribed fire treatments would reduce improvement to fire-hazard danger and would potentially result in additional high severity fire risk. Based on the natural range of variability in vegetation types, effects to wilderness setting and character from the vegetative perspective would be adverse, short to long term, negligible to major and local to regional.

Outstanding opportunities for solitude or a primitive and confined type of recreation wilderness character would be least affected in this alternative, as management activities and disturbance would be limited (fire-suppression activities only). Impacts from fire suppression activities to solitude or primitive recreation wilderness characteristic would be adverse, short term, minor, and local.

When analyzing wilderness character, other components such as natural resources (including soundscapes), cultural resources, and visitor experience need to be examined. As described throughout Chapter 4 (and summarized in Table 2-11) analysis for other resources includes a range of effects. The majority of these effects range from negligible to moderate, short to long term, local to regional, adverse as well as minor to moderate, short to long term, local to regional, beneficial. Due to non-fire emphasis, there are less beneficial impacts. Air Quality impacts for this alternative have a major, beneficial, impact due to decreased use of fire management activities. Soundscape impacts would be adverse, negligible to major, short term, local to regional but, due to vegetation's potential for reaching natural fire regime, impacts are moderate to major, long term, regional, beneficial. Cultural resources impacts due to planned events are negligible to minor, short term, local, adverse. Due to unplanned events impacts could range from negligible to major, long term, local, adverse.

Overall effects to wilderness character would be beneficial, moderate to major, local to regional, short to long term. Adverse impacts would range from negligible to major, local to regional, short to long term. Mitigation measures listed in Chapter 4 for Soundscapes and Cultural Resources intend to lower intensity to moderate or below.

Anticipated cumulative adverse, long-term, regional effects of implementing Alternative 3 with other projects discussed earlier would be adverse, moderate, long term, regional.

Impairment Alternative 3 Wilderness Character

Although major adverse impacts exist, they would not rise to the level of impairment. Impacts to this resource whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair wilderness character during the implementation of Alternative 3.

Unacceptable Impacts Alternative 3 Wilderness Character

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wilderness as a result of implementation of this Alterative.

4.5.1.14 Alternative 4 Prescribed Fire Emphasis Wilderness Character

In Alternative 4, program emphasis to treat vegetation would be through prescribed fire, burning approximately 90,000 acres. Approximately 24,070 acres would burn in suppression fires; wildland fire-use fire would be used least of all alternatives, at 5,500 acres; and, mechanical and manual treatments would occur on 800 priority-area acres. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 4 Wilderness Character
Natural Fire Regime for Vegetation Types

In this alternative, a mixture of adverse and beneficial impacts would occur to the vegetation component of wilderness character from emphasis on prescribed fire. Whether the impact would be adverse or beneficial depends on vegetation type. In ponderosa pine, relatively little treatment is planned on North Rim, although extensive treatments are planned on South Rim. On South Rim, there would be a beneficial, major, long-term impact on ponderosa pine. On North Rim, there would be an adverse, moderate, long-term impact on ponderosa pine. Impact to mixed-conifer would be beneficial, regional and long term, since a large proportion would be treated. For spruce-fir, there is a beneficial, moderate, local, long-term impact in treated areas. Effects to piñon-juniper and grasslands are similar to Alternative 1. Effects to wilderness character would vary depending on location: adverse in untreated areas and beneficial in treated areas.

Reduction in wildland fire use and emphasis on prescribed fire could limit potential ecosystem restoration to treatment areas in proposed wilderness or have similar effects to wildland fire use, depending on prescription. In untreated proposed wilderness areas, there is a greater increase in high severity suppression fires. This adverse effect would be worse in mixed-conifer and spruce-fir vegetation types and less adverse for ponderosa pine vegetation type.

Physical Fire Management Activities Alternative 4 Wilderness Character

Increased acres treated with prescribed fire under this alternative would likely decrease aircraft use (i.e., less aerial monitoring) but there would continue to be manipulation of fire areas such as firelines, causing impact to wilderness character. This alternative proposes the highest amount of handline construction at 124 miles. It is assumed the majority of handline would occur in proposed wilderness areas.

Overall, adverse impacts would be short term, minor to moderate, and local. Mitigation measures described in 4.5.1.5 would reduce several of these adverse effects.

Mitigation of Effects Alternative 4 Wilderness Character

Mitigation measures will decrease adverse impacts to wilderness character. These mitigation measures mainly focus on decreasing adverse effects from fire suppression activities. See 4.5.1.5.

Cumulative Effects Alternative 4 Wilderness Character

Additional aircraft noise and overflights related to other activities on KNF and tribal lands outside GRCA, when combined with flight activities, in particular helicopter use associated with the proposed FMP, would add to adverse effects frequency to the wilderness character of providing outstanding opportunities for solitude or a primitive and unconfined type of recreation. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long term, minor to major, and regional.

Cumulative effects would be similar to Alternative 2. Overall, anticipated cumulative beneficial effects of implementing Alternative 4 with projects discussed earlier, would be moderate, long term, and regional.

Conclusion Alternative 4 Wilderness Character

There would be a mixture of adverse and beneficial impacts to the vegetation component of wilderness character. On South Rim, there would be a beneficial, major, long-term impact on ponderosa pine. On North Rim, there would be an adverse, moderate, long-term impact on ponderosa pine. Impact to mixed-conifer would be beneficial, regional and long term, since a large proportion would be treated. For spruce-fir, there is a beneficial, moderate, local, long-term impact in treated areas. Effects to piñon-juniper and grasslands are negligible. Effects to wilderness character would vary depending on location: adverse in untreated areas and beneficial in treated areas.

Impacts to the solitude and a primitive and unconfined type of recreation component of wilderness character would be apparent locally during times of prescribed fire implementation and fire suppression activities. This alternative proposes the greatest amount of fireline construction that would likely directly adversely affect these characteristics. Overall, adverse impacts from physical fire-management activities would be short term, minor to moderate, and local.

When analyzing wilderness character, other components such as natural resources (including sound-scapes), cultural resources, and visitor experience need to be examined. As describedin Chapter 4 (summarized in Table 2-11) analysis for other resources include a range of effects. The majority of these effects range from negligible to moderate short to long term local to regional adverse and minor to major, short to long term local to regional beneficial. In this alternative, although there are major beneficial impacts, fewer resources are impacted by this benefit due to emphasis on prescribed fire activities. Soundscape impacts would be adverse, negligible to major, short term, local to regional but, due to vegetation's potential for reaching natural fire regime, impacts are moderate to major, long term, regional, beneficial. Cultural resources impacts due to planned events are negligible to minor, short term local adverse. Due to unplanned events impacts could range from negligible to major long term local adverse.

Overall effects to wilderness character would be beneficial, negligible to major, local to regional, short to long term. Adverse impacts range from negligible to major, local to regional, short to long term. Although mitigation measures listed in Chapter 4 for Soundscapes and Cultural Resources intend to lower intensity to moderate or below.

Anticipated cumulative beneficial effects of implementing Alternative 4 with projects discussed earlier would be moderate, long term, and regional.

Impairment Alternative 4 Wilderness Character

Although major adverse impacts exist, they would not rise to the level of impairment. These impacts to this resource whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair wilderness character during the implementation of Alternative 4.

Unacceptable Impacts Alternative 4 Wilderness Character

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wilderness as a result of implementation of this Alterative.

4.5.1.15 Alternative 5 Fire Use Emphasis Wilderness Character
Direct and Indirect Effects

Alternative 5 emphasis is to restore and maintain forest types with wildland fire use. With the focus on wildland fire use (88,000 acres), fewer fires will be suppressed, at a projected 18,050 acres, the lowest of all alternatives. This alternative de-emphasizes prescribed fire treatments, with treatment of 29,900 acres. Mechanical and manual treatments would be approximately 2,675 acres and occur in the WUI and along Highway 67 on North Rim. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 5 Wilderness Character
Natural Fire Regime for Vegetation Types

Overall, Alternative 5 impacts to wilderness setting (and character) would be beneficial, moderate to major, regional and long term on ponderosa pine, mixed-conifer, and spruce-fir. However, there is an unknown, and likely greater, level of uncertainty on amount of potentially adverse impact from large, intense, high severity wildland fire-use fires in mixed-conifer and spruce-fir vegetation types. Impact to piñon-juniper would be similar to Alternative 1. Overall, impact to wilderness setting (and character) related to vegetation and natural historic-fire regime would be beneficial, moderate and local in treated areas. Intensity of effect to wilderness character would vary from location to location.

Direct and Indirect Effects — Alternative 5 — Wilderness Character
Physical Fire Management Activities

The increase in acres treated with wildland fire-use fire under this alternative would create a moderate increase in aircraft use compared with Alternatives 1 through 3, plus handlines constructed (the least of all alternatives) would cause minor adverse impact to wilderness character as it relates to the wilderness characteristic of solitude and a primitive and unconfined type of recreation. This alternative assumes the least amount of suppression acres, but fire suppression activities could still include helispots, handline construction, potential fire retardant drops, aircraft noise, overflights, etc.

Overall, these adverse impacts would be short-term, minor, and local. Mitigation measures described in 4.5.1.5 would reduce several of these adverse impacts.

Mitigation of Effects — Alternative 5 — Wilderness Character

Mitigation measures will decrease adverse impacts related to wilderness character. These mitigation measures mainly focus on decreasing adverse effects from fire suppression activities. See 4.5.1.5.

Cumulative Effects — Alternative 5 — Wilderness Character

Additional aircraft noise and overflights related to other activities on KNF and tribal lands outside GRCA, when combined with flight activities, in particular helicopter use associated with the proposed FMP, would add to the adverse effect frequency to the wilderness character of providing outstanding opportunities for solitude or a primitive and unconfined type of recreation. Management actions to reduce occurrence of high intensity suppression fires would have cumulative beneficial impacts that would be long term, minor to major, and regional.

Cumulative effects would be similar to Alternative 2. Overall, anticipated cumulative beneficial effects of implementing Alternative 5 with projects discussed earlier would be moderate, long term, and regional.

Conclusion — Alternative 5 — Wilderness Character

Impacts to wilderness character of Alternative 5 would be beneficial, moderate to major, regional and long term on ponderosa pine, mixed-conifer, and spruce-fir. Impact to piñon-juniper and grasslands would be negligible. Overall, impact to wilderness character related to vegetation and natural historic fire regime would be beneficial, moderate and local in treated areas. Intensity of effect to wilderness character would vary from location to location.

Solitude and a primitive and unconfined type of recreation would be adversely affected by fire management short term in locations of fire treatment and suppression fires if those locations are in proposed wilderness. Overall, these adverse impacts would be short term, minor, and local.

When analyzing wilderness character, other components such as natural resources (including soundscapes), cultural resources, and visitor experience need to be examined. As described throughout Chapter 4 (and summarized in Table 2-11) analysis for other resources includes a range of effects. The majority of these effects range from negligible to moderate, short to long term, local to regional, adverse as well as minor to major, short to long term, local to regional, beneficial. Soundscape impacts would be minor to major, short term, local to regional, adverse but, due to vegetation's potential for reaching natural fire regime, impacts are minor to major, long term, regional, beneficial. Cultural resources impacts due to planned events are negligible to minor, short term, local, adverse. Due to unplanned events, impacts could range from negligible to major, long term, local, adverse.

Overall effects to wilderness character would be beneficial, minor to major, local to regional, short to long term. Adverse impacts would range from negligible to major, local to regional, short to long term. Although mitigation measures listed in Chapter 4 for Soundscapes and Cultural Resources intend to lower intensity to moderate or below.

Anticipated cumulative beneficial effects of implementing Alternative 5 with projects discussed earlier would be moderate, long term, and regional.

Impairment **Alternative 5** **Wilderness Character**

Although major, adverse impacts exist, they would not rise to the level of impairment. These impacts to this resource whose conservation is 1) necessary to fulfill specific purposes identified in GRCA's establishing legislation or proclamation, 2) key to the park's natural or cultural integrity, or 3) identified as a goal in the park's GMP or other relevant NPS planning documents, would not impair wilderness character during implementation of Alternative 5.

Unacceptable Impacts **Alternative 5** **Wilderness Character**

Because impacts previously described are not inconsistent with the park's purpose and values; do not prevent attainment of desired future conditions for natural and cultural resources; do not create an unsafe environment; do not diminish opportunities for future enjoyment of the park; and do not unreasonably interfere with park programs or activities, an appropriate use, concessioner or contractor operations, there would not be unacceptable impacts on wilderness as a result of implementation of this Alterative.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Wilderness Character**

Unavoidable adverse impacts are adverse environmental consequences that cannot be avoided, whether by implementing mitigation measures or changing the nature of a proposed action. Thus unavoidable adverse impacts could persist throughout the action's duration.

Unavoidable adverse impacts would occur as described in the analysis above. There will be unavoidable adverse impacts to the soundscape and cultural resource components of wilderness character. Impacts to cultural resources are from unplanned fire events.

Loss in Long-Term Availability Or Productivity of the Resource to Achieve Short-Term Gain

There are no short-term gains resulting in long-term availability or productivity of wilderness character.

Irreversible/Irretrievable Commitments Of Resources **Wilderness Character**

An irreversible resource commitment occurs if the commitment cannot be changed once made, throughout the plan's lifespan. Irretrievably committed resources are used, consumed, destroyed, or degraded during plan implementation and could not be reused or recovered during the plan's lifespan.

There would be no irreversible or irretrievable resource commitments to wilderness character except for cultural resources losses during unplanned events in which those resources could not be protected.

4.6 Sociological Resources

4.6.1 Visitor Experience

4.6.1.1 Guiding Regulations And Policies — Visitor Experience

Existing management direction for visitor experience in GRCA includes

- National Environmental Policy Act
- National Park Service Organic Act of 1916
- The Historic Sites Act (1935)
- The Clean Air Act (1977)
- The Clean Water Act (1972)
- The Endangered Species Act (1973)
- The Organic Act Redwood National Park Amendments (1978) express a legal duty to protect park resources against threatening activities arising on adjacent lands
- The Outdoor Recreation Act (1963) declares a national policy to support recreation activities and identifies the NPS as the leading agency
- The National Parks and Recreation Act (1978)

National Park Service Management Policies 2006 states

- Enjoyment of park resources and values by the people of the United States is part of the fundamental purpose of all parks
- The NPS will encourage visitor activities appropriate to the purpose for which the park was established; are inspirational, educational, or healthful, and otherwise appropriate to the park environment; will foster understanding of and appreciation for park resources and values or will promote enjoyment through a direct association with, interaction with, or relation to park resources; and, can be sustained without causing unacceptable impacts to park resources or values
- The NPS will encourage studies that support the mission by providing an understanding of park visitors, the non-visiting public, gateway communities and regions, and human interactions with park resources
- The saving of human life will take precedence over all other management actions as the park service strives to protect human life and provide for injury-free visits

Grand Canyon National Park GMP objectives include

- Preserve, protect, and interpret the park's natural and scenic resources and values, and its ecological processes
- Preserve, protect, and improve air quality and related values such as visibility
- Preserve, manage, and interpret cultural resources (archeological, ethnographic, architectural, and historic resources, trails, and cultural landscapes) for the benefit of present and future generations
- Protect the park's natural quiet and solitude, and mitigate or eliminate effects of activities causing excessive or unnecessary noise in, over, or adjacent to the park
- Provide a wide range of interpretive opportunities and information services to best assist, inform, educate, and challenge visitors
- Educate and influence the public through positive action to preserve and protect the world they live in, including but not limited to the park
- Provide canyon viewing opportunities, access to views and trails, and interpretation and information recognizing these are the most important elements of the South Rim visitor experience
- Understand, assess, and consider the effects of park decisions outside the park as well as inside

4.6.1.2 Management Objectives — Visitor Experience

The goals and objectives for the proposed FMP related to visitor experience include

Goal 1 Protect human health and safety, and private and public property

- Conduct wildland fire management activities with the most current risk assessment and mitigation techniques available to ensure firefighter and public safety is the highest priority
- Non-fire fuel treatments will be used in areas where fire use is not practical due to safety or smoke concerns. Even in these areas, however, fire will be used as fully as possible to maintain desired conditions once restored
- Minimize impact of smoke on human health
- Provide the fire management workforce with training, equipment, operating procedures, safety measures, and information needed to manage risks and carry out activities safely

Goal 5 Educate, inform, consult, and collaborate with tribes, stakeholders, and the public

- Maintain government-to-government and informal relationships with Native American tribes to exchange knowledge about fire management and traditional cultural practices
- Develop and implement a proactive process that disseminates current and accurate information to the public, park employees, media representatives, and cooperators that encourages support of the fire management program
- Conduct wildland fire prevention, education, and other activities in communities within and adjoining the park. Work in collaboration with local communities, county, state, and Federal fire agencies with fire management interests
- Develop interpretive displays and educational programs, working with the Division of Interpretation, to foster understanding and acceptance of the fire management program

4.6.1.3 Methodology For Analyzing Impacts — Visitor Experience

Tools And Methodology Used To Analyze Effects

Visitor experiences at Grand Canyon National Park will be affected by fire management mostly through changes in landscape aesthetics, restrictions on access, impacts on visibility, and opportunities to learn about wildland fire and its role in fire-adapted ecosystems. Fire management impacts on economic value of visitor experiences are described in 4.6.2. The focus here is on visitor experience by user groups.

Both quantitative and qualitative methods were used. Regression analysis completed for this analysis found no relationship between GRCA acres burned and GRCA visitor number 1979 to 2004. Factors affecting visitor experience are identified from research literature including

- A study questioning park visitors demonstrated a relationship between visibility and visitor willingness to pay for their park experience (MacFarland et al. 1983)
- More recent research (not of GRCA visitors) has shown a relationship between fire and willingness to pay for backcountry trail use (Elgin et al. 2001)
- A survey of park visitors found relationships between visitor characteristics and acceptability of prescribed fire in the park (Muleady-Mecham et al. 2004)
- Other research (not GRCA visitors) related to fire and landscape aesthetics is recapped by Ryan (2005)
- Littlejohn et al. (2004; Littlejohn and Hollenhorst 2004) report on relative importance of different visitor experiences from park visitor surveys

Predicted landscape and visibility changes under proposed alternatives are compared to the literature to describe likely effects of the alternatives on GRCA visitor experiences, encompassing all senses.

4.6.1.4 Impact Thresholds — Visitor Experience

Analysis focus is to display impacts from implementation of the five alternatives to visitor experience from various user groups. Impacts to visitors were analyzed according to visitor use in four distinct park areas (Developed Areas, Colorado River, Proposed Wilderness, and Air [air tours]).

Type of Impact

Adverse Activities that lead to temporary visitor displacement, or trails and recreation-area closure during peak recreation use; smoke accumulation during peak recreation use; long-term change in vista scenic integrity; and/or temporary presence of fire-fighting or mechanical equipment in a local area

Beneficial Activities that enhance visitor experience including: vista opening, undergrowth reduction to improve depth of view into the forest, and opportunities for environmental education through interpretation of fire management and fire as an ecological process

Intensity

Negligible A majority of all visitors would not notice any effects of changes in visitor-use patterns and levels, and effects would not change experience of park resources and values. Little noticeable change in visitor experience (or in defined visitor-experience indicators) or behavior. No threats to visitor safety. Mitigation would not be necessary.

Visual resources would not be affected, or level of detection would be slight or barely perceptible with little consequence to visitor experience. Examples of negligible impacts on visibility would be no visible smoke, or smoke rising and dispersing in plumes that do not impact canyon vistas

Minor Desired visitor experience would be changed, but without appreciably limiting or enhancing critical experience characteristics such as access to park facilities and impacts to visual resources. Examples of minor visibility impacts would include smoke visible in the canyon and obscuring color and texture when looking toward, but not away from, the sun, some smoke draining into the canyon but clearing before noon, or smoke limited to individual side canyons. No threats to visitor safety. If mitigation was necessary to offset adverse visitor experience effects it would be relatively simple and likely successful

Moderate Impacts to critical characteristics of desired experience would be readily apparent to visitors. Access to park facilities or areas would be decreased. Potential concerns to visitor safety. Effects to visual resources readily apparent and widespread. Examples of moderate visibility impacts include smoke clearly visible in the canyon and obscuring colors and textures during part or most of the day, but substantially unnoticeable for at least some time(s) each day, or smoke that limits ability to see distant canyon features

Major Impacts would eliminate, detract from, or greatly enhance multiple critical characteristics of desired experience or greatly reduce or increase participation. Access to park facilities or areas would be denied. Effects to visual resources would be very obvious, widespread, and long term. Substantial consequences to visitor experience, and visitor satisfaction measures would decline substantially. Examples of major visibility impacts include smoke obscuring colors and textures for multiple days, or smoke that severely limits ability to see across the canyon. Visitor safety would be a serious concern

Context

Regional Impacts would be realized concurrently at several sites and/or locations

Local Impacts would be realized at specific sites or locations (e.g. developed areas, trails, campgrounds, overlooks, roads)

Duration

Short Term Impacts would be realized for a few hours to three days

Long Term Impacts would be realized for more than five days

Timing In general, effects would be greater during high-use seasons (summer) when the park has the most visitors. Additionally, GRCA visibility tends to be best in winter and worst in spring and summer. This seasonal pattern coincides with a high fire incidence in the dry months, May through mid-July, so smoke periodically compounds already hazy conditions. Time of day (day versus night) is important for visibility and pollutant dispersal; winds generally shift at sunset. Seasonal weather patterns contribute to cumulative visibility effects (smoke-trapping inversions during fall and winter) and also emissions dispersal

4.6.1.5 Mitigation of Effects — Visitor Experience

The following mitigation measures are common to all five alternatives.

- Close trails and roads providing access to fuel reduction projects, and wildland or prescribed fires if projects and/or fires present unacceptably hazardous conditions to visitors, as determined by the Incident Commander or Superintendent
- Close portions or entire park by Superintendent's order if any threat exists to public or firefighter safety from wildland fire or fire management activities. When and if such action occurs, adjacent agencies, neighboring communities, and authorities will be notified as soon as possible
- Institute smoke warning signs or roadway traffic control during fire operations as warranted at direction of the Burn Boss, Incident Commander, Safety Officer, or visitor protection representative
- Adhere to regulations of the Arizona Department of Environmental Quality Final Forest and Range Management Burn Rule and any other provisions of permits issued by the Department for specific burns to minimize undesirable impacts to public health, public welfare, and visibility-related values
- Implement as many Emission Reduction Techniques (as prescribed in AAC R18-2-1509) as feasible to reduce smoke produced by prescribed fires, subject to economic, technical, legal, and safety implications of the techniques, and burn management objectives
- Implement as many Smoke-Management Techniques (as prescribed in AAC R18-2-1510) as practicable to manage smoke produced during any prescribed or wildland fire-use fire
- Rehabilitate affected sites (e.g., control lines, staging areas, and helispots) as soon as possible following disturbance. Develop BAER plans as appropriate
- Avoid, to the extent possible, prescribed burns on or immediately before major holidays
- Provide information to visitors about closures and optimal view locations during fires

4.6.1.6 Cumulative Impacts — Visitor Experience

Activities in GRCA and on adjacent lands that effect visual air quality and soundscape could affect visitor experience. In addition, other GRCA activities could also affect visitor experience. Visitor experience cumulative effects areas considered are corridors along access roads to the park and the area in the park boundary. Activities outside these areas could have indirect impacts to these areas due to visual air quality (smoke from adjacent lands). Coordination through the Interagency Smoke Coordinator for Arizona would assist in reducing cumulative smoke impacts by managing smoke produced by a number of agencies in a particular area. In addition, an existing Memorandum of Understanding between the NPS and USFS acknowledges the two agencies share the Tusayan airshed and attempt to coordinate activities to minimize adverse cumulative impacts to the airshed and thus visitor experience.

Fire information, prevention, interpretation, and education activities, especially in the Grand Canyon region will affect how visitors interpret and respond to smoke, visible flames, fire effects on the landscape, and fire management activities.

Cumulative impacts to visitor experience were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions (Appendix G).

4.6.1.7 Assumptions Visitor Experience

It is assumed that variations in acres burned per unit time are good indicators of variations in fire management impacts on recreation resources, settings, and opportunities affecting visitor experiences. Visitors use different characteristics of Grand Canyon and its social setting to create benefits for themselves. The quality of resources they use (and their ability to use resources effectively) effects value of resulting visitor experience.

A regression analysis was completed to estimate the extent to which visitor number (per one million people in the U.S.) changed with number of GRCA acres burned. Based on the regression analysis, number of GRCA acres burned per year has very little influence on number of people who visit the park. This analysis only relates to how number of burned acres would affect visitor number, and does not address fire management impacts on individual visitor experiences.

Regression analysis found a very small relationship between acres burned and visitation numbers. (If there is any actual effect, an increase in 100 acres burned per year will result in a reduction of three visits per million people in the U.S. population, which amounts to approximately 900 visitors. More than four million people visit Grand Canyon each year. The reduction equals about .02%. In comparison, a one cent (2006 dollars) increase in gasoline prices will result in 4,822 fewer visitors per million U.S. population.

With regard to fire and fire-management effects on visitor experience quality, it is assumed visitors will respond to fire and fire effects on landscape similarly to those observed in outdoor-recreation resource-users in other wildland settings where responses have been studied. For example, changes to forest setting character, wildlife viewing opportunities, natural quiet and solitude, and opportunities to study and directly experience wildland fire and its effects on Grand Canyon environment are also important and long-lasting. Fire management also contributes to visitor, resident, and employee safety; vulnerable cultural resource protection; and re-establishment and sustainability of wildland ecosystems that contribute to visitor and passive-user experiences. Direct experience of burned landscapes on relatively small scales can contribute to visitor experience quality, especially if interpretation is provided.

Developed areas include North and South Rims outside proposed wilderness areas. The majority of visits occur in these areas; therefore, fire management in these areas would have an effect on the greatest visitor number. Some visitor experience could include smoke-obscured views, limited access to some areas due to fire management activities or safety concerns, and fire-management aircraft noise.

In experiments reported in 1983, more than half the visitors questioned said they would increase length of stay if visual air-quality improved, 43% would not change length of stay if visual air-quality changed. Length of time people at leisure spend in an environment is a measure of pleasure associated with the experience (Gustke and Hodgson 1980). This suggests that visitor experience quality increases when visibility is better and decreases when visibility is reduced. Again, however, correlation is weak.

Visitor willingness to pay for park experience increases as visibility increases. McFarland et al. (1983) found that visitors' stated willingness to pay above the (then) $2.00 entrance fee to enjoy improved visibility was $1.61 ($3.16 in 2005 dollars) when visual air quality improved from 7.02 $\mu g/m^3$ (68 miles or 110km) to 2.43 $\mu g/m^3$ (130 miles or 210km). When visual air quality improved from 7.02 $\mu g/m^3$ (110km) to 0.27 $\mu g/m^3$ (330 miles or 350km), visitors said that they would pay $2.74 ($5.37 in 2005 dollars) above the entrance fee. Relationship between visual air quality, stay length, and willingness to pay appear to be a straight line ($\mu g/m^3$ is micrograms per cubic meter).

Results are based on studies completed 25 years ago and may not be applicable today and through the planning period. Public understanding of wildland fire and smoke are likely different today. It would be unwise to place too much confidence in the results without updated studies with today's visitor population. No other studies were found that follow up on these early findings.

However, fire management effects much more in the environment than visibility. Other effects would also have important impacts on visitor experience quality. There is no doubt that canyon vistas are very important to visitor experience quality, but there is also evidence that fire would have positive, as well as negative effects, on other important visitor experience dimensions.

WUI suppression fires in GRCA are unlikely except under extreme fire-weather conditions. Nevertheless, such fires would have potential to affect visitor experience and safety.

Fire interpretation and educational programs are proposed as mitigation measures designed to address GRCA's fire management program (including issues such as smoke, aircraft noise, temporary closures, and manual/mechanical treatments). This interpretation program will aid in educating visitors and decreasing negative effects on visitor experience. Wildland fire interpretation and education have potential to inform visitors of fire's role in creating and sustaining park ecosystems, and enhance appreciation of fire as a powerful and essential ecological force, substantially increasing visitor experience quality. Interpretative experiences may also provoke lasting visitor interest in wildland fire ecology and engagement in fire management issues beyond GRCA. As people understand fire better, meanings of smoke and fire-altered landscapes may change for them. Meanings affect perceived beauty of landscapes and can be expected to influence visitor experience quality (Hodgson, R.W. and Thayer, R.L. 1980).

4.6.1.8 Incomplete and/or Unavailable Information — Visitor Experience

Little research specifically addressed GRCA visitor interest in fire and fire ecology or visitor emotional and behavioral responses to fire, smoke, or burned landscapes. Available studies point out likely differences among visitor types, responses to fire and smoke, and landscape effects. Little GRCA-specific research is available to assist in design of effective fire interpretation and education programs.

Most studies useful in managing fire to enhance fire benefits on visitor experiences were completed decades ago. Recently, increasing attention is focusing on fire social science in USFS research stations and by the Joint Fire Sciences Program. However, most of that research is focused on the WUI. Very little recent research addresses fire and fire effects on quality of park experiences.

Assessing visitor experience effects of fire management programs, or any other GRCA resource or visitor management program, would be materially enhanced by sustained and systematic social science research targeting questions derived from information needs for fire and other management decisions.

4.6.1.9 Impact Analysis — Visitor Experience

Mitigation of Effects for Action Alternatives

In addition to mitigation measures acknowledged in 4.6.1.5, the following recommended mitigation measures are proposed to further reduce adverse effects on visitor experience.

- Develop fire interpretation and educational programs designed to address the fire management program (including smoke, aircraft noise, temporary closures, manual/mechanical treatments, prevention of invasive exotic plant species, and other resource topics)
- Develop and implement treatment prescriptions that create defensible space around structures and within cultural landscapes
- Update evacuation plan by addressing communications with people of various cultures (and languages) and directing them to safe places. Evacuation plans exist and have been practiced, but additional attention may be needed to communicate with people during disasters (Mileti et al. 2004). Provide

preparedness provisions and encourage communication and cooperation with adjacent public agencies and communities
- Schedule, to the extent possible, WUI treatment to minimize impacts on visitors and residents

4.6.1.10 Alternative 1 No Action, Existing Program Visitor Experience

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same suppression level of approximately 20,050 acres; 64,200 acres treated through prescribed fire (primarily in ponderosa pine and mixed-conifer FMUs); 55,000 acres treated through wildland fire use; and 400 acres manually treated (primarily in piñon-juniper habitat). Manual treatment description includes chainsaws use with cut vegetation chipped, piled, or otherwise disposed offsite. For a full description of this alternative, see Chapter 2.

Direct and Indirect Effects Alternative 1 Visitor Experience
Developed Areas, South and North Rims

For Alternative 1, 17 prescribed fires are proposed on South Rim and 15 on North Rim during the life of the plan. In addition, some wildland fire-use and suppression fires would likely occur in these areas. Short-term adverse impacts to South and North Rim visitor experience from these fires would include reduced visual air quality, potential area closures (trails, roads), physical impacts to land from fire management activities (handlines, staging areas), and perceived risk. These adverse effects could be mitigated with air quality and fire activity restoration mitigation measures included in alternative descriptions (4.4.1.6), and the mitigation measure proposing fire interpretation and educational programs designed to address the GRCA fire management program (4.4.1.6).Therefore adverse impacts to visitor experience would be minor local short term.

The majority of prescribed fire proposed on South Rim is in ponderosa pine vegetation; on North Rim the majority is in ponderosa pine and mixed-conifer. In general, long-term landscape characteristics from this treatment would be attractive to visitors. More open stands would permit visitors to see into them, provide more forest openings and spatial diversity, and likely provide more opportunities for wildlife encounters, all of which would enhance visitor experience quality (Ryan 2005).

Proposed treatments and suppression fires on North Rim would have less effect on South Rim visitor experience and vise versa. Depending on fire location on North and South Rim, short-term adverse impacts would include reduced visual air quality and potential increased aircraft traffic.

Under Alternative 1, smoke would occasionally reduce visual air quality and could shorten average length of stay. As noted earlier, about one half those studied said visual air quality would affect length of stay. According to 4.4.1.11 Air Quality, an estimated 13 days annually would be unacceptable due to visibility, and approximately 138 annual plume days would occur. Smoke events deemed unacceptable would be sufficiently rare, with only a small fraction of visitors affected. These adverse effects (visual and health) would be short term local moderate and would only affect visitors at the park during those specific days.

Reduced opportunity for clear views from canyon rims would reduce quality of visitor experiences when wildland fire smoke obscures canyon views or diminishes visibility. In addition, visible plumes without education and interpretation could have adverse impacts on visitor experience. Plumes and haze have vastly different effects on visibility and probably affect visitor experiences differently. Research on effects of wildfire smoke plumes on visitor experience is lacking. It should not be assumed that wildland fire smoke plumes are perceived negatively by visitors unless they obscure significant canyon views.

Where aircraft noise from fire management helicopters and air tankers use is likely to reduce quality of backcountry visitor experiences (and possibly North Rim visitors), South Rim visitors would not be as sensitive to such noise (Stewart 1997). Knowledge that aircraft are engaged in fire management reduces negative response for many visitors (Gramann 1999).

A large majority of visitors spend their time on South Rim (and lesser extent on North Rim) and experience the park environment from roads, trails, and vistas or roads leading into and out of the park. Canyon views are the greatest contributor to visitor satisfactions but landscapes along rims and travel routes probably contribute to visitor satisfactions in important ways.

As noted above, there is risk of a WUI suppression fire occurring in Grand Canyon Village under extreme weather conditions. Because little treatment is proposed in WUI, Alternative 1 would do little to minimize risk. Should severe damage to natural landscapes and structures occur, adverse impacts would be local moderate long term. Long-term adverse effects would also occur from disrupted visitor services, restricted access to high-recreation use sections, and under extreme conditions, emergency evacuations.

Alternative 1 proposes approximately 40 acres of manual treatment annually, mainly in the high-recreation use area in and around Grand Canyon Village. Manual treatment methods (e.g. chainsaw use, piling and burning approximately half the acres treated) may seem out of place to some visitors, but the mitigation measure to provide interpretation and education would decrease adverse impact. This small amount of treatment would have negligible direct short-term adverse effects to visitor experience and negligible long-term beneficial effects.

Colorado River **Alternative 1** **Visitor Experience**

Adverse impacts to Colorado River users would be local indirect short term. Smoke from fire activity could enter the river basin affecting the river recreation experience. Based on air quality analysis (4.4.1.11), it can be assumed heavy smoke impacts on river users would be similar to the number of days affecting rim visitors. To individuals impacted by decreased visibility, the affect could be minor to moderate. River users would not be impacted by manual treatments proposed.

Proposed Wilderness Area **Alternative 1** **Visitor Experience**

Under Alternative 1, suppression, wildland fire use, and prescribed fires are anticipated to affect an average 2,000; 5,500; and 5,850 acres respectively each year. Though these areas comprise 1% of the park's 1.2 million acres, visitors seeking wilderness (backcountry) recreation experience could be adversely impacted if the area they intended to use, or access to that area, is closed. Some past closures have affected large areas minimizing options for these visitors.

Direct adverse impacts (noise, smoke, fire personnel, and area closures) to backcountry users and backcountry experiences would be local to areas where fire management activities occur and have greatest adverse effect when activities coincide with times of highest backcountry use (spring to fall). To visitors directly affected, impact could be minor to moderate.

Alternative 1 has a mitigation measure requiring all prescribed and wildland fire-use fires burn at low intensity in all vegetation types to reduce potential MSO impacts. This was interpreted in this analysis to mean no more than 15% of acres would burn at moderate/high to high fire severity. Short-term effects to backcountry visitors would be minor beneficial local because fire scars would be far less than with higher intensity fire.

To the extent treatments restore natural fire regimes, effects on backcountry visitor experiences would be beneficial minor to moderate local long term.

Manual fuel reductions would primarily affect approximately 40 acres annually in areas in and around Grand Canyon Village. Vegetation manipulation in this area would not affect backcountry user experience in proposed wilderness areas.

Air Tours **Alternative 1** **Visitor Experience**

Though it is not known how many days in a calendar year would have visual air quality unacceptable to air visitors, it could be assumed the number would be comparable to number of days affecting rim visitors; therefore, adverse effects to the air tour recreation experience would be a small period in any given year. Unacceptable visual quality days occur during wildland fire-use and suppression fires; none occur during prescribed fire treatments. Because these fires occur naturally and cannot be predicted, air tours could not be warned. Fire aircraft activities could also adversely affect this user group when aircraft access is restricted around fires to prevent conflict. Most commercial aircraft operators would change to a different tour if a conflict were to arise between NPS and commercial operators, but the air tour visitor would have no knowledge of this change. Adverse impacts to this user group would be minor local indirect short term. Air tour users would not be impacted by manual treatments.

Cumulative Effects **Alternative 1** **Visitor Experience**

Forest restoration and hazard mitigation activities undertaken by the adjacent Kaibab National Forest and tribes, when combined with fire management activities proposed in Alternative 1, would contribute to cumulative effects to visual air quality, health issues caused by smoke and, depending on location, visitor use. Depending on suppression fires, adverse effects on visitor experience quality, as a whole, would be minor to moderate local short term. These combined activities would improve aesthetic quality of surrounding forest landscape. USFS fuel treatments, especially southwest of Grand Canyon Village and in the Tusayan WUI would help reduce potential suppression fires that could disrupt visitor services or visitor access, with resulting negative impacts to park visitor experience. Long-term impacts from these activities would be minor to major beneficial local. In addition, GRCA is proposing many rehabilitation projects (Appendix G). If rehabilitation occurs during the time fire management activities occur, cumulative effects to visitor experience would likely be adverse local short term and long term beneficial.

Conclusion **Alternative 1** **Visitor Experience**

Impacts to developed areas on North and South Rims due to fire activities would be adverse minor local short term. Due to MSO mitigation restrictions there could be damage to natural landscapes and structures. Impacts would be adverse moderate local short term. Due to the risk of potential WUI suppression fires, effects would be adverse moderate local long term. The small amount of manual treatment would have negligible direct short-term adverse effects to visitor experience and negligible long-term beneficial effects.

Adverse impacts to Colorado River users would be minor to moderate local indirect short term.

Impacts to backcountry users in proposed wilderness would be minor to moderate adverse short term local. Due to MSO mitigation restrictions, adverse impacts would be indirect minor beneficial long term to backcountry users from fewer fire scars. To the extent treatments restore natural fire regimes, effects on backcountry visitor experiences would be beneficial minor to moderate local long term. Impacts to visitor experience come from impletation of MSO mitigations which prevent attainment of more natural (desired) conditions.

Since fire aircraft activities may occur during visitor air-tour flights, there would be a minor direct and indirect short-term local impact to visitor experience.

Cumulative impacts for fire treatments on visitor experience would be minor to moderate adverse short term local. Cumulative impacts to visitor experience would be long term minor to major beneficial local.

4.6.1.11 Alternative 2 Preferred Alternative Mixed Fire Treatment Program Visitor Experience

Alternative 2 proposes a series of treatments similar to Alternative 1 but restrictions requiring low intensity fire are removed and mechanical treatments added to reduce fuel build-up. This alternative proposes approximately 2,492 acres of manual/mechanical treatment in wildland fire-use designated WUI. For a full description of this alternative, see Chapter 2.

Direct and Indirect Effects Alternative 2 Visitor Experience
Developed Areas, South and North Rims

Impacts from all fire types (prescribed, wildland fire-use, and suppression fires) on both South and North Rims would be the same as Alternative 1. Short-term adverse impacts to South and North Rim visitor experience from these fires would include reduced visual air quality; potential closures of areas, trails, and/or roads; physical impacts to the land from fire management activities (handlines, fire camps, staging areas); fire air traffic; and perceived risk. These adverse impacts could be reduced by implementing mitigation measures (those part of the alternative description, and those proposed in 4.4.1.6). Therefore adverse impacts to visitor experience would be minor localshort term.

As noted in Alternative 1, the majority of prescribed fire proposed on South Rim is in ponderosa pine; the majority proposed on North Rim is in ponderosa pine and mixed-conifer vegetation types. Treatment in ponderosa pine would have long-term beneficial effects to South and North Rim visitor experience.

According to 4.4.1.12, Air Quality, an estimated 13 days annually would be unacceptable to rim visitors due to visibility. Adverse effects (visual and health) would be short term local moderate, and would only affect visitors at the park during those specific days. Approximately half of visitors directly affected would shorten their planned stay and/or switch their recreation experience from a nature experience (e.g. scenic vista viewing) to a more urban-like experience (e.g. eating at restaurants, shopping, visiting interpretive sites). In addition, visible plumes (approximately 138 plume days annually) without education and interpretation could have adverse impacts to visitor experience, but there is very little research on visitor response to wildfire plumes as opposed to haze. Response to wildfire smoke plumes cannot be assumed similar to response to industrial smoke plumes.

Alternative 2 proposes approximately 195 acres of mechanical treatment annually in WUI (in and around Grand Canyon Village), and approximately 34 manual-treatment acres annually. Fuel treatments using manual/mechanical methods may seem out of place to some visitors. Additional direct short-term local adverse effects would include equipment noise, restricted access (e.g. slash on the ground, temporarily closed areas), reduced visual quality from slash piles (45% of manual treatment acres), scars (and possibly scorching) from burn piles (45% of manual treatment acres), and masticated material left onsite (35% of mechanical treatment). As with Alternative 1, mitigation measures to provide interpretation/education would decrease adverse impacts. Adverse impacts would be negligible to minor short term. Long-term impacts would be minor to major beneficial. Stands would be opened, risk of a WUI suppression fire would be reduced, and additional wildlife viewing opportunities may occur.

These treatments would also reduce risk of a high intensity WUI suppression fire that could cause minor adverse short- to long-term effects to South Rim (and to a lesser extent North Rim) visitor experience. In addition, mitigation measures proposing development and implementation of prescription treatments around buildings, and updating the evacuation plan, would further reduce risk and adverse impacts.

Colorado River **Alternative 2** **Visitor Experience**

Alternative 2 would have the same effect as Alternative 1. Adverse impacts to Colorado River users would be local indirect short term. Smoke from fire activity could enter the river basin affecting the river recreation experience. As noted in Alternative 1, assumed heavy smoke impacts on river users would be similar in number of days (13) as those affecting rim visitors. To individuals impacted by visibility, affect could be minor to moderate. River users would not be impacted by proposed non-fire treatments.

Proposed Wilderness Area **Alternative 2** **Visitor Experience**

Alternative 2 proposes the same amount of fire and manual treatment as Alternative 1. In addition, Alternative 2 proposes approximately 195 acres of mechanical treatment annually and removes the low intensity fire restriction for prescribed and wildland fire-use fires. Mechanical treatment would be outside proposed wilderness; therefore, would not affect backcountry users. Prescribed and wildland fire-use fires would likely burn at higher intensities. Although there would be some backcountry visitors that would potentially see effects of moderate/high and high intensity fires, benefits would outweigh any adverse impacts to visitor experience. To the extent treatments restore natural fire regimes, effects on backcountry visitor experiences would be beneficial moderate to major local long term.

As with Alternative 1, direct adverse impacts (noise, smoke, fire personnel, area closures) to backcountry users and experience would be local to areas where fire management activities occur, and have greatest adverse effect when activities coincide with times of highest backcountry use (spring to fall). Short-term, local adverse effects would be minor to moderate. A mitigation measure is proposed to provide signing at entrance points to proposed wilderness areas that could provide hikers information on potential smoke impacts and what they could do to reduce effects. Visitors seeking wilderness (backcountry) recreation experience could be adversely impacted should the area they plan to visit be closed. In the past, large areas of proposed wilderness have been closed during fire events.

Air Tours **Alternative 2** **Visitor Experience**

Alternative 2 would have the same effects as Alternative 1. Though it is not known how many days in a calendar year would have unacceptable visual air quality from this alternative's actions to these visitors. It could be assumed the number would be comparable to number of days affecting South Rim visitors; therefore, adverse effects on the air tour recreation experience would occur during a small period in any given year. Fire aircraft activities could also adversely affect this user group by preventing access to some canyon air space during fire activities. Although most commercial aircraft operators would change to a different tour if a conflict arose between NPS and commercial air tour operators, the air tour visitor would have no knowledge of this change. Adverse impacts to this user group would be minor local indirect short term. Air tour users would not be impacted by proposed non-fire treatments.

Cumulative Effects **Alternative 2** **Visitor Experience**

Cumulative effects for Alternative 2 would be similar to Alternative 1. With additional WUI mechanical/ manual treatment and removal of the low intensity fire constraint in all vegetation types, proposed WUI treatments would provide greater protection to Grand Canyon Village, and improve forest aesthetics for South Rim visitors and backcountry users when compared to Alternative 1.

Overall, it is anticipated cumulative effects of Alternative 2 implementation would have short-term, minor adverse local impacts, but long-term major beneficial local impacts to visitor experience.

Conclusion **Alternative 2** **Visitor Experience**

Fire activity impacts to visitor experience in North and South Rim developed areas would be minor local short term. Adverse effects (visual and health) would be short term local moderate, and would only affect visitors at the park during specific days. Adverse impacts from non-fire treatments would be negligible to minor short term. Long-term impacts from this treatment would be minor to major beneficial. Impacts to visitor experience come from removal of MSO mitigations which, when implemented in Alternative 1, prevent attainment of more natural (desired) conditions.

Adverse impacts to Colorado River users would be minor to moderate local indirect short term.

To the extent treatments restore natural fire regimes, effects on backcountry visitor experiences would be beneficial moderate to major local long term.

Since fire aircraft activities may occur during visitor air-tour flights, there would be an adverse minor direct and indirect short-term local impact to visitor experience.

Overall, cumulative effects of implementing Alternative 2 would be short term minor adverse local, but impacts to visitor experience would be long term major beneficial local.

4.6.1.12 Alternative 3 Non-Fire Treatment Emphasis Visitor Experience

Alternative 3 emphasis is on non-fire mechanical/manual treatments in WUI. Alternative 3 proposes the highest amount of manual/mechanical treatment in WUI and least amount of prescribed and wildland fire-use fire compared with the other alternatives. There would be approximately 4,000 WUI acres treated through mechanical/manual treatment. This alternative treats the lowest number of total acres, with estimates of 25,400 for prescribed fire; 8,800 for wildland fire-use fire; and a projected 26,070 acres in fire suppression. The majority of these additional suppression acres are assumed primarily in North Rim forests. A description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 3** **Visitor Experience**
Developed Areas, South and North Rims

When compared with Alternatives 1 and 2, number of South Rim prescribed fires would decrease slightly (three less prescribed fires) and decrease more on North Rim (six prescribed fires proposed versus 15 in Alternatives 1 and 2). Where prescribed fire is proposed, impacts would be the same as Alternatives 1 and 2. Short-term local minor adverse impacts to South and North Rim visitor experience from these fires would include reduced visual air quality; potential closures of areas, trails, and/or roads; physical land impacts from fire management activities (handlines, fire camps, staging areas); and perceived risk.

The majority of fire suppression is anticipated on North Rim; thus, adverse impacts from fire suppression activities would have greatest effect on North Rim visitors. Impacts include potential closures to impacted areas, fire-suppression equipment noise, and smoke. Depending on fire size, these adverse impacts could be minor to moderate short or long term local, and are likely to occur during peak visitation periods.

Overall, this alternative would produce 11 annual days of unacceptable visual air quality, slightly less than Alternatives 1 and 2; therefore, impacts would be short term adverse minor local. During these days approximately half of visitors might shorten length of stay; recreation experience could change from a natural to a more urban experience. In addition, visible plumes (approximately 116 plume days annually) without education and interpretation could have adverse impacts to visitor experience. There is, however, no evidence wildland fire plumes negatively or positively affect visitor experiences.

Because of proposed WUI treatment amount, this alternative provides potentially the lowest risk of a WUI suppression fire causing damage to natural environments and structures; therefore, risk of these adverse effects to South Rim visitors would be decreased when compared with the other alternatives. Therefore, impacts to visitor experience would be adverse negligible short term.

Because this alternative proposes the most manual/mechanical treatment, impacts from these treatments types would be similar to Alternative 2 except time and area would be greater. Still, adverse impacts would be direct short term local, and include equipment noise, restricted access (e.g. slash on ground, temporary closed areas), reduced visual quality from slash piles (45% of manual treatment acres), burn pile scars (45% of manual treatment acres), and masticated material left onsite (35% of mechanical treatment). Mitigation measures to provide interpretation/education would decrease adverse impacts. Adverse impacts would be moderate short term local. Long-term impacts would be moderate to major beneficial local. Stands would be opened, risk of WUI suppression fire reduced, and additional wildlife viewing opportunities may occur.

Colorado River **Alternative 3** **Visitor Experience**

Alternative 3 would have similar effects as noted in Alternatives 1 and 2. Adverse impacts to Colorado River users would be local indirect short term. Smoke from fire activity could enter the river basin affecting river recreation experience. Based on air quality analysis, it can be assumed heavy smoke impacts on river users would be similar to, but slightly fewer than, days affecting rim visitors (11 vs. 13). To individuals from this user group impacted during this time, affect would be minor. River users would not be impacted by proposed non-fire treatments.

Proposed Wilderness Area **Alternative 3** **Visitor Experience**

Under Alternative 3, suppression, wildland fire-use, and prescribed fires are anticipated to affect an average 2,600 acres; 880; and 2,540 respectively each year. Though these areas comprise 1% of the park's 1.2 million acres, visitors seeking wilderness (backcountry) recreation experience could be adversely impacted due to inflexibility to relocate (difficulty changing backcountry itineraries through the backcountry permit system, ability, time constraints, landscape character, large closure area).

This alternative focuses on mechanical/manual treatments in areas not proposed for wilderness. These activities would have no effect on the wilderness user. This alternative proposes least fire treatment amount, and fire staff anticipates a slight increase in fire suppression when compared with the other alternatives. Direct adverse impacts (noise, smoke, fire personnel, area closures) to backcountry users and backcountry experience would be local to areas where fire management activities occur and would have greatest adverse effect when these activities coincide with times of highest backcountry use (spring to fall). These short-term local adverse effects would be minor to moderate. As with the other alternatives, long-term effects to backcountry users in these treatment areas would be local beneficial, but because area treated is the least of all alternatives, this beneficial affected area would be minimal. To the extent treatments restore natural fire regime, effects on backcountry visitors would be beneficial minor local long term. Short- to long-term effects to backcountry users in untreated areas could be adverse due to higher risk of large high severity suppression fires.

Air Tours **Alternative 3** **Visitor Experience**

Alternative 3 would have effects similar to Alternatives 1 and 2. Though it is not known how many days of a calendar year would have unacceptable visual air quality to these visitors, it could be assumed the number would be similar to, but slightly fewer than, days affecting rim visitors (11 vs. 13); therefore, adverse effects on air-tour recreation experience would occur during a small period in any given year. In addition, these days are not predictable; therefore, air tours could not be forewarned. Fire aircraft activities could also adversely affect this user group by restricting access to some canyon air space during fire activities should there be a conflict. Although most commercial aircraft operators would change to a different tour if a conflict arose between NPS and commercial air-tour operators, the air tour visitor would have no knowledge of this change. Adverse impacts to this user group would be local indirect short term. To individuals impacted, affect would be negligible to minor. Air tour users would not be impacted by proposed non-fire treatments.

Cumulative Effects Alternative 3 Visitor Experience

Cumulative effects for Alternative 3 would be similar to Alternative 2. Additional mechanical/manual proposed WUI treatments would provide greater beneficial long-term cumulative effects to Grand Canyon Village (South Rim visitors) when compared to Alternative 1 and, to a lesser degree, Alternative 2.

Overall, cumulative effects of implementing Alternative 3 would have short-term minor adverse local impacts, but long-term minor to moderate beneficial local impacts to visitor experience.

Conclusion Alternative 3 Visitor Experience

In developed areas short-term local minor adverse impacts to South and North Rim visitor experience from these fires would include reduced visual air quality; potential closures of areas, trails, and/or roads; and physical land impacts from fire management. Adverse impacts from fire suppression activities would have greatest effect on North Rim visitors. Impacts include potential closures to impacted areas, fire-suppression equipment noise, and smoke. Depending on fire size, these adverse impacts could be minor to moderate short or long term local, and are likely to occur during peak visitation periods. Long-term impacts would be moderate to major beneficial local. There is slightly lessened risk for potential WUI suppression fire damaging natural environments and structures. Therefore, impacts to visitor experience would be adverse negligible short term. Impacts to visitor experience come from removal of MSO mitigations which, when implemented in Alternative 1, prevent attainment of more natural (desired) conditions.

Colorado River Users experience impacts would be adverse minor local indirect short term.

To individuals directly impacted during this time, effects could be minor to moderate. As with the other alternatives, long-term effects to backcountry users would be local beneficial, but because area treated is least of all alternatives, this beneficial affected area would be minimal. To the extent treatments restore natural fire regime, effects on backcountry visitors would be beneficial minor local long term.

Adverse impacts to the air-tour user group would be negligible to minor local indirect short term.

It is anticipated cumulative effects of implementing Alternative 3 would have short-term minor adverse local impacts, but long-term minor to moderate beneficial local impacts to visitor experience.

4.6.1.13 Alternative 4 Prescribed Fire Emphasis Visitor Experience

In Alternative 4, fire management program emphasizes treats vegetation through prescribed fire burning approximately 109,000 acres. Approximately 24,070 acres would burn from suppression fires; wildland fire-use fire would be used least of all alternatives at 5,500 acres; and mechanical/manual treatments would occur at approximately 800 acres in priority areas. A description of this alternative is in Chapter 2.

Direct and Indirect Effects Alternative 4 Visitor Experience
Developed Areas, South and North Rims

Alternative 4 provides the most prescribed fire treatment on South and North Rims, and provides the second lowest treatment amount in the WUI (Grand Canyon Village), when compared with the other alternatives. Because of the treatment amount proposed, it is unlikely there would be much suppression and wildland fire-use fire on South Rim. It is assumed the majority would occur on North Rim, and/or wildland fire-use acres would occur where prescribed fire had recently occurred. As with all other alternatives, short-term moderate adverse local impacts from prescribed fire treatment in these areas would include reduced visual air quality; potential closures of areas, trails, and/or roads; physical impacts to land from fire management activities (e.g. handlines); and perceived risk. These adverse effects could be mitigated with air quality and fire activity restoration mitigation measures included in the alternative description (4.4.1.6); mitigation measures proposing fire information, interpretation, and educational programs designed to address the fire management program and enhance quality of visitor experiences; and a more general program used by the region (4.4.1.6). In general, landscape characteristics from these treatments would be attractive to visitors providing long-term moderate beneficial local effects.

As noted earlier, Alternative 4 proposes the highest amount of prescribed fire treatment on South and North Rims. Depending on fire location, moderate short-term local adverse impacts would include reduced visual air quality and potential increased aircraft traffic.

Overall, this alternative would produce the same number of annual days of unacceptable visual air quality (11) as Alternative 3; therefore, impacts are short term adverse minor to moderate. Approximately half of visitors during these days might reduce stay length, and recreation experience would likely change from natural to a more urban experience. In addition, visible plumes (approximately 128 plume days annually) without education/interpretation could have adverse impacts to visitor experience.

Because proposed WUI mechanical/manual treatment amount is slightly less than under Alternatives 2, 3, and 5, this alternative provides the second lowest protection from risk of a high intensity suppression WUI fire that could cause damage to natural environments and structures. Should severe damage to natural landscapes and structures occur, adverse impacts would be local minor to moderate long term. Long-term adverse impacts would be minor to moderate on South Rim visitors which could affect visitor services, and closure of areas and/or facilities. Since mitigation measures would be implemented as proposed there is a reduced risk of adverse impacts.

Impacts from mechanical/manual treatments would be similar to Alternatives 2 and 5 except time and area would be less. Still, adverse impacts would be negligible to minor direct short term local, and would include equipment noise, restricted access (e.g. slash on the ground, temporarily closed areas), reduced visual quality from slash piles (45% of manual treatment acres), scars from burning piles (45% of manual treatment acres), and masticated material left onsite (35% of mechanical treatment). Mitigation measures to provide interpretation/education would decrease adverse impacts. Long-term impacts from this treatment would be moderate beneficial local. Stands would be opened, WUI suppression fire risk would be reduced, and additional wildlife viewing opportunities may occur.

Colorado River **Alternative 4** **Visitor Experience**

Alternative 4 would have similar effects as Alternatives 1 and 2. Adverse impacts to Colorado River users would be local indirect short term. Smoke from fire activity could enter the river basin affecting river recreation experience. Based on air quality analysis, assumed heavy smoke impacts on river users would be similar in number of days (11) affecting rim visitors. Impact from reduced visibility to this user group would likely be adverse minor. River users would not be impacted by proposed non-fire treatments.

Proposed Wilderness Area **Alternative 4** **Visitor Experience**

Under Alternative 4, suppression, wildland fire-use, and prescribed fires are anticipated to affect an average 2,400; 550; and10,000 acres respectively each year. Though these areas comprise a little more than 1% of the park's 1.2 million acres, visitors seeking wilderness (backcountry) recreation experience could be adversely impacted due to their inflexibility to relocate (difficulty in changing backcountry itineraries through the backcountry permit system, ability, time constraints, landscape character, large closure area).

Intensity of short-term adverse impacts (from aerial fire management activities, fireline construction, and smoke) to backcountry user experience under Alternative 4 would be adverse moderate local depending on location relative to the wilderness user and mitigation measures included in project descriptions. By trending vegetation types toward the natural fire regime, risk of a devastating high severity fire would be decreased and positive effects of stand openness, spatial diversity, aspen reinvigoration, and opportunities to experience fire and learn its ecological effects would be increased. This would have moderate beneficial local long-term effects to the backcountry user.

Air Tours **Alternative 4** **Visitor Experience**

Alternative 4 would have effects similar to those in Alternatives 1 and 2. Though it is not known how many days/calendar year would have unacceptable visual air quality to these visitors, it could be assumed the number would be comparable to number of days (but reduced from 13 to 11) affecting rim visitors; therefore, adverse effects on air tour recreation experience would occur during a small period in any given year. In addition, these days are not predictable; therefore, air tours could not be forewarned. Fire aircraft activities could also adversely affect this group by restricting air tour access to portions of canyon air space should there be a conflict. Although most commercial aircraft operators would change to a different tour if a conflict arose between NPS and commercial air-tour operators the air tour visitor would have no knowledge of this. Adverse impacts to this group would be minor local indirect short term. Air tour users would not be impacted by proposed non-fire treatments.

Cumulative Effects **Alternative 4** **Visitor Experience**

With decreased mechanical/manual treatment in WUI, proposed WUI treatments would provide less beneficial long-term cumulative effects to Grand Canyon Village (and South Rim visitors) compared with Alternatives 2, 3, and 5. Very few projects other than this alternative would affect proposed wilderness.

Overall, cumulative effects of implementing Alternative 4 would have short-term moderate adverse local impacts, but long-term moderate to major beneficial local impacts to visitor experience.

Conclusion **Alternative 4** **Visitor Experience**

Alternative 4 proposes the most prescribed fire treatment and second least non-fire treatment in WUI. Due to fire activities on South and North Rims, visitors would be adversely affected, but effect would be minor to moderate short term local when activities occur. Beneficial impacts would be moderate long-term local. Should severe damage to natural landscapes and structures occur, adverse impacts would be local minor to moderate long term. Long-term adverse impacts would be minor to moderate to South Rim visitors which could affect visitor services, and area and/or facility closure. Impacts from mechanical/ manual treatments would be similar to Alternatives 2 and 5, except time and area would be less. Still, adverse impacts would be negligible to minor direct short term local. Impacts to visitor experience come from removal of MSO mitigations which, when implemented in Alternative 1, prevent attainment of more natural (desired) conditions.

River users would be impacted from reduced visibility to this user group and would likely result in adverse minor local indirect and short-term effects.

Backcountry visitor experience would also receive short-term local moderate adverse impacts during fire management activities, but long-term effects would be beneficial moderate local. These beneficial impacts would be widespread across forest types on North and South Rims.

Impacts to Air tour visitors would be minor local indirect short term.

Overall, cumulative effects of implementing Alternative 4 would have short-term moderate adverse local impacts, but long-term moderate to major beneficial local impacts to visitor experience.

4.6.1.14 Alternative 5 Fire Use Emphasis Visitor Experience

Alternative 5 fire program emphasis is to restore and maintain forests with wildland fire use (88,000 acres). With focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative de-emphasizes prescribed fire treatments, treating 29,900 acres. Mechanical/manual treatments would total approximately 2,676 acres and occur in WUI and along Highway 67 on North Rim. A detailed description can be found in Chapter 2.

Direct and Indirect Effects Alternative 5 Visitor Experience
Developed Areas, South and North Rims

Amount of prescribed fire treatment proposed on South Rim is similar to that in Alternatives 1 and 2; therefore, impacts would be similar. Prescribed fire treatment amount proposed on North Rim is similar to that in Alternative 3; therefore, impacts to visitor experience would be similar in prescribed fire treatment areas. In addition, fire-use fires would likely occur on North and South Rims, but the majority of acres treated with wildland fire-use fires would likely occur on North Rim. Minor to moderate short-term, adverse impacts to South and North Rim visitor experience from these fires would include reduced visual air quality; potential closures of areas, trails, and/or roads; physical impacts to the land from fire management activities (e.g. handlines, staging areas); fire air traffic; and perceived risk. These adverse impacts could be reduced by implementing mitigation measures (part of the alternative description and those proposed). Where treatments occur, forest aesthetics would improve over time. Treatment areas would have long-term beneficial effects to North and South Rim visitor experience.

According to 4.4.1.15, Air Quality, an estimated 14 days annually would be unacceptable due to visibility on the rim. Adverse effects (visual and health) would be short term local moderate and would only affect visitors at the park during those specific days. As noted in the other alternatives, approximately half of visitors directly affected may shorten their planned stay, and/or recreation experience may switch from a natural (e.g. scenic vista viewing) to an urban experience (e.g. eating at restaurants, shopping, visiting interpretive sites). In addition, visible plumes (approximately 134 plume days annually) without education and interpretation could have adverse impacts to visitor experience. There is, however, no evidence that wildland fire plumes negatively or positively affect visitor experiences.

Alternative 5 proposes similar mechanical/manual treatment amount in the WUI as Alternative 2; thus, impacts would be similar. Fuel treatments using manual/mechanical methods may seem out of place to some park visitors. Additional direct short-term local negligible to minor adverse effects would include equipment noise, restricted access (e.g. slash on the ground, temporarily closed areas), reduced visual quality from slash piles (45% of manual treatment acres), burn pile scars (and possibly scorching) (45% of manual treatment acres), and masticated material left onsite (35% of mechanical treatment). As with the other alternatives, mitigation measures to provide interpretation/education would decrease adverse impacts. Long-term impacts from this treatment would be minor to major beneficial. Stands would be opened, WUI suppression fire risk reduced, and additional wildlife viewing opportunities may occur.

Colorado River Alternative 5 Visitor Experience

Adverse impacts to Colorado River users would be minor to moderate local indirect short term. Smoke could enter the river basin affecting the river recreation experience. Based on air quality analysis, it can be assumed heavy smoke impacts on river users would be similar to number of days (increasing by one, to 14) affecting rim visitors. River users would not be impacted by proposed non-fire treatments.

Proposed Wilderness Area **Alternative 5** **Visitor Experience**

Under Alternative 5, suppression, wildland fire-use, and prescribed fires are anticipated to affect an average 1,800; 8,800; and 2,990 acres respectively, each year. Though these areas comprise little more than 1% of the park's 1.2 million acres, visitors seeking wilderness (backcountry) recreation experience could be adversely impacted due to inflexibility to relocate (difficulty changing backcountry itineraries through the backcountry permit system, ability, time constraints, and landscape character).

Increased acres treated with fire-use fire under this alternative would create a moderate increase in aircraft use, plus new handlines would cause moderate impacts to backcountry user experience although these impacts would be local short term.

Natural processes after wildland fire use would be observed by wilderness users more often and, as shown in various studies, (Englin et al. 2001) "recently burned areas provide opportunities to educate visitors . . . about fire ecology and the need for fire or its reintroduction in . . . forests." Multiple fire intensities would increase potential for a mosaic of vegetation varieties, increasing visual interest to the visitor.

When compared with the other alternatives, Alternative 5 would likely have the highest number of days of unacceptable visibility for backcountry visitors because wildland fire-use fires tend to burn longer. In addition, if a number of fire-use fires occurred in sequence, creating a string of days when visibility is low, and a greater number of areas closed to entry, there would be a decrease in backcountry user experience satisfaction. As with Alternatives 1, 2, and 4, by trending vegetation types to the natural fire regime, risk of devastating high severity fires would be decreased. As conditions approach natural fire regime, forest aesthetics would generally improve leading to improvements in visitor experiences. This would have major beneficial local regional long-term effects to backcountry users.

Air Tours **Alternative 5** **Visitor Experience**

Though it is not known how many days/calendar year would have unacceptable visual air quality to these visitors, it could be assumed number of days (14) would be similar to affected rim visitors. When compared with the other alternatives, adverse effects on air tour recreation experience would occur during a small period in any given year. This adverse impact would be adverse moderate local indirect short term. In addition, poor air quality days are not predictable; therefore, air tours could not be forewarned. Fire aircraft activities could also adversely affect this user group by restricting air tour access to portions of park air space during fire activities, should there be a conflict. Although most commercial aircraft operators would change to a different tour if a conflict arose between NPS and commercial air-tour operators, the air tour visitor would have no knowledge of this change. Air tour users would not be impacted by the non-fire treatments proposed.

Cumulative Effects **Alternative 5** **Visitor Experience**

Cumulative impacts to visitor experience would be very similar to Alternative 2 except a higher number of days adversely affected by visibility. When compared with other air quality issues, this cumulative impact, especially during the high-use season, could be adverse moderate local regional short term. There will also be long-term major beneficial local impact to visitor experience.

Conclusion **Alternative 5** **Visitor Experience**

Alternative 5 proposes the most wildland fire-use fires. Effects to South and North Rim visitors would be adverse minor to moderate short to long term local. These adverse effects (visual/health) would be short term local moderate, and would only affect visitors at the park during specific days. Effects to visitors from manual/mechanical treatments would be direct short term local negligible to minor adverse.

Beneficial impacts would be minor to major long term local. Impacts to visitor experience come from removal of MSO mitigations which, when implemented in Alternative 1, prevent attainment of more natural (desired) conditions.

River users would be impacted from reduced visibility and would likely result in adverse minor to moderate local indirect short-term effects.

Backcountry visitor experience would also receive short-term local moderate adverse impacts during fire management activities, but long-term effects would be beneficial major local and regional. These beneficial impacts would be widespread across forest types on North and South Rims.

Impacts to Air tour visitors would be moderate local indirect short term.

Overall, cumulative effects of implementing Alternative 5 would have short-term moderate adverse local impacts, but long-term major beneficial local impacts to visitor experience.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Visitor Experience**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternatives 1-5 effects would be adverse minor to moderate short-term local due to potential visual and health impacts only during specific days from fire management activities.

Alternatives 2, 4, and 5 would have adverse negligible to minor short-term local impacts from mechanical treatment equipment noise, restricted access, and reduced visual quality from slash piles.

Alternative 3 would have adverse moderate short-term local impacts to visitors from mechanical treatment equipment noise, restricted access, and reduced visual quality from slash piles.

Alternatives 1, 2 and 5 impacts would be adverse minor to moderate short term local due to reduced visibility by river users.

Alternatives 3 and 4 would have adverse minor short-term local impacts to reduced river users visibility.

Alternatives 1, 2, and 3 would have adverse minor to moderate short-term local impacts to backcountry users due to reduced visibility and restricted access.

Alternatives 4 and 5 would have adverse moderate short-term local impacts to backcountry users due to reduced visibility and restricted access.

Alternative 5 would have adverse moderate short-term local impacts to air tour visitors from reduced visibility.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Visitor Experience**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during the implementation of the plan and could not be reused or recovered during the lifespan of the plan.

There would be no irreversible or irretrievable commitments of resources.

4.6.2 Socioeconomic Environment

4.6.2.1 Guiding Regulations And Policies — Socioeconomics

Assessments of social and economic impacts resulting from major Federal actions are required by NEPA. NPS Management Policies 2006 state the NPS cooperate with others to improve GRCA conditions; enhance public service, and integrate into sustainable ecological, cultural, and socioeconomic systems.

Community economies surrounding GRCA depend heavily on tourism. GRCA is the major, but not only, regional attractor for new money though tourism expenditures. The NPS also injects money into local economies through salaries and local purchase of goods and services.

Other regulations and policies guiding NPS relationships with governments, tribes, communities, and stakeholders are

- National Environmental Policy Act
- National Park Service Organic Act of 1916
- The Historic Sites Act (1935)
- The Clean Air Act (1977)
- The Clean Water Act (1972)
- The Endangered Species Act (1973)
- The Organic Act Redwood National Park Amendments (1978)
- The Federal Grant and Cooperative Agreement Act (1978) and separate NPS authority (1996)
- The Outdoor Recreation Act (1963)
- The National Parks and Recreation Act (1978)
- Executive Order 13352 (August 26, 2004) Facilitation of Cooperative Conservation
- National Park Service Management Policies 2006
- Grand Canyon National Park GMP

4.6.2.2 Management Objectives — Socioeconomics

Social and economic goals and objectives for the proposed FMP include

Goal 1 Protect human health and safety, and private and public property

- Conduct wildland fire management activities with the most current risk assessment and mitigation techniques available to ensure firefighter and public safety is the highest priority
- Use non-fire fuel treatments in areas where wildland fire use is not practical due to safety or smoke concerns. Even in these areas, however, fire will be used in the future as fully as possible to maintain desired conditions once restored through non-fire fuel treatments
- Minimize smoke impacts on human health
- Provide fire management workforce with training, equipment, operating procedures, safety measures and information needed to manage risks and perform activities safely

Goal 3 Protect park natural, cultural, and social values

- Managing the ecosystem and natural processes are the primary objectives that will lead to healthy critical habitat for listed threatened, endangered and sensitive species.
- Use fire management tools and techniques to maintain, restore, and protect cultural resources while minimizing adverse impacts from fire and fire management activities
- Conduct fire management activities in proposed wilderness in a manner that will not diminish suitability for designation or result in changes to the current wilderness proposal
- Use minimum-impact management techniques to reduce impacts to wilderness values, cultural and soil resources, and to limit spread of invasive plant species
- Minimize smoke impacts on air quality values including visibility

Goal 5 Educate, inform, consult, and collaborate with tribes, stakeholders, and the public

- Maintain government-to-government and informal relationships with Native American tribes to exchange knowledge about fire management and traditional cultural practices
- Develop and implement a proactive process that disseminates current and accurate information to the public, park employees, media representatives, and cooperators that encourages support of the Fire Management Program
- Conduct wildland fire prevention, education, and other activities in communities within and adjoining the park. Work in collaboration with local communities, county, state, and Federal fire agencies with fire-management interests
- Develop interpretive displays and educational programs, working with the Division of Interpretation, to foster understanding and acceptance of the Fire Management Program

4.6.2.3 Methodology For Analyzing Impacts Socioeconomics
Tools Used to Analyze Economic and Social Effects Methodology

People react strongly to wildland fire, smoke, and fire effects on the landscape. Some reactions are positive and others negative. Section 4.6.1 describes effects on the individual park visitor. This section attempts to describe social and economic effects on a regional and community scale.

GRCA fire management may produce economic impacts of three kinds. Proposed alternatives may have different impacts on *visitor spending* in communities near the park resulting in changes in economic activity. They may alter physical and social environments changing the *economic value* of visitor and passive-user experiences. Fire management also *prevents losses* due to injury or death of visitors, residents, and employees as a result of wildfire. Fire management reduces likelihood of wildfire damage to buildings, infrastructure, irreplaceable cultural resources, and livestock injury or death.

Fire management social impacts include effects fire management might have on social structure of local communities and relations among community members or between communities and the NPS. Fire management might conflict with or support local values and traditions or might affect established park and surrounding environment uses.

Visitor spending can be affected in two ways. First, fire management might change visitor numbers. Visitors spend large sums of money with concessioners and in regional businesses. Second, fire management may alter visitor behaviors resulting in changes where and how they spend money.

A study of economic impacts of visitor spending at GRCA was completed by Stynes and Sun (2005). This study was not used to analyze impacts in this FEIS/AEF because researched impacts were too low to achieve valid results. However, if fire management program impacts increase, if fire management actually does influence visitor number, and if effect can be determined, results of the Stynes and Sun study can be used to estimate local economic impacts of different alternatives.

Tools Used to Analyze Economic and Social Effects **Socioeconomics**
Estimating Fire Management Effects On Number Of Visitors **Methodology**

One published study was found that estimated air quality impacts on national parks visitation (Hill 2000). Another study described changes in wildland trail use associated with wildland fire (Elgin et al. 2001). No direct estimates were found of fire effects on park visitor number or comparable destinations.

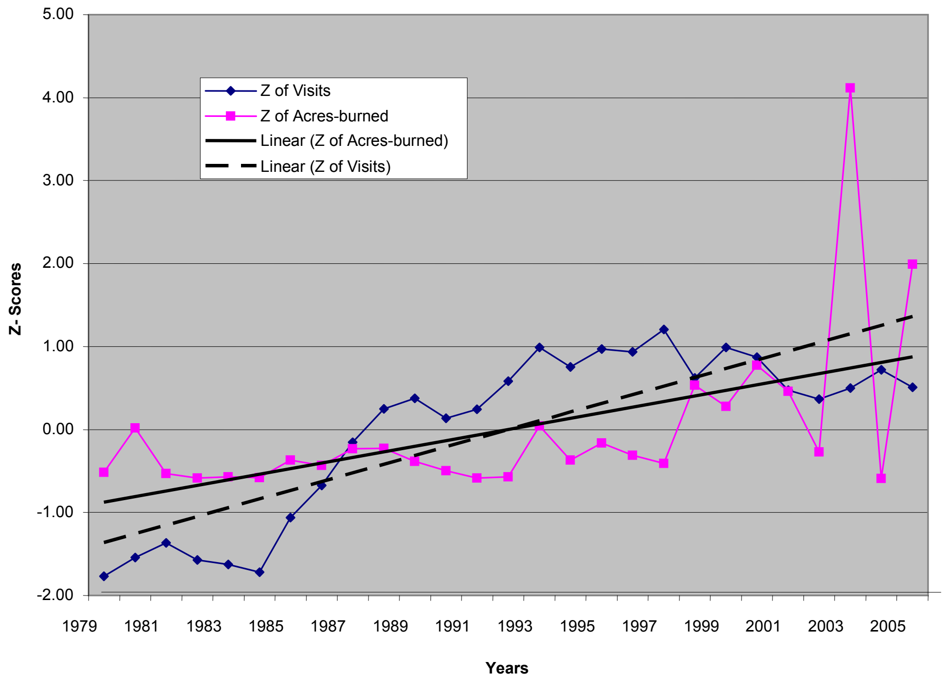
Because no existing information was found to predict how proposed fire management alternatives would affect visitor number, regression analysis was used to determine the mathematical relationship between visitor number and acres burned. Different alternatives result in different acreage burned by prescribed, wildland fire-use, and suppression fire. More acres burned should correlate with more smoke, noise, fire-management activity, and restricted backcountry access; all have potential to affect visitor numbers.

Regression analysis is a mathematical procedure that analyzes data to find an equation that best predicts changes in one variable from changes in another. Acres burned is a variable and so is visitor number. Yearly 1979 through 2004, GRCA has numbers of acres burned and visitation. Regression analysis produces an equation that tells how many visitors will not visit GRCA if an additional acre burns in any year. When the equation is plotted on a graph, one can find acreage burned on the horizontal axis, go up the curve and across to the vertical access to see how many visitors would come if that many acres burned.

Visitation and acres-burned data are compared in Figure 4-8. Graph numbers are Z-scores for visits and acres burned. Z-scores allow different kinds of data (visits and acres) to be compared on the same graph. A Z-score is computed by subtracting mean (average) acres burned from acres burned value for each year. The difference is divided by the standard deviation for acres burned numbers. The mean represents an average number for acres burned between 1979 and 2004. The standard deviation represents an average difference between each year's acres burned value and the mean number of acres burned for years between 1979 and 2004. The same computations are made for number of GRCA visits for those years.

It is assumed for analysis that fire-related variables such as smoke, aircraft noise, fire management activities, and access restrictions to some GRCA areas will increase or decrease directly with acres burned. More acres burned are associated with more smoke, for example.

Figure 4-8 GRCA Visits and Number of Acres Burned Per Year, 1979 through 2005



Multiple regression analysis allows one to see how more than one variable effects visitation. Three other variables were used in addition to acres burned. The U.S. population by year was included because number of visits might increase if population increased even if nothing else changed. Price of gasoline corrected to a base year was included because decisions on travel might be affected by fuel cost. Correction to a base year was used so that a 1979 dollar and a 2004 dollar would represent the same visitor buying power. Finally, a measure of consumer confidence was included because when consumers are more confident, they might be more willing to spend money on travel than when less confident.

Data used in regression analysis cover 1979 through 2004. Numbers of visits were acquired from the NPS website. Number of acres burned was determined from data provided by GRCA Fire Management. Consumer sentiment data are from the University of Michigan and used with permission. Gasoline price data corrected to the base year 1949 was provided by S. H. Williamson (2006), used by permission. U.S. population data are from the U.S. Census.

To determine how much fire management might affect visitation, a regression analysis was completed to estimate extent to which visitor number (per one million people in the U.S.) changed with GRCA acres burned. Gasoline prices corrected for inflation, a consumer sentiment index, and year were also included.

The regression equation that resulted explains 72.7% of variation in park visitation. (R Square = .769, Adjusted R Square = .727)
VPM 137.7 Year – 38578.4
Gas 1949 – 42.3CS – 0.03
Acres 246505.8
Where VPM = Number of park visits per million U.S. population
Year The year for which data are entered
Gas 1949 = the price of gasoline corrected for inflation to the year 1949. Any year could be used as the base. 1949 was used because corrections had already been calculated by Williamson.
CS University of Michigan Consumer Sentiment Index measures consumer expectations for their own financial situation and performance of the general economy over the near and long term
Acres Number of GRCA acres burned during the year

Analysis predicts a decrease of 38,578 visits per million if gas price increases by one cent (1949 dollars, 8 cents 2006 dollars), but only 3 visits per million if 100 more acres burn. In 2006, 4,356,144 visits were made to GRCA. (The base year 1949 was used in the equation. One cent in 1949 would buy what 8 cents bought in 2006. A one cent (2006) increase would result in 4,822 fewer visitors per million U.S. population.)

Number of acres burned per year clearly has very little influence on visitor numbers. If acres burned is a proxy for smoke, access restrictions, and related fire-management actions, then one can conclude that none of the fire management alternatives would affect GRCA visitor number very much, and differences among alternatives on local economic impact are likely trivial.

Park visitation estimates are not entirely accurate. Some errors result from counting, and count data are converted to visitation data by multiplying the count by a factor determined by sample surveys of parties visiting GRCA. Confidence intervals were not found for GRCA visitation data, but it is likely that apparent effect of fire on visitation may be so small that it cannot be known whether effect is real or can be accounted for by visitation estimate errors. Visitor counting methods are explained at http://www2.nature.nps.gov/stats/pdf/grcaci1996.pdf.

Acres burned will not serve as proxy for fire effects on landscape setting. For example, they do not represent increased openness of forest stands, increased aspen vigor, changes in chances for wildlife viewing, tree scorch, or opportunities to observe and learn about fire as a powerful ecological force.

Fire management might change visitor spending patterns without affecting visitation. Earlier research at GRCA determined effects of visibility changes in visitor intended length of stay. About one half of visitors participating in an experiment reported in 1983 said they would decrease their length of stay at vista points and in the park if visibility declined, and increase their length of stay if visibility improved. No follow-up studies are reported. It is not known whether actual stay lengths vary with visibility. It is possible they do not because other factors may intervene between intention and action. Even if stay length does change with visibility changes, effects on spending patterns are not known. It is possible that less time viewing the canyon translates into more time in cafes, gift shops, and other commercial attractions. A shortened GRCA visit may be made up with additional time spent at other destinations on the visitor's itinerary. That might be more likely than visitors cutting short their vacations and returning home early. Many visitors report Grand Canyon is only one destination on their trip. Some alternative destinations are in vicinity of Grand Canyon and money spent would not be lost to the region. However, effects of fire management on visitor spending patterns remain speculation in absence of appropriate studies.

Changes to the economic value of visitor and passive-user experiences, and costs of achieving those experiences, are described from reports of research completed at Grand Canyon and other locations, and direction and magnitude of potential effects are described.

Proposed fire management alternatives would influence potential WUI fire behavior. Qualitative estimates are made of potential for avoiding property loss and increasing visitor safety as a result of quantitative estimates of changes in expected fire behavior resulting from WUI fuels treatments under the alternatives.

Estimates of social impacts of proposed fire management alternatives are based on social assessments conducted for the Kaibab National Forest. The Kaibab National Forest and GRCA share much the same local social environment. The social assessment addressed perceptions and values associated with fire held by people in local communities. Together with demographic and social trends identified in other studies, potential social impacts can be described.

4.6.2.4 Impact Thresholds — Socioeconomics

Five classes of potential economic and social impacts are analyzed for each proposed fire-management alternative: local and regional economy, economic value of visitor experiences, passive-use values, engagement and collaboration, and WUI.

Type of Impact

Adverse — Alters the environment in ways that discourage visitation, length of stay, or spending amounts and patterns in ways that reduce direct and indirect economic impacts on local economy. Creates demands for local services that result in un-reimbursed expenses to local government, businesses, nonprofit organizations, or individuals. Produces direct injury to human beings and livestock, illness, property damage, inventory loss. Impact(s) cause psychological distress and social disturbance that reduce quality of life for local-community residents. Reduces economic value of visitor experience or adds to cost of obtaining the experience

Beneficial — Alters the environment in ways that increase attractiveness to visitors, resulting in more visits, increased length of stay, and changed spending amounts and purchasing patterns that have greater multipliers in local economy. Directly and/or indirectly effects spending in local economy and changes to structure of local economy that increases local multipliers. Costs and losses averted as a result of changes in fire behavior, particularly in the WUI and along transportation corridors. Changes that alter economic value of visitor experiences and experiences of non-using publics

Intensity

Negligible — Impacts would have little to no detectable socioeconomic effects to concessioners, local and/or regional communities, including Native American reservations

Minor — Socioeconomic effects to concessioners, local and/or regional communities, including Native American reservations, would be detectable but would not be expected to have any overall effects

Moderate — Socioeconomic effects to concessioners, local and/or regional communities, including Native American reservations, would be clearly apparent

Major — Socioeconomic effects to concessioners, local and/or regional communities, including Native American reservations, would have substantial, highly noticeable impacts and could be expected to alter those environments on a long-term or permanent basis

Context

Regional — Impacts would be realized at several areas and/or locations

Local — Impacts would be realized at specific areas or locations

Duration

Short Term — Impacts would be temporary and associated with a specific action

Long Term — Impacts would last beyond the timeframe of a specific action or may be permanent

Timing — Socioeconomic values are generally more sensitive to impacts during summer (high tourist season)

4.6.2.5 Mitigation of Effects — Socioeconomics

The following mitigation measures are common to all five alternatives. These mitigation measures are part of each alternative description, address impacts from socioeconomics, and may be addressed in other sections of this Chapter.

- Close trails and roads providing access to fuel reduction projects, and wildland or prescribed fires if fires and/or projects present unacceptably hazardous conditions to visitors
- Close portions or entire park by Superintendent's order when a threat to public or firefighter safety exists from wildland fire or fire management activities. Notify adjacent agencies, neighboring communities, and authorities as soon as possible
- Institute smoke warning signs or traffic control on roads during fire operations as conditions warrant at the direction of the Burn Boss, Incident Commander, Safety Officer, or visitor protection representative
- Adhere to ADEQ Final Forest and Range Management Burn Rule regulations and any other provisions (if any) of permits issued by ADEQ for specific burns to minimize undesirable impacts to public health, public welfare, and visibility-related values
- Implement as many Emission Reduction Techniques (as prescribed in AAC R18-2-1509) as feasible to reduce smoke produced by prescribed fires, subject to economic, technical, legal, and safety implications of the techniques and burn management objectives
- Implement, to manage smoke produced during any desired fire, as many Smoke Management Techniques (as prescribed in AAC R18-2-1510) as practicable
- Provide information to visitors about closures and optimal view locations during fires

4.6.2.6 Cumulative Impacts — Socioeconomics

Fire management activities in GRCA and on adjacent lands, and actions that could affect the region's economy and social environment have potential to affect socioeconomics cumulative impacts. Therefore, lands and communities adjacent to these areas, both in and neighboring the park, mainly define the geographic scope of this cumulative impact analysis.

Cumulative impacts on socioeconomics were determined by combining impacts of each alternative with other past, present, and reasonably foreseeable future actions. (See Appendix G).

4.6.2.7 Assumptions — Socioeconomics

It is assumed fire management program local spending variations among alternatives are insignificantly small compared to the magnitude of visitor spending. This assumption is made because no data exist on local expenditures by different alternative. If such estimates are made in the future, multipliers provided by Stynes and Sun (2004) and Stynes (2005) can be used to evaluate differences in local economic impact.

4.6.2.8 Incomplete and/or Unavailable Information — Socioeconomics

Several studies apply directly to GRCA social and economic impacts. The best of these are North and South Rim visitor studies (Littlejohn et al. 2004; Littlejohn and Hollenhorst 2004), river user studies (Gloss et al. 2005), the study of economic impact of visitor spending on local economies (Stynes and Sun 2005), and social assessments completed for the Kaibab National Forest (University of Arizona 2005; University of Arizona 2005a; Russell and Adams-Russell 2006).

Although many studies have been completed on Grand Canyon visitors, potential effects of management practices on visitor experiences haven't been addressed systematically. There are studies of crowding effects on backcountry use and of noise on satisfactions. Visibility effects were studied 20 years ago but have apparently not been repeated or expanded. Little is known of visitor spending patterns and how they are affected by alterations in visitor experience quality. Studies of visibility effects on stay length, for example, were not followed with studies to learn what people do when they shorten their stay. It is not known if they leave the region earlier or distribute time over other activities and experiences in the region. Very little is known about substitutability among visitor experiences or among resources used by visitors to generate satisfactions through those experiences.

Interpretation and fire education apparently have important effects on visitor responses to fire and smoke. However, little research was found addressing visitor interest in fire and fire ecology or visitor emotional and behavioral responses to burned landscapes. Available studies sometimes suffer from design problems; nevertheless, they reveal likely differences among visitor types and response to fire, smoke, and fire effects on the landscape.

Most studies that might be useful in managing fire to reduce negative social and economic impacts and enhance benefits of fire on visitor experiences were completed decades ago. Increasing attention is focusing on fire social science in USFS research stations and the Joint Fire Sciences Program. However, most of that research focuses on WUI.

Assessing social and economic effects of fire management programs, or any GRCA resource or visitor management program, would be enhanced by a sustained and systematic social science research effort targeting questions derived from information needs for fire and other management decisions.

4.6.2.9 Impact Analysis Socioeconomics
Effects Common to All Alternatives Direct and Indirect Effects
Local and Region Economy

Economic activity would be affected principally by visitor spending changes. If fire management reduced visitor numbers or stay length in the region, it would alter economic activity. Regression analysis predicted number of GRCA visits per million U.S. population by GRCA acres burned, gasoline prices, and consumer sentiment. Only gasoline prices were a significant visitation predictor. Neither fires nor acres burned in the previous year predicted visitation. Based on this analysis none of the proposed alternatives would result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

Research conducted in the 1980s showed about half of visitors intended to reduce stay length at vista sites and in GRCA in response to reduced visibility (MacFarland et al. 1983). Although relationship between visibility and intended stay is statistically significant, it is not strong. If a relationship is statistically significant, the relationship seen in the data is very probably real. However, correlation between changes in visibility and changes in intended stay is only r=.16 meaning that a very small amount, a little less than 3% (r^2=.026) in differences in intended stay is shared by visibility differences. That weak relationship has little practical usefulness in predicting stay changes from visibility changes.

Although there is considerable uncertainty in knowledge available about effects of visibility alterations on visitor spending, it appears unlikely spending in the region would be affected.[3] It is possible reduced time spent viewing the canyon would result in more time and money spent in shops and restaurants, increasing income for concessioners and other local businesses. If wildland fire results in many periods of longer than average stay length when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier, adverse effect would likely be less.

[3] Hall (2000) conclude that national park visitation will be substantially affected by visibility changes. Analysis shows substantial increases in sales, tax revenue, and employment benefits as a result of GRCA visibility improvement. However, analysis is based on haze and not episodic fire events, and assumes reduced stay length in park in response to reduced visibility will also mean people spend less time in the region.

Fire may sometimes force restrictions on visitor access to portions of GRCA. The Outlet and Warm Fires resulted in closure of North Rim developments for several days. During access restrictions concessioner businesses would likely suffer income loss. If visitors leave the region or divert to alternative destinations outside the region as a result of access restrictions, the rest of the regional economy would also suffer losses. However, to the extent that visitors divert to other attractions in the region, income to businesses, government, and workers in the region would not be lost. For every 1,000 visitor days lost to the region because visitors leave or do not come in the first place because of access restrictions, regional economy loses $59,000 in salaries and wages (Stynes and Sun 2005).

None of the alternatives would affect river use numbers or stay length; thus, would have no effect on local economy related to river use.

Should a high intensity fire occur in WUI, adverse impacts would be major. Potential adverse effects are described in more detail under WUI.

Effects Common to All Alternatives **Socioeconomics**
Economic Value of Visitor Experiences **Direct and Indirect Effects**

Economic value of visitor experiences is measured by willingness to pay to enjoy the experience. Willingness to pay is revealed by actual expenditures or stated in contingent valuation studies. As with any product or service, willingness to pay is higher for experiences perceived of higher quality. For any experience of a given quality, total value of visitor experiences will be the sum of values to visitors.

Based on results of regression analysis described earlier, fire management is not expected to affect a large number of GRCA visitors as a result of smoke, access restrictions, noise, or other factors associated with acres burned per year; therefore, proposed alternatives would have a negligible adverse affect on total economic value of visitor experiences simply by changes in numbers. However, fire management would affect quality of many different kinds of visitor experiences. For example, smoke would reduce economic value of visitor experiences on occasions when it contributes to visibility reductions. Improved visibility increases willingness to pay, and reduced visibility decreases willingness to pay. Smoke plumes known by visitors to be associated with wildland fires may not negatively affect economic value of visitor experiences. No research was found on GRCA visitor response to wildland fire plumes, but other research shows that acceptability of wildland fire smoke is greater than acceptability of smoke from agriculture burning, for example (Weisshaupt et al. 2005). Further, plumes typically obscure less of the canyon view than does haze. Any minor adverse impact that would occur could be mitigated if interpretation makes clear fire's meaning and effects on ecosystems.

Similar results would no doubt be observed for fire effects on forest aesthetics, wildlife encounters, wilderness experiences, hiking, and other visitor experiences if studies were done. An excellent study has demonstrated the value of wildland trails used for non-motorized recreation increases following fire and remains higher than the pre-fire condition for many years (Elgin et al. 2001).

Effects Common to All Alternatives **Socioeconomics**
Passive Use Values **Direct and Indirect Effects**

Even people who do not visit Grand Canyon, and many who never will, may place value on GRCA they are willing to pay to preserve, as demonstrated by public contributions to conservation organizations. Some value is option demand. People wish to preserve the option to visit the park in the future or for their heirs to visit. Some value arises from simply knowing that GRCA and its resources exist. Most park-existence value probably derives from the canyon and its spectacular views. However, heritage resources no doubt contribute to existence value. People are willing to pay to preserve GRCA historic structures, for example. GRCA forests also contribute. None of the alternatives would adversely affect GRCA passive-use values. WUI fire, however, presents serious threat to historic structures, especially from embers and even low intensity surface fires ignited by embers in the landscape among structures.

Effects Common to All Alternatives — Socioeconomics
Engagement And Collaboration — Direct and Indirect Effects

Increased engagement and collaboration on GRCA fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts, especially if community members engage as partners, not just stake-holders, in land management. Increased collaboration with other agencies and communities would result in improved working relations between the park and surrounding communities. Studies conducted for the Kaibab National Forest (University of Arizona 2005; University of Arizona 2005a; Russell and Adams-Russell 2006) found maintenance of a rural, resource-based lifestyle and associated values is important to communities in the Grand Canyon region. Forest landscape setting is essential to community identity. Public lands have traditionally provided a commons for communities where family and community events are staged and outdoor recreation activities pursued. Established residents identify closely with the land. A key value is taking responsibility for how one's actions affect one's neighbors and the expectation that one will participate in landscape protection and improvement, including public lands.

Closer collaboration between NPS, USFS, and Grand Canyon region communities may help relieve concerns about sustainability of once fire-adapted forest ecosystems and potential wildfire threats to communities and their landscape settings. In addition, communities are concerned that newcomers (seasonal employees) do not understand fire's role in forests or that forest conditions are unsustainable and need hazard reduction and fire restoration. Communities value agency partnerships to manage public lands including fire prevention and fire education for newcomers. Unless newcomers are educated, current strong support for prescribed and wildland fire-use fire and fire restoration to ecological functions would erode as more retirees and second-home owners move in. This could eventually affect the park's ability to use fire.

This would also be a beneficial effect by providing opportunities for the NPS to contribute to the sustainability of desired community lifestyles, and engage residents in land management.

Effects Common to All Alternatives — Socioeconomics
Wildland-Urban Interface — Direct and Indirect Effects

All alternatives reduce potential for high intensity fire in WUI. Planned treatments make crown fire highly unlikely in ponderosa pine, especially in WUI. Treatments of stands near WUI by the NPS and USFS reduce potential for embers to produce crown fire and torching. Potential for high intensity fire and significant ember production is limited to periods of extreme fire weather.

If structures ignite, they are most likely to do so from embers deposited on highly flammable building materials, in wood piles, or other flammable materials against or near structures. Embers may also ignite low intensity surface fires that burn to buildings not separated from flammable vegetation, and ignite them with direct flame impingement. Embers and low intensity surface fire are a major cause of structure ignitions in WUI fires even when the flaming front is prevented from closely approaching structures (Cohen 2000). Probability of neighboring structures burning increases substantially after one structure ignites (Foote 1994).

The small threat is important as economic loss potential would have major long-term adverse impact to the region. Irreplaceable heritage resources are concentrated in WUI and vulnerable to wildfire. Direct economic losses are potentially large from damage or destruction of residences and historic structures.

Direct adverse economic impacts would result from damage to residential and historic structures and contents. Loss of historic structures would permanently eliminate an important resource. Burning structures would kill nearby large trees even if understory vegetation would not support intense surface fire. Loss of large trees in substantial numbers would reduce forest aesthetics (Ryan 2005). Proposed mitigation lessens risk by developing treatment prescriptions around structures to minimize potential of embers igniting structures and killing adjacent large trees.

Although structures necessary to support park operations and sustain visitor services are highly unlikely to burn in a WUI fire because building materials are less flammable, visitor safety and fire operations would probably result in access restrictions lasting days, a week, or more. Normal operations would likely take longer to restore.

The economic impact of damaging wildfire in WUI result in loss of income and employment for many in the region. Effects would last as long as required to restore services allowing visitors to return to the park in numbers similar to those pre-fire. Certainly access restrictions and limited services would last more than five days; therefore, effect would be long term major. Wildfire also imposes costs on local governments and organizations to manage traffic and evacuations, shelter displaced persons, provide emergency health care, and protect property and resources from fire. Individuals and families may experience health problems from smoke exposure or psychological distress and its impacts on personal relationships, work effectiveness, and related effects. Communities experiencing damaging fires often find it difficult to restore social and economic conditions to earlier levels of activity and efficiency. Effects decline with time, but may last two years or more depending on the speed with which infrastructure can be repaired or replaced and life is returned to normal for affected people.

Electricity to South Rim developments is delivered through a powerline vulnerable to fire over a large distance. If power is interrupted by wildfire, it would not be possible to pump water to Grand Canyon Village until restored. Visitor services would not be restored until power and water services were restored, an indirect adverse effect for government, residents, and businesses.

If visitors, employees, and residents perceive serious danger to their families and selves, and are trapped temporarily in WUI or hastily evacuated, major adverse social effects could be expected. On an average July day, 19,000 visitors are on South Rim; approximately 8% (1,520) may not speak English as a first language. Few would be familiar with park roads and very few would know escape routes or where to find safety zones. Many would be on foot, far from their automobiles. Many would be without effective communications with families or the NPS. It would be difficult to inform people to evacuate or find shelter and even more difficult to direct a safe evacuation. Adverse social effects could be lessened by proposed mitigation measures, additional preparedness, and planning in most WUI communities. However, nearly all affected by a South Rim WUI fire would have little knowledge of wildfire or environment. Relatively few emergency service personnel would be available to assist so many people and still protect structures. Should this occur, adverse social effects would be major.

Property loss from wildlife and threat of injury to one's self or family could cause intense psychological distress. Strong emotions sometimes lead to behaviors that create social difficulties and disrupt economic activity. Adverse effects can last up to two years for those most seriously distressed, although nearly all recover without professional help (Fowler 2003). Visitors, residents, and employees may experience negative impacts from perceived danger. When a high percentage of any community is impacted, recovery is difficult for individuals, and efforts requiring collaboration are harder to achieve.

4.6.2.10 Mitigation of Effects — Socioeconomics

In addition to mitigation measures in 4.6.2.5, the following recommended mitigation measures are proposed to further reduce adverse socioeconomics effects.

- Develop and implement treatment prescriptions that create defensible space around structures and in cultural landscapes
- Update evacuation plans by addressing communications with people of various cultures (and languages) and how to direct them to safe places. Evacuation plans exist and have been practiced but communicating with people during disasters may need additional attention (Mileti et al 2004). Provide preparedness provisions and encourage communication and cooperation with adjacent public agencies and communities

4.6.2.11 Alternative 1 No Action, Existing Program Socioeconomics

This alternative continues the existing program as described in the 1992 Fire Management Plan, as amended. Alternative 1 assumes the same level of suppression of approximately 20,050 acres; 58,500 acres treated through prescribed fire (primarily in ponderosa pine and mixed-conifer FMUs); 55,000 acres treated through wildland fire use; and 400 acres manually treated (primarily in piñon-juniper habitat). Manual treatment includes chainsaw use with cut vegetation chipped, piled, or otherwise disposed off-site. For a full description of Alternative 1, see Chapter 2.

Direct and Indirect Effects Alternative 1 Socioeconomics
Local and Regional Economy

In Alternative 1, smoke would occasionally reduce visibility and may shorten average visitor stay. As noted earlier, only about half those studied said visual air quality would affect stay length and, according to 4.6.2.3, smoke events would be sufficiently rare that only a small fraction of visitors would be affected during the year. Based on this information, adverse impact would be local short term minor. There is no research describing effects of stay length on visitor spending patterns. It is unlikely visitors who leave the park would immediately leave the region. Grand Canyon is typically only one of multiple destinations on visitors' itineraries. Visitors may spend more time at alternative sites in the region and spend money there. It has been suggested that when visitors must spend less time in outdoor pursuits, they spend more time in shops and restaurants, possibly increasing spending and thus economic impact. However, no research evidence was found to support either speculation.

Over time, fire and mechanical treatments would enhance aesthetic landscape qualities that may result in more visitors. Increased visitation would increase positive economic impact on local communities. It is not possible from available research to estimate additional visitor numbers attracted due to enhanced landscape aesthetics or even if enhanced landscape aesthetics would increase visitor numbers.

Under Alternative 1, based on GRCA fire closure history, closure number and duration would be small and cause a negligible to minor adverse effect on visitor spending in the region. Concessioners may experience some business loss, however. No reports are available that evaluate park closure effects on concessionaire business.

Based on this analysis, Alternative 1 would not result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of visitors.

If wildland fire results in many periods of longer-than-average stay length when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely many visitors who leave GRCA earlier than planned also leave the region, this adverse effect would likely be less. Based on this information, adverse impact to local and regional economy would be local short term minor.

Should a large, high intensity WUI suppression fire occur, adverse effects would be major to local and regional economies. A detailed impact description is in the WUI section below.

Direct and Indirect Effects **Alternative 1** **Socioeconomics**
Economic Value of Visitor Experiences

Alternative 1 would have the same effect as noted in Effects Common to all Alternatives: fire management would not affect a large number of park visitors; therefore, would have a negligible adverse affect on total economic value of visitor experiences, other things being equal. Wildfire smoke would occasionally adversely affect visibility and, therefore, value of visitor experiences associated with canyon views. On the other hand, forest openness and spatial diversity would increase with treatments under Alternative 1, enhancing forest aesthetics. This may increase GRCA visitation long term. Net effect on value of visitor experiences would be beneficial minor to moderate local long term.

Direct and Indirect Effects **Alternative 1** **Socioeconomics**
Passive-Use Values

Alternative 1 proposes a mixture of fire treatments along with suppression fires. Because Alternative 1 has restrictions on low intensity fires, beneficial impact would likely be minor and limited mostly to ponderosa pine. In other vegetation types, beneficial effects would be negligible. Though this restriction would not provide restoration of fire-adapted wildland ecosystems, it would slowly trend vegetation types toward the natural fire regime. This would probably increase park-existence value. Naturalness is highly valued as a park characteristic (Littlejohn et al. 2004; Littlejohn and Hollenhorst 2004). No research reports of passive-use values for resources (other than the Colorado River) were found for Grand Canyon. It is likely that forest restoration to more native conditions would have a beneficial impact on passive-use values. Because Alternative 1 has restrictions on low intensity fires this beneficial impact would likely be minor to moderate regional long term.

Direct and Indirect Effects **Alternative 1** **Socioeconomics**
Engagement and Collaboration

Alternative 1 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Direct and Indirect Effects **Alternative 1** **Socioeconomics**
Wildland-Urban Interface

Level of fuels treatment proposed for Alternative 1 in WUI is low, and current fuel conditions around many structures makes ignition risk relatively high. As noted in 4.2.1, under current conditions, ponderosa pine in WUI is in high departure from historic fire conditions. Some treatment has occurred, but high intensity fire remains a threat. With Alternative 1implementation, potential would remain for relatively intense surface fire and torching in WUI. Surface fuels would be receptive to embers. Even where fires are low intensity, lack of adequate separation between highly flammable structures and surface fuels would allow structural ignition from direct flame impingement. Many structures are vulnerable to direct ember ignition. Wood piles and other flammable materials next to some structures are easily ignited by embers. Proposed mitigation measure to develop and implement treatment prescriptions around structures would lessen this risk, but may not be effective given WUI fuel conditions.

In absence of treatment, conditions would grow more dangerous. Overall, Alternative 1 does little to reduce potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of a major damaging wildfire in WUI would be adverse major long term regional.

Mitigation of Effects **Alternative 1** **Socioeconomics**

Mitigation measures in alternative descriptions (4.6.2.5) and the two proposed as common for all alternatives (4.6.2.10) will decrease adverse impacts to socioeconomic environment.

Cumulative Effects **Alternative 1** **Socioeconomics**

Forest restoration and hazard mitigation activities undertaken by the Kaibab National Forest and tribes along with vegetative treatment proposed in Alternative 1 would contribute to cumulative aesthetic quality of the forest landscape in and around the park, and increase economic value of visitor experiences. Fuels treatments by the USFS, especially southwest of Grand Canyon Village and in the Tusayan WUI, would also cumulatively help reduce potential for fires that could disrupt visitor services for long periods with resulting negative social and economic impacts in the region.

Fire on the Kaibab National Forest has potential to close major park access roads. Access to North Rim was restricted during 2006 by the Warm Fire. Continued fuels treatments by GRCA and adjacent public land agencies will reduce potential for fire closures and associated negative economic impacts.

Overall, it is anticipated cumulative beneficial social and economic effects of implementing Alternative 1 with projects discussed earlier, would be minor to moderate regional long term.

Conclusion **Alternative 1** **Socioeconomics**

Based on this analysis, Alternative 1 would not result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of visitors to the park. If wildland fire results in many periods of longer-than-average stay length when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region, this adverse effect would likely be less. Based on this information, adverse impact to local and regional economy would be local short term minor.

Outside WUI, Alternative 1 would slowly improve landscape qualities through vegetation treatment known to enhance visitor experiences. Smoke would reduce economic value of visitor experiences on those occasions when it contributes to reductions in visual air quality. Smoke plumes known by visitors to be associated with wildland fires probably would not negatively affect quality of visitor experiences as much as increased haze. Any minor adverse impact that would occur could be mitigated if interpretation makes clear fire’s effects on forest ecosystems. Net effect on value of visitor experiences would be beneficial minor to moderate local long term.

It is likely forest restoration to more native conditions would have a beneficial impact on passive-use values. Because Alternative 1 has low intensity fire restrictions, beneficial impact would likely be minor to moderate regional long term.

Alternative 1 would have the same effect as noted in effects common to all alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

The greatest adverse impact on local and regional social wellbeing and economic activity from fire management results from reduced potential for dangerous and damaging wildfire in WUI. Alternative 1 would make slow progress in hazard reduction in WUI. Proposed mitigation measures to develop treatment prescriptions around structures would reduce this adverse affect, but of all the alternatives, this has least effect in reducing risk of social and economic losses to damaging WUI fire. Overall, Alternative 1 does little to reduce potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of a major damaging WUI wildfire would be adverse major long term regional.

Cumulative beneficial social and economic effects of implementing Alternative 1 with projects discussed earlier would be minor to moderate regional long term.

4.6.2.12 Alternative 2 Preferred Alternative Socioeconomics Mixed Fire Treatment Program

Alternative 2 proposes similar treatment to Alternative 1 but with low intensity fire restrictions removed and mechanical treatments added to reduce fuel build-up. For a full alternative description, see Chapter 2.

Direct and Indirect Effects Alternative 2 Socioeconomics
Local and Regional Economy

Mechanical/manual treatment proposed in WUI for Alternative 2 would enhance protection from dangerous and damaging WUI suppression fires. Minimizing risk of damaging WUI suppression fires would reduce likelihood of extended restrictions on park visitation and attendant reductions in visits to the park and region. Otherwise, local economic impacts would not differ from those under Alternative 1.

Economic activity would be affected principally by changes in visitor spending. If fire management reduced visitor numbers to the region or stay lengths, it would alter economic activity in the region. Regression analysis predicted number of GRCA visits per million U.S. population by GRCA acres burned, gas prices, consumer sentiment, and year. Only gasoline prices were a significant visitation predictor. Neither fires nor acres burned in the previous year predicted visitation. Based on this analysis none of the proposed alternatives would result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

Under Alternative 2 wildfire smoke occasionally reduces visibility and may shorten average length of stay. As noted earlier, only about half of those studied said visual air quality would affect length of stay and, according to 4.6.2.3, smoke events would be sufficiently rare that only a small fraction of visitors would be affected during the year. Based on this information, adverse impact would be local short term minor.

Over time, fire and mechanical treatments would enhance aesthetic landscape qualities that may result in more visitors. Increased visitation would increase positive economic impact on local communities.

Under Alternative 2, based on GRCA fire closure history, closure number and duration would be small and would cause a negligible to minor adverse effect on visitor spending in the region. Concessioners may experience some loss of business, however.

Based on this analysis, Alternative 2 would not result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

If wildland fire results in many longer-than-average stay lengths when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region, this adverse effect would likely be less. Based on this information, adverse impact to local and regional economy would be local short term minor.

Direct and Indirect Effects **Alternative 2** **Socioeconomics**
Economic Value of Visitor Experiences

Alternative 2 would have the same effect as noted in effects common to all alternatives: fire management would not affect a large visitor number; therefore, would have a negligible adverse affect on total economic value of visitor experiences. Enhanced WUI landscape aesthetics resulting from mechanical treatments would increase economic value of visitor experiences by an undetermined amount. Because treatments are in high-use areas, total beneficial effects may be relatively large. Net effect on economic value of visitor experiences would be beneficial minor to moderate local long term.

Direct and Indirect Effects **Alternative 2** **Socioeconomics**
Passive-Use Values

Alternative 2 has similar landscape treatments as Alternative 1 except all prescribed and wildland fire-use fires on North Rim are not restricted to low intensity. Fires in mixed-conifer and spruce-fir would likely burn more representative of the natural fire regime for these vegetation types. These areas are not easily viewed by the majority of park visitors, but from a passive-use value perspective this alternative would likely provide more beneficial effects to park-existence value than Alternative 1. This beneficial impact would likely be minor to moderate regional long term.

Direct and Indirect Effects **Alternative 2** **Socioeconomics**
Engagement and Collaboration

Alternative 2 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Direct and Indirect Effects **Alternative 2** **Socioeconomics**
Wildland-Urban Interface

Mechanical/manual treatment proposed in WUI would enhance protection from dangerous and damaging WUI suppression fires. Reduced risk would aid in protecting WUI historic structures and landscape characteristics that contribute to visitor experience quality. WUI economic values would be better protected under Alternative 2 than Alternative 1 resulting largely from reductions in potential for crown and high intensity fires in WUI as a consequence of increased manual/mechanical treatment. Threats to life, property, historical structures, and forest aesthetics, especially large trees, would be reduced. Alternative 2 would provide increased protection to infrastructure and reduce risk of interrupted visitor services. Alternative 2 would reduce the chance of negative local and regional economic impacts resulting from WUI high intensity suppression fires. There would be less risk of small business closures from prolonged reduced visitation. Likelihood of visitors, residents, and employees facing wildfire threat and resulting psychological distress would be reduced.

Overall, Alternative 2 reduces potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting the WUI would be beneficial minor to moderate long term regional.

As noted in Effects Common to All Alternatives, there would still be risk from low intensity fires and embers causing WUI structures to burn. The mitigation measure to develop and implement a treatment prescription around structures would reduce this risk.

Mitigation of Effects **Alternative 2** **Socioeconomics**

Mitigation measures incorporated in alternatives (4.6.2.5) and two proposed as common to all alternatives (4.6.2.10) will decrease adverse impacts to the socioeconomic environment.

Cumulative Effects **Alternative 2** **Socioeconomics**

Cumulative effects for Alternative 2 would be similar to Alternative 1. Alternative 2 would include additional WUI mechanical/manual treatment. Cumulative effects from proposed WUI work would provide greater beneficial cumulative effects to Grand Canyon Village when combined with other fuel treatment projects proposed, completed, or presently active on South Rim and south of the park.

Overall, anticipated cumulative beneficial effects of implementing Alternative 2 with projects discussed earlier would be moderate long term regional.

Conclusion **Alternative 2** **Socioeconomics**

Based on this analysis, Alternative 2 would not result in significant economic activity changes in local communities or the region compared to current conditions as a result of effects on number of people visiting the park. If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

Enhanced landscape aesthetics in the WUI area resulting from mechanical treatments would increase economic value of visitor experiences by an undetermined amount. Because treatments are in high-use areas, total beneficial effects may be relatively large. Net effect on economic value of visitor experiences would be beneficial minor to moderate local long term. From a passive-use value perspective this alternative would likely provide more beneficial effects to park-existence value than Alternative 1. This beneficial impact would likely be minor to moderate regional long term.

Alternative 2 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Alternative 2 would result in moderate improvements in WUI protection from dangerous and damaging wildfire. Potential social and economic impacts of protecting the WUI would be beneficial minor to moderate long term regional.

Overall, anticipated cumulative beneficial effects of implementing Alternative 2 with projects discussed earlier would be moderate long term regional.

4.6.2.13 Alternative 3 Non-Fire Treatment Emphasis Socioeconomics

Alternative 3's emphasis would be non-fire, WUI mechanical/manual treatments. Alternative 3 proposes the highest amount of manual/mechanical treatment in WUI and least amount of prescribed fire and wildland fire use compared with other alternatives. There would be approximately 3,950 acres treated in WUI through mechanical/manual treatment. This alternative treats the lowest number of total acres, with acreage estimates of 25,400 for prescribed fire; 8,800 for wildland fire-use fire; and a projected 26,070 acres fire suppression. The majority of these additional suppression acres are assumed primarily in North Rim forests. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects **Alternative 3** **Socioeconomics**
Local and Regional Economy

Alternative 3 provides the most WUI treatment (compared with other alternatives). This would substantially reduce likelihood of major visitation disruption to the region due to damaging interface suppression fire. Otherwise, local economic impacts would be similar to those with Alternatives 1 and 2.

Economic activity would be affected principally by changes in visitor spending. If fire management reduced visitor numbers to the region or stay length, it would alter economic activity in the region. Regression analysis predicted number of GRCA visits per million U.S. population by GRCA acres burned, gasoline prices, consumer sentiment, and year. Only gasoline prices were a significant visitation predictor. Neither fires nor acres burned in the previous year predicted visitation. Based on this analysis none of the proposed alternatives would result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

Under Alternative 3 wildfire smoke occasionally reduces visibility and may shorten average length of stay. As noted earlier, only about half of those studied said visual air quality would affect length of stay and, according to 4.6.2.3, smoke events would be sufficiently rare that only a small fraction of visitors would be affected during the year. Based on this information, adverse impact would be local short term minor.

Over time, fire and mechanical treatments would enhance aesthetic landscape qualities that may result in more visitors. Increased visitation would increase positive economic impact on local communities.

Under Alternative 3, based on the history of GRCA fire closures, number and duration of area closures would be small and would cause a negligible to minor adverse effect on visitor spending in the region. Concessioners may experience some loss of business, however.

If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse minor to moderate short term regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, this adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

Direct and Indirect Effects **Alternative 3** **Socioeconomics**
Economic Value of Visitor Experiences

Although fire management would not affect number of park visitors, Alternative 3 would result in the greatest improvement in visual air quality, which would increase value of visitor experiences. In addition, increased vegetation management in WUI and along travel routes would result in improved forest aesthetics and possibly increased wildlife encounters where visitors spend the greatest time. This would result in increases in economic value of visitor experiences when compared with other alternatives. Because visitors focus in these areas, impacts would be beneficial moderate to major long term.

Effects on forest aesthetics outside WUI in immediate vicinity of travel routes would be negative as stands become more closed, understory more dense, and aspen more suppressed. The majority of untreated areas are on North Rim. Adverse impact to economic value of visitor experience would be negligible.

Direct and Indirect Effects **Alternative 3** **Socioeconomics**
Passive-Use Values

This alternative provides greatest protection to historic structures and iconic WUI landscapes, and has least adverse effect on visual air quality. Based on this, it would have beneficial impacts on passive-use values. Slower restoration of fire-adapted landscapes outside WUI to near-native condition would reduce potential gains in beneficial effects on passive-use values. Overall, impact to passive-use values would be beneficial moderate regional long term.

Direct and Indirect Effects **Alternative 3** **Socioeconomics**
Engagement and Collaboration

Alternative 3 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts. Significant reduction in potential for dangerous and damaging WUI fire would reduce potential for psychological distress and associated undesirable social impacts.

Direct and Indirect Effects **Alternative 3** **Socioeconomics**
Wildland-Urban Interface

This alternative focuses treatment in and around WUI; thus has greatest potential to reduce economic losses to property, infrastructure, business inventory, livestock, and increased local businesses costs and lost revenue associated with WUI wildfire. In addition, better protection of historic WUI structures, large trees, and forest aesthetics would have beneficial impacts on economic value of visitor experience. As with all alternatives, there would still be risk of direct structural ignition by embers and flame impingement from low intensity surface fire. Proposed mitigation measures to develop and implement treatment prescriptions around structures would lessen this risk. Overall, Alternative 3 does most to reduce potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting WUI would be beneficial moderate long term regional.

Mitigation of Effects **Alternative 3** **Socioeconomics**

Mitigation measures incorporated in alternatives (4.6.2.5) and two proposed as common to all alternatives (4.6.2.10) will decrease adverse impacts to socioeconomic environment.

Cumulative Effects **Alternative 3** **Socioeconomics**

Alternative 3 has the greatest beneficial cumulative effects to socioeconomic environment when compared with other alternatives. Focused treatment is in and around South Rim where the majority of development and use exists. When treatments outside the park on the Kaibab National Forest are included in effects, beneficial impacts increase.

Overall, anticipated cumulative beneficial effects of implementing Alternative 3 with projects discussed earlier would be moderate to major long term regional.

Conclusion **Alternative 3** **Socioeconomics**

Alternative 3 lowers risk of high intensity WUI suppression fire and, consequently, reduces risk of serious negative social and economic impacts to the region.

Based on this analysis, Alternative 3 would not result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park. If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse, minor to moderate, short term, and regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, this adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

More extensive and rapid WUI landscape treatment would increase forest aesthetics but only in the WUI and along travel routes. Visual air quality would be best protected when compared to other alternatives resulting in increases in value of visitor experiences, especially for the large majority of visitors who experience the park mostly from South Rim and roadways. Because the majority of visitors focus in these areas, impacts to the value of visitor experience would be beneficial, moderate to major, and long term.

This alternative provides greatest protection to WUI historic structures and iconic landscapes and least adverse effect on visual air quality; beneficial moderate regional long-term impacts on passive use values.

Alternative 3 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Overall, Alternative 3 does most to reduce potential damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting WUI would be beneficial moderate long term regional.

Alternative 3 has the greatest beneficial cumulative effects to socioeconomic environment when compared with other alternatives. Overall, it is anticipated cumulative beneficial effects of implementing Alternative 3 with the projects discussed earlier would be moderate to major long term regional.

4.6.2.14 Alternative 4 Prescribed Fire Emphasis Socioeconomics

In Alternative 4, fire management program emphasis is to treat vegetation through prescribed fire burning on approximately 90,000 acres; 24,070 acres burned from suppression fires; wildland fire-use fire would be used least of all alternatives, at 5,500 acres; and mechanical/manual treatments would occur at 800 acres in priority areas. A detailed description of this alternative can be found in Chapter 2.

Direct and Indirect Effects Alternative 4 Socioeconomics
Local and Regional Economy

Alternative 4 would have the same effect as noted in effects common to all alternatives and Alternatives 1-3. Economic activity would be affected principally by changes in visitor spending. If fire management reduced visitor number to the region or stay lengths, it would alter economic activity in the region. Regression analysis predicted number of GRCA visits per million U.S. population by GRCA acres burned, gasoline prices, consumer sentiment, and year. Only gasoline prices were a significant visitation predictor. Neither fires nor acres burned in the previous year predicted visitation. Based on this analysis none of the proposed alternatives would result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse, minor to moderate, short term, and regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, this adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

Direct and Indirect Effects **Alternative 4** **Socioeconomics**
Economic Value of Visitor Experiences

For South Rim visitors, minor beneficial effects on forest aesthetics and wildlife encounters (and economic value of visitor experiences) could be expected where prescribed fire-treated areas are visible from travel routes. Adverse minor effects on economic value of visitor experiences would occur due to smoke from fire activities. Mitigation measures including fire interpretation, information, and education would mitigate this adverse effect. Backcountry visitors above the rim would have greater opportunities to experience fire effects first hand which could enhance economic value of their experience. More diverse landscapes and more wildlife encounters would also increase economic value of visitor experiences.

Based on proposed Alternative 4 treatment, forest aesthetic effects (and economic value to visitor experience) would be mixed on North Rim and generally enhanced on South Rim (Ryan 2005).

Enhanced landscape aesthetics in WUI resulting from mechanical treatments would increase economic value of visitor experiences by an undetermined amount. Because treatments are in high-use areas, total beneficial effects may be relatively large. Net effect on economic value of visitor experiences would be beneficial minor local long term.

Direct and Indirect Effects **Alternative 4** **Socioeconomics**
Passive-Use Values

Alternative 4 would provide less protection for historical structures concentrated in the WUI than Alternatives 2 and 3. Potential for adverse effects on passive-use values is marginally higher than under Alternative 2 and substantially higher than under Alternative 3.

As with Alternative 5, more rapid restoration of fire-adapted ecosystems and of fire as an ecological process would result in moderate to major beneficial regional long-term effects on existence values.

Direct and Indirect Effects **Alternative 4** **Socioeconomics**
Engagement and Collaboration

Alternative 4 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Direct and Indirect Effects **Alternative 4** **Socioeconomics**
Wildland-Urban Interface

Under this alternative, potential for dangerous and destructive WUI suppression fire would be somewhat greater compared with Alternatives 2 and 3. Nevertheless, Alternative 4 provides minor to moderate reductions in potential direct economic losses due to WUI fire. As with all alternatives, direct structural ignition by embers and flame impingement from low intensity surface fire remain a threat. Proposed mitigation measures to develop and implement treatment prescriptions near structures would lessen risk.

Potential for major regional long-term economic disruptions resulting from reduced visitation and direct economic losses to WUI fire is marginally greater under this alternative than under Alternative 2, and substantially greater than under Alternative 3. Overall, Alternative 4 reduces potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting the WUI would be beneficial minor long term regional.

Mitigation of Effects **Alternative 4** **Socioeconomics**

Mitigation measures incorporated in alternatives (4.6.2.5) and two proposed as Common to All Alternatives (4.6.2.10) will decrease adverse impacts to socioeconomic environment.

Cumulative Effects **Alternative 4** **Socioeconomics**

Cumulative effects would be very similar to Alternative 2. Anticipated cumulative beneficial effects of implementing Alternative 4 with projects discussed earlier would be moderate long term regional.

Conclusion **Alternative 4** **Socioeconomics**

Based on this analysis, Alternative 4 would not result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park. If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse, minor to moderate, short-term, and regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, this adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

Minor beneficial effects on forest aesthetics and wildlife encounters (and economic value of visitor experiences) could be expected where prescribed fire-treated areas are visible from travel routes. Adverse minor effects on economic value of visitor experiences would occur due to smoke from fire activities. Enhanced landscape aesthetics in WUI resulting from mechanical treatments would increase economic value of visitor experiences by an undetermined amount. Because treatments are in high-use areas, total beneficial effects may be relatively large. Net effect on economic value of visitor experiences would be beneficial minor local long term.

Rapid restoration of fire-adapted ecosystems and fire restoration as an ecological process would result in moderate to major beneficial regional long-term effects on passive-use and/or existence values. Alternative 4 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Under this alternative, potential for dangerous and destructive suppression WUI fire would be somewhat greater when compared with Alternatives 2 and 3. Nevertheless, Alternative 4 provides minor to moderate reductions in potential for direct economic losses due to WUI fire. Overall, Alternative 4 reduces potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting the WUI would be beneficial minor long term regional.

Cumulative effects would be very similar to Alternative 2. Anticipated cumulative beneficial effects of implementing Alternative 4 with projects discussed earlier would be moderate long term regional.

4.6.2.15 Alternative 5 Fire Use Emphasis Socioeconomics

Alternative 5 emphasis is to restore and maintain forest types with wildland fire use (88,000 acres). With the focus on wildland fire use, fewer fires will be suppressed, at a projected 18,050 acres, lowest of all alternatives. This alternative de-emphasizes prescribed fire treatments 29,900 acres. Mechanical/manual treatments would total approximately 2,675 acres and occur in WUI and along Highway 67 on North Rim. Consult Chapter 2 for a detailed description of this alternative.

Direct and Indirect Effects **Alternative 5** **Socioeconomics**
Local and Regional Economy

Alternative 5 has the same effect noted in Effects Common to All Alternatives and Alternative 1.

Economic activity would be affected principally by changes in visitor spending. If fire management reduced visitor numbers to the region or stay lengths, it would alter economic activity in the region. Regression analysis predicted number of GRCA visits per million U.S. population by GRCA acres burned, gasoline prices, consumer sentiment, and year. Only gasoline prices were a significant visitation predictor. Neither fires nor acres burned in the previous year predicted visitation. Based on this analysis none of the proposed alternatives would result in significant changes in economic activity in local communities or the region compared to current conditions as a result of effects on number of people visiting the park.

If wildland fire results in many periods of longer-than-average length of stay when canyon visibility is obscured all day, and up to half of visitors on such days leave the park and the region, and if spending patterns do not change, regional economic impacts might be adverse, minor to moderate, short term, and regional. However, because it is unlikely that many visitors who leave GRCA earlier than planned also leave the region earlier than planned, this adverse effect would likely be less. Based on this information, adverse impact to the local and regional economy would be local short term minor.

Direct and Indirect Effects **Alternative 5** **Socioeconomics**
Economic Value of Visitor Experiences

Alternative 5 would have similar effects as Alternative 4. Backcountry visitors above the rim would have greater opportunities to experience fire effects firsthand which could enhance economic value of their experience. More diverse landscapes and more wildlife encounters would also increase economic value of visitor experiences. In addition, wildland fire-use fires could increase negative smoke effects on economic value of visitor experiences on the rim and in the canyon because wildland fire-use fires burn longer than prescribed fires, and greater opportunity would exist for smoke events to adversely affect the canyon.

Enhanced landscape aesthetics in WUI resulting from mechanical treatments would increase economic value of visitor experiences by an undetermined amount. Because treatments are in high-use areas, total beneficial effects may be relatively large. Net effect on economic value of visitor experiences would be beneficial minor local long term.

Direct and Indirect Effects **Alternative 5** **Socioeconomics**
Passive-Use Values

Due to treatment proposed, Alternative 5 would provide slightly less protection for historical structures concentrated in WUI than Alternative 3, and slightly more than Alternative 2. Potential for adverse effects on passive-use values is marginally higher than Alternative 3, and slightly less than Alternative 2.

As with Alternative 4, rapid restoration of fire-adapted ecosystems and fire as an ecological process would result in moderate to major beneficial regional long-term effects on existence and/or passive-use values.

Direct and Indirect Effects **Alternative 5** **Socioeconomics**
Engagement and Collaboration

Alternative 5 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Direct and Indirect Effects **Alternative 5** **Socioeconomics**
Wildland-Urban Interface

Alternative 5 proposes the second highest WUI treatment amount (Alternative 3 proposes the highest). Amount is slightly less than proposed in Alternative 3; therefore, effects to WUI would be slightly less, if not the same, as Alternative 3. Overall, Alternative 5 reduces potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting WUI would be beneficial moderate long term regional.

As with all alternatives, there would still be risk of direct structural ignition by embers, and flame impingement from low intensity surface fire would remain a threat. Proposed mitigation measures to develop and implement treatment prescriptions around structures would lessen this risk.

Mitigation of Effects **Alternative 5** **Socioeconomics**

Mitigation measures incorporated in alternatives (4.6.2.5) and two proposed as common to all alternatives (4.6.2.10) will decrease adverse impacts to socioeconomic environment.

Cumulative Effects **Alternative 5** **Socioeconomics**

Alternative 5 would have similar socioeconomic cumulative effects as Alternative 3. Anticipated cumulative beneficial effects of implementing Alternative 1 with projects discussed earlier would be moderate to major long term regional.

Conclusion **Alternative 5** **Socioeconomics**

Alternative 5 has the second highest WUI treatment. Potential of a dangerous and destructive WUI suppression fire would be reduced with this alternative.

Wildland fire-use fire would increase negative smoke effects on economic value of visitor experiences on the rim and in the canyon because wildland fire-use fires burn longer than prescribed fires, and opportunity would be greater for smoke events that could adversely affect the canyon. On the other hand, wildland fire-use fires produce more diverse fire effects than prescribed fires typically do, and could increase economic value of visitor experiences for above the rim backcountry use. Net effect on economic value of visitor experiences would be beneficial minor local long term.
As with Alternative 4, rapid restoration of fire-adapted ecosystems and fire as an ecological process would result in moderate to major beneficial regional long-term effects on existence and/or passive-use values.

Alternative 5 would have the same effect as noted in Effects Common to All Alternatives: increased engagement and collaboration on fire management with other agencies and local communities would have potential for moderate to major regional long-term beneficial social impacts.

Alternative 5 proposes the second highest WUI treatment amount (Alternative 3 proposes the highest). Amount is slightly less than proposed in Alternative 3; therefore, effects to WUI would be slightly less, if not the same, as in Alternative 3. Overall, Alternative 5 reduces potential for damaging WUI fire resulting in serious negative social and economic impacts. Potential social and economic impacts of protecting WUI would be beneficial moderate long term regional.

Alternative 5 would have similar socioeconomic cumulative effects as Alternative 3. Anticipated cumulative beneficial effects of Alternative 5 with projects discussed earlier would be moderate to major long term regional.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts **Socioeconomics**

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternatives 1-5 would have adverse minor short-term local impacts since suppression fire would obscure visibility, which may cause shorter regional visitation lengths.

Only Alternative 1 would have major adverse long-term regional impacts due to restricted manual fuel reduction projects in WUI areas which will not noticeably reduce fuels that increase wildland fires.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short-term gains affecting long-term productivity.

Irreversible/Irretrievable Commitments of Resources **Socioeconomics**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during the implementation of the plan and could not be reused or recovered during the lifespan of the plan.

There would be no irreversible or irretrievable commitments of resources.

4.6.3 Park Management and Operations

4.6.3.1 Guiding Regulations and Policies — Park Management and Operations

- NPS Management Policies 2006 provides guidance for fire-management visitor safety and emergency response, law enforcement, aviation use, natural resources and cultural resources management, wilderness preservation and management, and park uses
- Director's Order 18, Wildland Fire Management, provides policy affecting park fire management personnel and operations. According to DO-18, agency administrators "...will ensure that trained and certified employees are made available to participate in wildland fire management activities, as the situation demands, and that employees with operational, administrative, or other skills support the wildland fire program as needed."

4.6.3.2 Methodology for Analyzing Effects — Park Management and Operations

Park management and operations include the human and fiscal resources available and/or needed to protect and preserve park natural and cultural resources and provide safe and enjoyable visitor experiences. Park staff evaluated impacts of each alternative and based analysis on current park management and operations summarized in Chapter 3.

Fire management activities fluctuate based on weather patterns, personnel and equipment availability, routine activities, and unplanned wildland fire incidents. These fluctuations cause varying impacts on routine park operations.

4.6.3.3 Impact Thresholds Park Management and Operations

Effects on park management and operations are characterized in terms of intensity, context, duration, and timing for each alternative based on impact thresholds below. Each alternative was also evaluated to determine if effects are direct or indirect. A direct effect is caused by an action and occurs in the same time and place. An indirect effect is caused by an action but is later in time or farther away, but is still reasonably foreseeable.

Intensity

Negligible — Effects on park management and operations would not be apparent to park staff or the public. Differences in costs would be less than 5% of existing levels

Minor

Adverse — Impacts would result in small but measurable detrimental effects on park management and operations. Measurable increases in cost would be 5% to 15% of existing levels

Beneficial — Impacts would result in small but measurable improvements in park management and operations. Measurable reductions in cost would be 5% to 15% of existing levels

Moderate

Adverse — Impacts would result in detrimental changes to park management or operations in a manner noticeable to staff and the public. Measurable increases in cost would be 15% to 30% of existing levels

Beneficial — Impacts would result in improvements in management and operations in a manner noticeable to staff and public. Measurable decreases in cost would be 15% to 30% of existing levels

Major

Adverse — Impacts would be readily apparent and would result in a substantial detrimental change to park management or operations in a manner very noticeable to staff and the public. Measurable increases in cost would exceed 30% of existing levels

Beneficial — Impacts would be readily apparent and would result in a substantial improvement to park management and operations in a manner very noticeable to staff and the public. Measurable decreases in cost would exceed 30% of existing levels

Context

Local — Effects would be realized at specific sites or locations

Regional — Effects would be realized at several sites and/or locations and would be applicable to one or more management zones

Duration

Short term — Effects would occur for the project's or incident's duration, a period less than one year, based on short-term funding

Long term — Effects would last longer than the project or incident's duration, for a period of one year or more

Timing — Effects could be realized year-round or during specific seasons

4.6.3.4 Cumulative Impacts — Park Operations

Cumulative impacts on park management and operations were determined by combining impacts of each alternative with other past, present, or reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time.

Uncontrolled high intensity catastrophic wildfire has greatest potential for cumulative impacts on park management and operations, as it may result in an emergency situation which completely disrupts all other operations, up to the potential for evacuation and/or closure of park facilities and offices, and possible destruction of park facilities, offices, and records. Therefore, the extent that alternatives increase or reduce potential for such catastrophic wildfires are the focus of the cumulative impacts analyses.

Fire management activities in and adjacent to GRCA have potential to impact park management and operations. GRCA fire management personnel may be called to assist with fire management activities originating on adjacent lands. In addition, GRCA has interagency agreement with the Kaibab National Forest to share fire management resources (personnel, equipment) in a way that best meets both agencies' management objectives and benefits national forest and park. Similar agreements for interagency cooperation in other park areas are possible during the life of this plan to increase efficiency of fire management programs across boundaries and reduce costs for both NPS and adjacent land managers.

Fire management activities on adjacent lands could potentially impact park operations because fires originating on adjacent lands may cross park boundaries requiring park fire management actions and possible closures or other access restrictions that affect transportation and facilities management. Adjacent lands include Kaibab National Forest, Grand Canyon-Parashant National Monument, Lake Mead National Recreation Area, Glen Canyon National Recreation Area, the Navajo Nation, Hualapai Indian Reservation, and Havasupai Indian Reservation.

Alternative 1 is the baseline condition, and would have a negligible long-term cumulative regional impact on park management and operations. The other alternatives will be compared against Alternative 1 in terms of potential risk of uncontrolled high intensity wildfires and their effects to park management and operations. Fire management activities on adjacent lands have potential for negligible to major beneficial or adverse cumulative effects on park operations in the event activities on adjacent lands decrease or increase potential for an uncontrolled high intensity fire to start on adjacent lands and move into the park. Similarly, fire management activities on park lands have potential for negligible to major adverse or beneficial effects on adjacent lands.

Other park plans and operations that would have a negligible effect on park fire management programs or operations (and therefore are not discussed further in the analysis) include

- South Rim Transportation Plan, with additional shuttle bus facilities being considered near the South Rim Firebase/Helibase
- Park Structural Fire Operations, which are expected to remain almost entirely separate from Wildland Fire Operations organizationally and physically
- Future projects that may result in changes in utilities, housing, parking lots, roads, or other facilities that might affect fire protection priorities

4.6.3.5 Assumptions — Park Operations

The following assumptions are based on the best professional judgment of GRCA and regional fire management personnel when projecting past experience with fire management activities to conditions expected in the alternatives. These assumptions form the basis for calculated values in Appendix H and the impacts analysis that follows.

- Initial vs. Subsequent Treatments
  - The first time an area is treated requires the most personnel, equipment, and subsequent cost because risks are usually greater and require greater preparation to ensure safety

- Funding
  - At present, funding from the national NPS base fire account (FIREPRO) supports almost all park fire management programs and operations, including staff positions not funded out of park base (ONPS) funds. It is assumed that this would continue, so alternatives would not affect other park programs through competition for base or project funds
- Program Cost and Operations
  - See Appendix H for all specific cost and operations assumptions. Assumptions include personnel days, operation days, flight hours, trail closures, road closures, and handline construction miles

4.6.3.6 Impact Analysis Impacts Common to All Alternatives Park Operations

The current fire management organization is expected to continue unchanged under all alternatives. Alternatives examine different ways the organization can be deployed and supplemented to accomplish fire management objectives described in Chapter 1.

4.6.3.7 Alternative 1 No Action Park Operations Management and Operations Existing Program

Under the No Action Alternative, approximately 5,320 acres will be treated annually with prescribed fire; 5,000 acres with wildland fire use; 1,800 acres suppression fire; and 40 acres manual thinning. About 12,100 total acres would be treated annually. There will be years when annual acres treated will be much greater or less than this average. The average annual cost/acre for all fire management activities would be approximately $163/acre.

Annually, it could take approximately 3,130 person days for park personnel; 3,742 person days for non-park personnel; and about 120 operation days to accomplish acres listed above. Average annual impacts to trails and roads could include about 12 trail closure days and 10 road closure days. There would be roughly 9 handline miles constructed during suppression, wildland fire use, and prescribed fire operations. Fire operations that require helicopter use could add up to 156 flight time hours annually.

Because Alternative 1 is the No Action Alternative, the above numbers are the baseline condition against which other alternatives will be compared to assess changes in park management and operations. Because Alternative 1 would continue the existing program, direct impacts would be negligible long-term regional on overall management and operations. Direct impacts would be greatest April through October (with the most active time being May to August), when most fire management activities take place.

Cumulative Impacts Alternative 1 Park Operations

Since Alternative 1 is the baseline condition, it would have a negligible long-term cumulative regional impact on park management and operations as discussed above in the cumulative impact methodology for park management and operations.

Conclusion Alternative 1 Park Operations

Because it is the No Action baseline condition, Alternative 1 will have negligible long-term regional impacts on park management and operations. Cumulatively, Alternative 1 is the baseline condition, so it would have a negligible long-term regional impact on park management and operations.

4.5.3.8 Alternative 2 Management and Operations | Preferred Alternative Mixed Fire Treatment Program | Park Operations

Under Alternative 2, approximately 5,300 acres will be treated annually with prescribed fire; 5,000 acres with wildland fire-use fire; 1,800 acres of suppression fire; and 40 acres with manual thinning. An additional 210 mechanical thinning acres would occur annually in WUI. Approximately 12,400 total acres would be treated annually. There will be years when annual acres treated will be much less or greater than this average. The average annual cost/acre for all fire management activities would be approximately $167/acre. Even though Alternative 1 and 2 are very similar, addition of mechanical thinning increases acres treated, cost/acre, and staff requirements.

Annually, it could take approximately 3,162 person days for park personnel; 4,130 person days for non-park personnel; and about 180 operation days to accomplish acres listed above. Average annual impacts to trails and roads could include approximately 12 trail closure days and 10 road closure days. There would also be roughly 9 handline miles constructed during suppression, wildland fire use, and prescribed fire operations. Fire operations that require helicopter use could reach 156 flight time hours annually.

Compared to Alternative 1, Alternative 2 has an average additional cost of $9 per acre (a 6% increase), a 1% increase in person-days for park personnel, a 10% increase in person-days for non-park personnel, a 49% increase in operation-days, and an 8% increase in annual cost. Addition of mechanical thinning creates these increases. Overall, this would result in negligible to minor long-term regional adverse impacts for all indicators except operation days, which would be at a moderate adverse impact level.

Cumulative Impacts | Alternative 2 | Park Operations

Similar to Alternative 1, fire management practices in Alternative 2 would benefit treated areas, but areas not treated would continue at risk to adverse effects of uncontrolled high intensity fire. As treatments proposed in the alternative occur, potential should decline over time.

Because Alternative 2 proposes more WUI treatment, a more balanced approach, and more effective fire management zones than Alternative 1, it would reduce potential for adverse effects of a large uncontrolled high intensity wildfire on park management and operations to the extent that it would have moderate beneficial long-term regional cumulative impacts compared to Alternative 1.

Conclusions | Alternative 2 | Park Operations

Overall, Alternative 2 will have negligible to moderate long-term regional adverse direct impacts on park management and operations compared to Alternative 1. Alternative 2 has the same totals as Alternative 1 for all treatment types except 2,117 additional mechanical thinning acres, which, along with fire management zone changes, will help protect park facilities, residents, and visitors in WUI to a greater extent than Alternative 1.

Alternative 2 would have moderate beneficial long-term regional cumulative indirect impacts compared to Alternative 1 due to reduced potential for high intensity wildfire.

4.6.3.9 Alternative 3 Management and Operations | Non-Fire Treatment Emphasis | Park Operations

Under Alternative 3, approximately 2,230 acres will be treated annually with prescribed fire; 800 acres with wildland fire-use fire; 2,400 acres with suppression fire; 60 acres with manual thinning; and 335 acres with mechanical thinning. Approximately 5,900 total acres would be treated annually. Annual acres treated is less than half of all other alternatives. There will be years when annual acres treated will be much less or greater than this average. Average annual cost/acre for all fire management activities would be approximately $227/acre. Since emphasis of this alternative is protecting WUI with manual/mechanical thinning projects, the cost per acre will increase. Alternative 3 is most expensive in cost/acre.

Annually, it could take approximately 1,580 person days for park personnel; 3,225 person days for non-park personnel; and about 180 operation days to accomplish acres listed above. Average annual impacts to trails and roads could include approximately 7 trail closure days, and 7 road closure days. There would also be roughly 10 handline miles constructed during suppression, wildland fire use, and prescribed fire operations. Fire operations that require helicopter use could add up to 155 hours of flight time annually.

Compared to Alternative 1, Alternative 3 has an average additional cost of $64 per acre (a 39% increase); a 50% decrease in person-days for park personnel; a 15% decrease in person-days for non-park personnel; a 49% increase in operation days; and a 33% decrease in annual cost. Cost/acre would increase by 39%, and total acres treated would be less than half the acres treated in Alternative 1. Overall, this would result in moderate long-term regional adverse impacts to cost per acre and operation days, but also minor to major long-term regional beneficial impacts to park and non-park person-days and annual cost.

Cumulative Impacts Alternative 3 Park Operations

Similar to Alternative 1, fire management practices in Alternative 3 would generally benefit treated areas, but areas not treated would continue at risk to adverse effects of uncontrolled high intensity fire. As proposed treatments occur, that potential should decline over time. Because Alternative 3 treats the fewest acres of all alternatives by a large margin, it would result in the highest risk of uncontrolled high intensity wildfires among all alternatives, resulting in potential moderate to major adverse long-term regional cumulative impacts on park management and operations compared to Alternative 1.

Conclusions Alternative 3 Park Operations

Overall, Alternative 3 will have moderate adverse long-term impacts on park management and operations compared to Alternative 1. Alternative 3 has highest cost per acre and fewest acres treated. Alternative 3 will also have minor to major beneficial long-term impacts on park management and operations as Alternative 3 also has lowest total cost, and lowest park personnel days required to implement.

Because Alternative 3 treats the fewest acres of all alternatives by a large margin, it carries highest risk of uncontrolled high intensity wildfires resulting in potential moderate to major adverse long-term regional cumulative impacts on park management and operations compared to Alternative 1.

4.6.3.10 Alternative 4 Prescribed Fire Emphasis Park Operations Management and Operations

Under Alternative 4, approximately 8,200 acres will be treated annually with prescribed fire; 500 acres with wildland fire-use fire; 2,200 acres with suppression fire; 20 acres with manual thinning; and 100 acres with mechanical thinning. Approximately 10,980 total acres would be treated annually. Annual acres treated with prescribed fire is most of all alternatives. There will be years when annual acres treated will be much less or greater than this average. The average annual cost/acre for all fire management would be approximately $134/acre. Since alternative emphasis is treating forested landscapes with prescribed fire, the cost of this alternative is lower than all other alternatives except 3. Alternative 4 is the least expensive alternative when considering cost/acre.

Annually, it could take approximately 3,030 person days for park personnel; 2,500 person days for non-park personnel; and about 89 operation days to accomplish acres listed above. Average annual impacts to trails and roads could include approximately 9 trail closure days and 9 road closure days. There would also be roughly 11 handline miles constructed during suppression, wildland fire use, and prescribed fire operations. Fire operations that require helicopter use could add up to 156 hours of flight time annually.

Compared to Alternative 1, Alternative 4 has an average cost of $29 per acre (a 22% decrease); a 4% decrease in person-days for park personnel; a 49% decrease in person-days for non-park personnel; a 34% decrease in operation days; and a 35% decrease in annual cost. Overall, this would result in negligible to major long-term regional beneficial impacts to cost per acre, non-park person-days, operation days, and annual cost.

Alternative 4 does not allow many opportunities to manage wildland fire under a fire use strategy which may reduce attainment of a mosaic of fire effects throughout the park. This alternative is the least expensive alternative in terms of cost per acre due to use of aerial ignition techniques to ignite large prescribed burn units in a very short time. Large time commitments will be required to plan and prepare such a large prescribed fire program, thus this alternative requires the largest time commitments for staff.

Cumulative Impacts Alternative 4 Park Operations

Similar to Alternative 1, fire management practices in Alternative 4 would generally benefit treated areas, but areas not treated would continue at risk to adverse effects of uncontrolled high intensity fire. As treatments proposed in the alternative occur, potential should decline over time.

Because Alternative 4 proposes the second highest total treated acres, but does so primarily using prescribed fire treatments rather than a more balanced approach, it would reduce potential for adverse effects of a large uncontrolled high intensity wildfire on park management and operations, and thus have minor beneficial long-term regional cumulative impacts compared to Alternative 1.

Conclusions Alternative 4 Park Operations

Overall, Alternative 4 will have negligible to major long-term regional beneficial impacts to management and operations; beneficial impacts come from the alternative's annual cost being lower than Alternative 1.

Cumulatively, Alternative 4 would have minor beneficial long-term regional cumulative impacts compared to Alternative 1.

4.6.3.11 Alternative 5 Fire Use Emphasis Park Operations Management and Operations

Under Alternative 5, approximately 2,700 acres will be treated annually with prescribed fire; 8,000 acres with wildland fire-use fire; 1,640 acres with suppression fire; 40 acres with manual thinning; and 225 acres with mechanical thinning. Approximately 12,636 total acres would be treated annually. The annual acres treated with wildland fire use is the most of all alternatives. There will be years when annual acres treated will be much less or greater than this average. The average annual cost/acre for all fire management would be approximately $197/acre.

Annually, it could take approximately 3,070 person days for park personnel; 4,800 person days for non-park personnel; and about 205 operation days to accomplish acres listed above. Average annual impacts to trails and roads could include approximately 14 trail closure days and 11 road closure days. There would also be roughly 8 handline miles constructed during suppression, wildland fire use, and prescribed fire operations. Fire operations that require helicopter use could add up to 158 hours of flight time annually.

Compared to Alternative 1, Alternative 5 has an average greater cost per acre of $34 (a 20% increase); a 2% decrease in person-days for park personnel; a 28% increase in person-days for non-park personnel; and a 72% increase in operation days. Overall, this would result in moderate long-term regional adverse impacts to cost per acre, non-park person-days, and annual cost. It would also have major long-term regional adverse impacts on operation days. In addition, it would have negligible long-term regional beneficial impacts to park person-days.

Alternative 5 would require more non-park fire managers and fire fighters than any other alternative to assist with increased wildland fire-use fires that could occur. Managing wildland fire under a fire use strategy will increase opportunities to a mosaic of fire effects throughout the park. Due to reduced prescribed fire planning and preparation needs, more attention could be spent on planning and implementing non-fire treatments. This alternative includes the second largest non-fire treatment program, allowing completion of all but a few WUI treatment units.

Cumulative Impacts Alternative 5 Park Operations

Similar to Alternative 1, fire management practices in Alternative 5 would generally benefit treated areas, but areas not treated would continue at risk to adverse effects of uncontrolled high intensity fire. As treatments proposed in the alternative occur, potential should decline over time.

Alternative 5 proposes the second lowest total treated acres, but the total is only about 300 acres per year less than the alternative with the highest total treated acres. Alternative 5 will reduce potential for adverse effects of a large uncontrolled high intensity wildfire on park management and operations, but not as much as a more balanced approach. Therefore, overall Alternative 5 will have minor beneficial long-term regional cumulative impacts compared to Alternative 1.

Conclusions Alternative 5 Park Operations

Overall, Alternative 5 will have moderate to major adverse regional long-term direct impacts to management and operations. Adverse impacts would come from increased operation days and annual cost compared to Alternative 1. However, Alternative 5 will also have negligible beneficial long-term regional impacts to management and operations. Benefits would come from reduced in-park personnel-days compared to Alternative 1.

Cumulatively, Alternative 5 will have minor beneficial long-term regional cumulative impacts compared to Alternative 1.

THE NEXT THREE TOPICS COVER ALTERNATIVES 1, 2, 3, 4, AND 5.

Unavoidable Adverse Impacts Park Operations

Unavoidable adverse impacts are environmental consequences that cannot be avoided, whether it be by implementing mitigation measures or by changing the nature of a proposed action, Thus unavoidable adverse impacts would persist throughout the duration of the action.

Alternative 2 would have adverse negligible to moderate long-term regional impacts due to increased mechanical thinning operations, program costs, and operation days.

Alternative 3 would have adverse moderate long-term regional impacts from high cost/acre and fewest acres treated. Alternative 3 effects from cumulative impacts would be adverse moderate to major long-term regional due to suppression wildland fire risk from less use of prescribed and wildland fire-use fires.

Alternative 5 would have adverse moderate to major long-term regional impacts from increased operation days and program costs due to increased fire management activities.

Loss in Long-Term Availability or Productivity of the Resource to Achieve Short-Term Gain

There would be no short- term gains affecting long- term productivity.

Irreversible/Irretrievable Commitments of Resources **Park Operations**

An irreversible commitment of resources occurs if the commitment cannot be changed once made throughout the lifespan of the plan. Irretrievably committed resources are used, consumed, destroyed, or degraded during the implementation of the plan and could not be reused or recovered during the lifespan of the plan.

There would be no irreversible or irretrievable commitments of resources.