Chapter 3 Affected Environment

The region potentially affected by alternatives considered in this environmental impact statement is Grand Canyon National Park in northwestern Arizona. The area of analysis includes the rims north and south of the Colorado River, and falls mostly within the national park. The socioeconomic analysis regional area of potential impact includes adjacent lands and communities in northern Arizona, southern Utah, and southeastern Nevada that have socioeconomic ties to Grand Canyon.

3.1 Biological Environment

Five vegetation types in Grand Canyon National Park may be affected by the proposed Fire Management Plan. These vegetation types include one of the last relic spruce-fir forests in the Southwest and ponderosa pine forests with limited historical logging activity. North Rim's mixed-conifer forest is unique due to the lack of similar forest types in the Southwest. Piñon-juniper vegetated areas are common to northern Arizona, and will be subject to very limited planned projects (see Chapter 2 for alternatives descriptions). Fire histories differ for each forest type, but include a range of fire regimes including frequent low-intensity fires in ponderosa pine to infrequent mixed- or high-severity fires in spruce-fir in the park's highest elevations. Portions of the park's forested areas have experienced limited fire suppression efforts over the past 100 years.

3.1.1 Vegetation

3.1.1.1 Overview Vegetation

Grand Canyon's five major vegetation types likely affected by fire management practices are
- Spruce-Fir Forest
- Mixed-Conifer Forest
- Montane-Subalpine Grassland
- Ponderosa Pine Forest
- Piñon-Juniper Vegetation Type

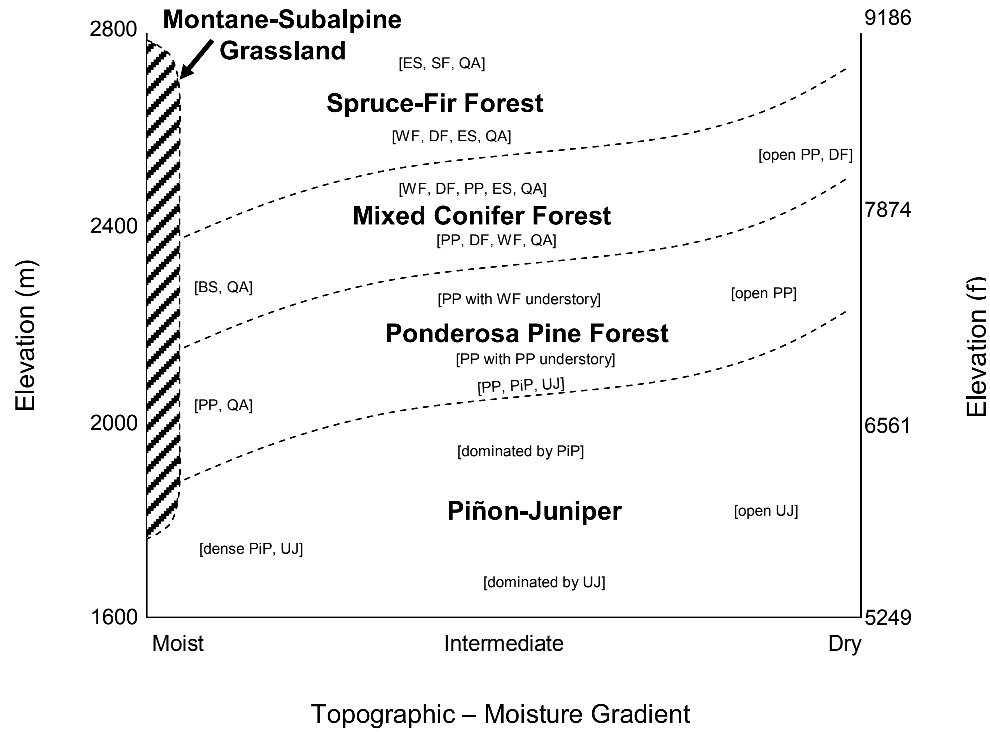
The only vegetation types not being treated are those located below the rim, in the Inner Canyon FMU.

Vegetation Type Distribution Overview Vegetation

GRCA's vegetation types are distributed primarily along an elevational gradient and secondarily along a topographic-moisture gradient in which moisture availability is determined largely by topographic position (e.g., valley bottoms are moist and ridge tops dry) (Figure 3-1).

GRCA's highest elevations have spruce-fir forest characterized by Engelmann spruce, subalpine fir, and quaking aspen. With decreasing elevation, there is a gradual, often patchy transition with mixed-conifer forest, which consists of a mosaic of topography-based patches dominated by different combinations of ponderosa pine (*Pinus ponderosa* var. *scopulorum*), Douglas fir, white fir, blue spruce, quaking aspen, and other species. With decreasing elevation, mixed-conifer forest intergrades with ponderosa pine forest, which is dominated by its namesake species. This forest intergrades, often patchily, at lower elevation with piñon-juniper vegetation dominated by piñon pine (primarily *Pinus edulis*) and Utah juniper (*Juniperus osteosperma*). In addition, montane-subalpine grassland dominated by fescues (*Festuca* spp.) and other grasses occurs in some valley bottoms across most of the elevational gradient.

Figure 3-1 Major Vegetation Types Affected by GRCA Fire Management Distributed Along Elevation Gradients and Topography-based Moisture Availability



Dominant tree species for specific sites are listed in brackets (BS = blue spruce, DF = Douglas fir, ES = Engelmann spruce, PiP = piñon pine, PP = ponderosa pine, QA = quaking aspen, SF = subalpine fir, UJ = Utah juniper, and WF = white fir)

3.1.1.2 Spruce-Fir Forest — Vegetation

Spruce-fir forest occupies North Rim's highest elevations, generally 8,202-9,186 feet (Merkle 1954, White and Vankat 1993). It occurs across all topographic positions above approximately 8,858 feet, but is limited to relatively moist sites such as north-facing hillsides and valley bottoms at lower elevations where mixed-conifer forest occupies drier sites (White and Vankat 1993). Therefore, the transition from spruce-fir to mixed-conifer forest is indistinct, involving mosaic stands determined by topographic position. The spruce-fir forest consists of approximately 17,700 acres on North Rim. This forest type covers 1.5% of the park and 16% of the coniferous forests in the park. Overstory species that make up the spruce-fir forest include Engelmann spruce, subalpine fir, aspen, ponderosa pine, white fir, and Douglas fir. Approximately 30% of the spruce-fir forest has experienced a recent fire event. The North Kaibab District of the Kaibab National Forest has identified approximately 29,000 acres of spruce-fir forests near or adjacent to the park's spruce-fir forests (USDA, 2008c).

Research evidence suggests spruce-fir forests formerly burned as infrequent stand-replacement fires and more frequent, less severe ground fires. Existing research for Southwestern fire regimes of spruce-fir forests includes work from Moir 1993, Swetnam and Baisan 1996, Allen 2002, and others. There is strong evidence that fire has been an important natural influence in spruce-fir forests (Leiberg et al. 1904, Merkle 1954, Grissino-Mayer et al. 1995, Fulé et al. 2003a).
There is some evidence suggesting a stand-replacement fire regime existed in the Southwest. Grissino-Mayer et al. (1995) reported trees greater than 300 years old in a stand in southeastern Arizona and

suggested they dated to a stand-replacement fire. A stand-replacement fire regime has also been proposed for GRCA (Merkle 1954, White and Vankat 1993). In addition, some historical accounts can be interpreted as suggestive of past stand-replacement fire. Lang and Stewart (1910) stated that the Kaibab Plateau in general contained “vast denuded areas, charred stubs and fallen trunks and the general prevalence of blackened poles” and that “old fires extended over large areas at high altitudes, amounting to several square miles.”

North Rim research conducted in Little Park and at Galahad Point by Fulé et al. (2003a) specifically addressed current forest stand composition and fire regimes from ponderosa pine to spruce-fir forests. Fire initiated forest stands (indicative of stand-replacing fire events) were distinguished by age and species composition data, and delineated by groups of trees that originated following stand-replacement fire. Fulé’s research indicated the truer spruce-fir stands, primarily on the north and east aspects, had 71% fire-initiated plots, indicating stand-replacement fire created current forest structure on those plots. On west and south aspects, a mixed-severity fire regime was indicated, with 51% fire-initiated plots versus 49% non-fire initiated plots. Most recorded historic fire scars occurred during summer, and wide-ranging fires correlated with dry years that generally followed several wet years. Mean fire intervals from 1700 to 1879 were 8.8 years for 10% scarring (15.9 years at greater than 9,022 feet elevation) and 31.0 years for 25% scarring.

Insects and Pathogens **Spruce-Fir Forest** **Vegetation**

Bark beetles, including spruce beetle, are important disturbance agents in Southwestern spruce-fir forests, with different beetle species affecting different tree species. In addition, western spruce budworm (*Choristoneura occidentalis*) can affect both Engelmann spruce and subalpine fir (Alexander 1987), but in the Southwest it affects mostly white fir and Douglas fir (Moir 1993, Dahms and Geils 1997). Therefore, it has greater impact on stands near the mixed-conifer forest transition where these tree species are more common. The most common pathogens are root diseases (Dahms and Geils 1997) and wood-rotting fungi, with basal decay occurring in old wounds and frost cracks (Alexander 1987).

Many studies have shown that spruce beetles have greatest impact in the Southwest of any insect or pathogen affecting spruce-fir forest. Outbreaks are considered natural. Populations are kept low by nematodes, insect parasites, and insect predators such as woodpeckers (Alexander 1987). Large population outbreaks are favored by several factors such as predominance of Engelmann spruce in the canopy, high stand-basal area concentrated in older, larger diameter Engelmann spruce, single aged or mixed-age stands; slow diameter growth; time since fire; mild winters; high elevation; and well-drained creek-bottom sites (Schmid and Hinds 1974, Schmid and Frye 1977, Veblen et al. 1994; Bebi et al. 2003).

Vegetation Dynamics **Spruce-Fir Forest** **Vegetation**

Old stands of spruce-fir forest on North Rim are currently experiencing high canopy tree mortality of Engelmann spruce and subalpine fir. With overstory mortality, young fir trees are growing into these stands along with young aspen. Dead spruce and fir are standing snags as well as fallen logs, providing a wide diversity of tree species, age classes, and ground fuel accumulations.

Vegetation Structure and Composition Pre-European-American Influence **Spruce-Fir Forest** **Vegetation**

Early descriptions indicate that Engelmann spruce and subalpine fir generally dominated at higher elevations. Lower elevations had quaking aspen, white fir, Douglas fir, blue spruce, and ponderosa pine (Moir 1993, Pase and Brown 1994b), reflecting transition with mixed-conifer forest. Blue spruce was most abundant in drainages and along meadow margins (White and Vankat 1993, Pase and Brown 1994b).

Vegetation Structure and Composition **Spruce-Fir Forest** **Vegetation**
European-American Influence

Various authors have suggested that current structure and composition of Spruce-Fir Forest in the Southwest are within the natural range of variation present before Euro-American influence. In areas where fire exclusion was effective, there would be fewer early successional stands, shifts toward Engelmann spruce and subalpine fir (Moir 1993), greater fuel loads (Fulé et al. 2004), and increased landscape homogeneity (White and Vankat 1993, Fulé et al. 2003a).

Understory cover declines can be inferred from the observation that cover can be high in young stands after canopy-opening disturbance (Yeager and Riordan 1953, Dye and Moir 1977, Moir 1993, Pase and Brown 1994b), but declines with increasing tree cover. The few data available on invasive exotic plants indicate that they are not an important stressor at this time (cover of 0.2% in GRCA; Fulé et al. 2002b).

Fire management activities of the last two decades have had little effect on GRCA's Spruce-Fir Forest.

3.1.1.3 Mixed-Conifer Forest — Vegetation

GRCA's mixed-conifer forest occurs only on North Rim from approximately 7,217 to 8,530 feet (Figure 3-1) and consists of a mosaic of forest patches of varying species composition related to elevation and topographic-moisture gradients (White and Vankat 1993). Upper and lower elevational boundaries are indistinct because some stands are similar to adjacent forest types, and some dominant species are shared with adjacent forest types. Transition stands of mixed species composition are included in this section. The mixed-conifer forest consists of approximately 33,800 acres on the North Rim plateau. This forest type covers 2.8% of the park and 30% of the coniferous forests in the park. Overstory species include aspen, ponderosa pine, white fir, Douglas fir, New Mexican locust, Engelmann spruce, and subalpine fir. Approximately 55% of the mixed-conifer forest has experienced a recent fire event, and 1,600 acres of this area has had at least two fires. The North Kaibab District of the Kaibab National Forest identified approximately 114,000 acres of mixed-conifer forests near or adjacent to the park's mixed-conifer forests (USDA, 2008c).

Within the mixed-conifer forest type there are approximately 27,100 acres of Mexican spotted owl mixed-conifer restricted habitat. Some areas the park classified as mixed-conifer do not meet restricted habitat definitions, like areas that have ponderosa pine and aspen associations, aspen forest associations, and grasslands. The following excerpts from the Recovery Plan (1995) and 50 CFR Section 17 (2004) along with the Recovery Plan Key to Forest Cover Types (p. 57) were used to determine what vegetation associations should be included in the Mixed-Conifer Restricted Habitat layer.

From the Recovery Plan for the Mexican Spotted Owl (1995)

- Where Douglas-fir, white fir, or blue spruce, either singly or in combination, constitute less than 5% cover or are considered "accidental" in late successional stands, these stands are not included in the mixed-conifer forest classification (page 53)
- USDA (1992) described old growth attributes by cover types, including a "mixed species group" Forest Cover Type, which included the Douglas-fir, white fir, blue spruce, and limber pine forest cover types (page 54)
- Moir (1993) described mixed-conifer forests as upper montane coniferous forests featuring Douglas-fir, white fir, several tall pine species, blue spruce, and quaking aspen. He included the following series in this general forest type: Blue spruce, White fir – Douglas-fir, Douglas-fir – Ponderosa pine, Douglas-fir - limber pine - bristlecone pine, Douglas-fir – silverleaf oak (page 54)
- Fletcher and Hollis (1994) described mixed-conifer forest cover types as those dominated by Douglas-fir and/or white fir, usually containing varying amounts of ponderosa pine, southwestern white pine, and/or limber pine...Douglas-fir and/or white fir typically comprise at least 40 percent and hardwood species less than 40 percent of the stand basal area (page 54)

- A general concensus, however, indicates that mixed-conifer forest types generally fall in the following four series: *Abies concolor, Pseudotsuga menziesii, Pinus flexilis, or Picea pungens* (page 54)
- 1. Any stand within the *Pinus aristata, Picea engelmannii,* or *Abies lasiocarpa* Series not having a plurality of basal area of any of *Pinus aristata, Picea engelmannii*, *Abies lasiocarpa,* or *Pinus ponderosa*, singly or in combination, should also be defined as mixed-conifer (page 56)

From 50 CFR Section 17, Final Designation of Critical Habitat for the Mexican Spotted Owl (2004)

- The owl is frequently associated with mature mixed-conifer, pine-oak, and riparian forests...Mature mixed-conifer forests are mostly composed of Douglas-fir, white fir, limber pine, or blue spruce (page 53183)
- Therefore, we believe that mixed conifer dominated by Douglas-fir, pine-oak, and riparian forests with high tree diversity are important to the owl (page 53183)

Climate is generally characterized by cool to cold temperatures producing a short to moderately long growing season of 90-120 days. Moisture usually is not limiting due to ample precipitation (Moir 1993). The combination of moisture availability and warm daytime temperatures during the growing season results in mixed-conifer forest being the Southwest's most productive coniferous forest (Moir 1993).

Evidence suggests that disturbance resulted in a vegetation mosaic involving quaking aspen superimposed on the topography-vegetation mosaic (Swetnam and Lynch 1989, Swetnam 1990, Moir 1993, White and Vankat 1993).

Fire was an important disturbance factor in mixed-conifer forest prior to Euro-American influence. Research results indicate a mixed-severity fire regime combining widespread surface fires and patchy crown fires (Jones 1974, Allen 1989, Moir 1993, Allen et al. 1995, Touchan et al. 1996, Fulé et al 2003a). Site-specific details appear to vary depending on stand structure, composition, and landscape position (Touchan et al. 1996). In general, fires burned as surface fires across landscapes, especially in relatively dry, open areas (i.e., ridgetops and south- and west-facing hillsides; Fulé et al. 2003a). In dry years, these surface fires likely occasionally crowned where fuels were greater and more continuous (such as north- and east-facing hillsides and valley bottoms). The limiting fire factor in mixed-conifer forest generally was moisture, not fuel (Allen et al. 1995, Swetnam and Baisan 1996, Touchan et al. 1996). Most fires occurred in summer (Dieterich 1983, Wolf and Mast 1998, Heinlein et al. 2005) when fuels were drier and lightning more frequent. Fires were more frequent when winter-spring precipitation was low (Touchan et al. 1996), and widespread fires occurred in extreme drought years (Swetnam and Baisan 1996).

Mean intervals for the surface-fire portion of the mixed-severity fire regime were similar to those of ponderosa pine forest. Low-, mid-, and high-elevation North Rim sites had mean fire intervals of 5, 8, and 10 years for all fires; 5, 9, and 12 years for 10% scarring; and 7, 10, and 19 years for 25% scarring (Wolf and Mast 1998). Another North Rim study found a mean fire interval of 9 years for 10% scarring (Fulé et al. 2003a). Fire intervals may be underestimated by an order of magnitude or more (Baker and Ehle 2001). More research is needed on surface fires, especially to clarify interrelationships with the topography-vegetation mosaic.

All studies in the Southwest indicate that crown fires were uncommon and patchy before Euro-American influence. Evidence of crown fire includes patches of even-aged, early successional trees such as quaking aspen. Research on North Rim found that today's forest consists of tree patches from past crown fires mingled with patches lacking evidence of past crown fire (Fulé et al. 2003a) and that past crown fires patches are less than or about 2 ha (Fulé et al. 2003b). In summary, all Southwest research has indicated that “extensive crown fires were rare to non-existent" prior to fire exclusion (Brown et al. 2001).

Fire frequency abruptly decreased in the 19th century, leading to increases in fuel loads (Fulé et al. 2004) and horizontal and vertical fuel continuity. Therefore, conditions for the crowning component of the mixed-severity fire regime increased across landscapes, and fires in mixed-conifer forest now may become larger crown fires than the former small-patch, mixed-severity fires (White and Vankat 1993, Fulé et al. 2003a, 2004, Mast and Wolf 2004). Recent GRCA fires with crown fire patches are the 2000 Outlet Fire and the 2003 Poplar Fire. Analysis of the Outlet Fire indicates that 94% of the area burned by crown fire was in patches larger than present before Euro-American influence.

Vegetation Structure and Composition   Mixed-Conifer Forest   Vegetation
Insects and Pathogens

In the Southwest, the primary insect is the western spruce budworm, a defoliator that feeds mostly on white fir and Douglas fir (Linnane 1986), but also may infest subalpine fir, Engelmann spruce, and blue spruce (Lynch and Swetnam 1992). Forests most susceptible to infestation are dense; old growth; closed-canopied; stressed by drought, dwarf mistletoe, high density, root disease, or marginal site conditions; and multi-layered, with white fir and Douglas fir as canopy dominants and shade-tolerant species in the understory (Linnane 1986, Fellin et al. 1990 in Moir 1993, Lynch and Swetnam 1992). Outbreaks can be extensive, but have not increased with fire exclusion (Swetnam 1987, Lynch and Swetnam 1992, Ryerson et al. 2003). Outbreaks occur with increased precipitation following dry periods (Ryerson et al. 2003). Western spruce budworm feeds primarily on understory trees (Brookes et al. 1987), especially individuals in a weakened condition; therefore, this defoliating insect acts as a thinning agent (Moir 1993). Stands can survive multiple outbreaks (Ryerson et al. 2003), but overstory trees can die with repeated defoliation and interaction with other insects and pathogens (Linnane 1986). Outbreaks can alter forest structure, composition, and dynamics (Lynch and Swetnam 1992, Moir 1993).

Vegetation Structure and Composition   Mixed-Conifer Forest   Vegetation
Vegetation Dynamics

Succession in areas burned by surface fire is limited to areas of single trees (see ponderosa pine forest). Succession in areas burned by patchy crown fire often involves quaking aspen (Touchan et al. 1996) and is affected by seed and bud banks surviving the fire, size of area burned (determining distance to seed sources), site conditions, and post-fire animal use. Succession in areas burned by modern, landscape-scale crown fire in GRCA begins with a pulse of weedy species, followed by increasing abundance and dominance of dry-spike sedge (*Carex foenea* var. *foenea*) and quaking aspen, as well as increasing abundance of cheatgrass (*Bromus tectorum*), an invasive exotic (Crawford, in review).

Recently, many North Rim stands have experienced high canopy tree mortality of at least white fir, Engelmann spruce, and subalpine fir. Causes of mortality are unknown.

Vegetation Structure and Composition   Mixed-Conifer Forest   Vegetation
Pre-European-American Influence

Mixed-conifer forest is thought to have consisted of a complex mosaic of patches that differed in stand structure and species composition (Moir 1993, White and Vankat 1993, Fulé et al. 2003a) In general, stands were more open than today (Moir 1993, Fulé et al. 2003a, Heinlein et al. 2005). In addition, stands dominated by quaking aspen were more abundant (Dieterich 1983, Bartos 2001) and, because they were younger successionally, more clearly defined (Dieterich 1983). High surface fire frequency favored regeneration of ponderosa pine, quaking aspen, and Douglas fir (Moir 1993, White and Vankat 1993), while restricting development of canopy-sized white fir to cooler, moister sites where fires were less frequent (White and Vankat 1993, Heinlein 1996) and/or less regular.

Dry sites such as south- and west-facing hillsides and ridgetops had open structure and were dominated primarily by ponderosa pine (Dieterich 1983, White and Vankat 1993). Stands likely had patchy ponderosa pine reproduction and, especially in wetter periods, other conifers such as Douglas fir. Presumably, dry sites had high fire frequencies (Fulé et al. 2003a), but crowning was rare or absent. Surface fires likely maintained open structure by thinning reproduction patches, leaving a multi-aged forest (see ponderosa pine forest). Sites with intermediate moisture, such as north- and east-facing hillsides, also had open structure, but more Douglas fir, white fir, and quaking aspen in the canopy (Dieterich 1983, White and Vankat 1993). Many of these trees had fire scars (Dieterich 1983), indicating frequent past surface fires. Fires likely crowned in small patches, primarily in drought years. Moist sites such as valley bottoms were denser and had more blue spruce, Engelmann spruce, and subalpine fir than intermediate sites (White and Vankat 1993). Blue spruce was common along drainages and meadow margins (Moir 1993, White and Vankat 1993). Moist conditions likely reduced surface fire frequency and resulted in high stand densities, fuel loads, and vertically continuous fuels, which made stands susceptible to crown fires in drought years. Quaking aspen regenerated by sprouting and seeding following fire, especially in relatively moist sites. Low elevations had greater abundance of ponderosa pine-dominated stands while upper elevations had more stands with Engelmann spruce and subalpine fir.

Vegetation Structure and Composition Mixed-Conifer Forest Vegetation
European-American Influence

Fire exclusion altered stand and landscape structure and composition (Dieterich 1983, Allen 1989, Moir 1993, White and Vankat 1993, Fulé et al. 2002a, 2003a, Mast and Wolf 2004, Heinlein et al. 2005, Vankat et al. 2005).

In addition to forest structure change, there has been a species composition shift, with increased abundance of white fir and other shade-tolerant, fire-sensitive species, formerly thinned by surface fires (Merkle 1962, White and Vankat 1993, Dahms and Geils 1997, Bastian 2001, Mast and Wolf 2004). The proliferation of these trees had multiple impacts. It increased the likelihood of larger-scale outbreaks of insects and pathogens (Lynch and Swetnam 1992, Moir 1993, Swetnam and Lynch 1993, Dahms and Geils 1997, Fulé et al. 2003a, Heinlein et al. 2005); however, impact on western spruce budworm outbreaks likely was small, even negligible (Swetnam 1987, Lynch and Swetnam 1992, Ryerson 2003). Second, increased densities likely resulted in reduced tree vigor, although greater moisture availability may have reduced this effect. Third, there were increases in stand and landscape homogeneity (White and Vankat 1993, Ryerson 2003, Heinlein et al. 2005), horizontal and vertical fuel continuity (White and Vankat 1993, Heinlein 1996), and canopy fuels (Fulé et al. 2004). Landscape homogeneity also increased as conifers became more dominant in stands of quaking aspen (Dahms and Geils 1997, Bartos 2001). These changes increased probability and occurrence of landscape-scale crown fires (Lynch and Swetnam 1992, White and Vankat 1993, Dahms and Geils 1997, Fulé et al. 2004), as described above for GRCA. Large crown fires can perpetuate landscape homogeneity (White and Vankat 1993).

Understory changes likely included decreases in cover and species number and species composition shifts (inferences from Huisinga et al. 2005). Exotic species currently appear unimportant, but they are increasing on recently burned sites where cheatgrass is a potential problem (Huisinga et al. 2005). Understory changes are attributed to increases in tree density, litter, and duff (Merkle 1962, Pase and Brown 1994a, Dahms and Geils 1997, Huisinga et al. 2005). Shrub cover is variable (Merkle 1962, Moir 1993). Additional information on the understory is in Moir (1993), Pase and Brown (1994a), Springer et al. (2000), and Huisinga et al. (2005).

Fire management activities of the last two decades have had both beneficial and negative effects on GRCA's mixed-conifer forest, depending on the degree to which affected areas are closer to or outside the natural range of variability. In general, areas of management fires involving small-scale patches of different fire severities are likely closer to the natural range of variability, although research is needed to test this hypothesis.

3.1.1.4 Ponderosa Pine Forest Vegetation

Ponderosa pine forest is the most widespread Southwestern coniferous forest, covering almost 6% of Arizona and New Mexico (Pase and Brown 1994a). Because much of this area has been logged, GRCA's Ponderosa pine forest has great state and regional significance since it was never extensively logged. Ponderosa pine forest is also the most thoroughly studied Southwestern coniferous forest. The ponderosa pine forest consists of approximately 59,600 acres on North and South Rims. This forest type covers 4.9% of the park and 54% of the coniferous forests in the park. Overstory species include ponderosa pine, aspen, white fir, Douglas-fir, piñon-juniper, and New Mexican locust. Approximately 76% of the ponderosa pine forest has experienced a recent fire event, and 2,500 acres of this area has had at least two fires. The North Kaibab and Tusayan districts of the Kaibab National Forest identified approximately 260,000 acres of ponderosa pine forests near or adjacent to the park's pine forests (USDA, 2008c).

GRCA's ponderosa pine forest occurs primarily at 6,561 to 7,545 feet (Figure 3-1). At low elevations, the forest intergrades with piñon-juniper vegetation, often in a mosaic. At high elevations, the forest intergrades with mixed-conifer forest, either as gradual transition or as mosaic. Where upper elevation transition occurs as a mosaic of stands, the mosaic often is correlated with topography, as stands of ponderosa pine forest occur on drier sites such as south-facing hillsides, and stands of mixed-conifer forest occur on more moist sites such as north-facing hillsides.

Fire has been a key influence on ponderosa pine forest structure and composition on the Kaibab Plateau for as long as ponderosa pine has been present as a dominant species (Weng and Jackson 1999). Frequent, low-intensity surface fires were characteristic before fire exclusion (Swetnam and Baisan 1996). Crowning was uncommon (Moir et al. 1997, citing Woolsey 1911 and Pyne 1996), covering areas of no more than one to two ha in GRCA (Fulé et al. 2003b). Estimated wind speeds necessary for carrying an active crown fire in GRCA averaged 128 km/hr in 1880 (Fulé et al. 2004), a value unlikely reached. However, fire exclusion led to increased fuel loads and fuel continuity. Estimated wind speeds necessary for crowning dropped to approximately 60 km/hr by 2000 (Fulé et al. 2004), a value more commonly reached.

Mean fire intervals for 1700-1900 from 53 Southwest sites dominated or co-dominated by ponderosa pine were 2-17 years for fires scarring one or more trees, and 4-36 years for 10 and 25% scarring (Swetnam and Baisan 1996). The range of mean fire intervals prior to Euro-American influence in GRCA is six to nine years for 25% scarring (Fulé et al. 2000). Fires were more common in dry years, particularly when preceded by one to three years of high precipitation that increased herb cover (Swetnam and Baisan 1996, Touchan et al. 1996, Fulé et al. 2000).

Prescribed burn studies in modern forests indicate soil properties were altered (Bennett 1974). The soil surface duff layer apparently was kept thin and patchy, enhancing moisture availability (Covington et al. 1997, Feeney et al. 1998). In addition, mineralization was increased (White 1986, White 1996), which increased nutrient mobilization (Covington and Sackett 1984) and soil surface nutrients (Covington and Sackett 1990), including nitrogen (Harris and Covington 1983, Covington and Sackett 1986, 1990, 1992, Ryan and Covington 1986). On a landscape-scale, patchy fires promoted greater heterogeneity (Laughlin et al. 2005).

Insects and Pathogens **Ponderosa Pine Forest** **Vegetation**

Bark beetles (*Dendroctonus* spp. and *Ips* spp.) can be an important disturbance agent (Allen 1989), as occurred in many southern Colorado Plateau areas in 2002-2004. Mortality on ponderosa pine even caused a one to 1.86 mile shift of the transition between ponderosa pine forest and piñon-juniper vegetation (Allen 1989). Research in northern Arizona indicated that several bark beetle species are present in ponderosa pine forest, likely persisting in lightning-scarred trees (Sánchez-Martínez and Wagner 2002). At least the more aggressive species infest scattered, small clusters of one to ten trees, but larger outbreaks have occurred, especially frequently on the Kaibab Plateau's northern portion (Douglas and Stevens 1979). Lang and Stewart (1910) indicated that insects were a major cause of mortality on the Kaibab Plateau in the early 20th century, with some areas having greater than 10% of merchantable trees killed by insects. One aggressive species appears to prefer larger, more mature trees (Miller and Keen 1960). Evidence does not support the assumption that high tree densities enhance probability of large outbreaks (Sánchez-Martínez and Wagner 2002).

Pandora moth (*Coloradia pandora*), which defoliates ponderosa pine on the Colorado Plateau, does not appear to significantly affect tree growth and vigor (Miller and Wagner 1989). Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) also affects ponderosa pine. Prior to Euro-American influence, mistletoe likely occurred throughout forests with a distribution similar to its current distribution; although its abundance may have been lower (Dahms and Geils 1997). Mistletoe can increase tree mortality in fires even where fire does not crown (Roth 1974, Harrington and Hawksworth 1990).

Vegetation Dynamics **Ponderosa Pine Forest** **Vegetation**

Before Euro-American influence succession occurred at the scale of individual trees because larger canopy-opening disturbances were uncommon. Following death of a large tree, fire would consume it, creating a microsite relatively rich in nutrients and competitor free. Ponderosa pine seedlings established when seed availability and necessary climate conditions co-occurred; otherwise, the microsite was colonized by grasses and other understory plants. Clusters of seedlings and saplings were thinned by surface fires, leaving few if any trees to enter the subcanopy and canopy. This pattern resulted in canopy trees of different ages.

Vegetation Structure and Composition Pre-European-American Influence **Ponderosa Pine Forest** **Vegetation**

The canopy of most stands was nearly a monoculture of ponderosa pine with a cover of 17-33% (Pearson 1923, 1950, White 1985, Covington and Sackett 1986). Species composition was likely correlated with factors related to moisture and soil chemical resources (Abella and Covington 2006). Many people describe the former stand structure as open and park-like, with widely spaced tall trees and a dense herbaceous layer dominated by grasses, i.e., a structure that was more woodland than forest. This description is often justified by reference to statements of Euro-American explorers. For example, an early description of the Kaibab Plateau stated "...where the pines predominate the forest is very open," with "…pines standing at intervals varying from 50 to 100 feet..." (Dutton 1882).

Modern studies from areas relatively little affected by fire exclusion generally support such descriptions (Madany and West 1983, Fulé and Covington 1995); however, the open, park-like paradigm has been challenged. Pollock and Suckling (1997) reported that the journal of one early explorer (Beale 1858) referred to dense, heavy, or heavily timbered forests three times as frequently as open forests. In addition, if Baker and Ehle (2001) are correct that fire intervals in Ponderosa Pine Forest are underestimated by at least an order of magnitude, it is likely that some sites would not have been open and park-like. Indeed, Woolsey (1911) wrote

> *An accurate picture of the pre- [Euro-American] settlement ponderosa pine forest would most likely describe a mosaic not only with an open, grass savanna and clumps of large, yellow-bark ponderosa pine, but also with a few dense patches and stringers of small [ponderosa] pines.*

Such a mosaic could have been caused by variations in fire frequency, especially as related to topographic features (Allen et al. 1995, Swetnam and Baisan 1996).

Only generalized, qualitative descriptions are available for ponderosa pine forest understory before or near the beginning of Euro-American influence. For example, "The ground was covered with fresh grass…" (Sitgreaves 1853). Such early descriptions, as well as relatively undisturbed contemporary stands, indicate that few shrub species occurred in undisturbed ponderosa pine forest, and were rarely abundant (Mead 1930, Madany and West 1983, Pase and Brown 1994a), except for Gambel oak. In addition, the herb layer was likely dense and usually dominated by grasses (Moir 1993, Pase and Brown 1994a). Understory tree species included piñon pine, juniper, Gambel oak, and New Mexico locust in low elevations, and Gambel oak and New Mexico locust in mid-elevations. Seedling and sapling ponderosa pine occurred throughout, but shared the understory with white fir and Douglas fir at higher elevations. Research on North Rim areas with relatively unchanged fire regimes indicates that understory composition was related to time since fire, ponderosa pine and Gambel oak basal area, and topography (Laughlin et al. 2005).

Vegetation Structure and Composition Ponderosa Pine Forest Vegetation European-American Influence

Fire exclusion resulted in alterations in ponderosa pine forest structure throughout the Southwest (Weaver 1951, Harrington and Sackett 1990, Covington and Moore 1994a, 1994b, Dahms and Geils 1997). In some areas, however, climate appears to have been more important in forest change (Savage 1991). Many southern Colorado Plateau areas experienced a burst of tree regeneration in 1919 (Moir 1993), correlated with human disturbance and uncommon weather (Savage et al. 1996). Research in GRCA revealed that forest structure changed primarily because of fire exclusion (Fulé et al. 2002a).

There are many aspects to change in forest structure including changes in forest densities, diameter class distribution, structural diversity, tree vigor, and landscape homogeneity. Most research has focused on forest densities, which in GRCA have been estimated to have increased approximately 25 to 600%.

Density changes were dominated by increases in small trees (Dahms and Geils 1997, Crocker-Bedford et al. 2005b). This decreased structural diversity in stands (Dahms and Geils 1997), as small trees filled open spaces between large trees and made forests more homogeneous across landscapes (Allen et al. 2002). Tree growth rates declined with increased competition, as well as decreased soil moisture and nutrients resulting from thicker litter (Clary and Ffolliott 1969 in Harrington and Sackett 1990, Biondi 1996). Data suggest competition from smaller, younger trees reduced vigor of larger, older trees (Feeney et al. 1998). Elevated GRCA mortality rates are related to older trees being more susceptible to pathogens, drought, and injury due to increased stress through increased competition (Kaufman and Covington 2001).

In contrast to large changes in forest structure, changes in tree composition have been relatively minor, at least at most elevations. Forest reconstructions for the Colorado Plateau suggested shifts in species composition toward relatively less ponderosa pine and relatively more piñon pine, Gambel oak, New Mexico locust, white fir, and Douglas fir (Fulé et al. 1997, 2002a, Menzel and Covington 1997), with specific species depending on elevation. The largest changes in forest composition occurred in high-elevation stands where shade-tolerant, fire-sensitive conifers such as white fir were present in the canopy before fire exclusion, and were sources of seeds as ponderosa pine forest converted into mixed-conifer forest (Mast and Wolf 2004, Crocker-Bedford et al. 2005a).

Data from prescribed burning studies (often coupled with tree thinning) also suggest that shrubs and herbs decreased with Euro-American influence (Covington et al. 1997). Invasive exotic plant abundance is highly variable in GRCA (Springer et al. 2000). Values are low (2-3%) in sites with a relatively uninterrupted fire regime, intermediate (4-9%) in drier more disturbed sites, and highest (21%) where fire regime was more interrupted. Laughlin et al. (2004) also reported that exotics were not abundant on a site with a relatively unchanged fire regime (exotics accounted for 5-7% of recorded species).

Fire management activities of the last two decades appear to have had mostly beneficial effects on GRCA's ponderosa pine forest, bringing most stands closer to the natural range of variability.

3.1.1.5 Piñon-Juniper Vegetation Vegetation

Piñon-juniper vegetation can be divided into three subtypes based on tree density and understory cover: savanna, woodland, and forest (Moir and Carleton 1987, Dick-Peddie 1993, Romme et al. 2003). Piñon-juniper vegetation is widespread in the Southwest, covering about 20% of Arizona and New Mexico (Arnold et al. 1964, Dick-Peddie 1993). GRCA's piñon-juniper vegetation has been protected from livestock grazing for several decades. The following piñon-juniper vegetation description is based primarily on research from the Colorado Plateau and review papers applicable to the Southwest, because little research has been done on piñon-juniper vegetation in GRCA. The depth of this description is limited; however, few fire management activities are planned for this vegetation. The piñon-juniper vegetation type consists of approximately 309,800 acres on North and South Rims. The piñon-juniper forest covers 25.4% of the park. Approximately 2% of the piñon-juniper forest has experienced a recent fire event, and less than 100 acres of this area has had at least two fires. The Tusayan district of the Kaibab National Forest identified approximately 189,000 acres of piñon-juniper vegetation near or adjacent to the park's piñon-juniper vegetation (USDA, 2008c).

Piñon-juniper vegetation occurs below ponderosa pine forest (Figure 3-1), with a transition at about 6,561 feet. The transition often consists of a mosaic of stands, and species of piñon-juniper vegetation, including dominant trees, extend into low-elevation ponderosa pine forest as subcanopy and understory species. Piñon is usually more abundant than Utah juniper at higher elevations (Dick-Peddie 1993); vice-versa at lower elevations.

The fire regime of Southwestern piñon-juniper vegetation is poorly understood, because there are few fire history studies (Miller and Tausch 2001, Floyd et al. 2004, Miller 2005). A review of 23 studies in the western U.S. showed that, 1) spreading surface fires have been uncommon (except possibly in savannas and areas transitional with ponderosa pine forest), 2) crown fires have been reported in many studies, and 3) mixed-severity fires are an unreported possibility (Baker and Shinneman 2004). Surface fire intervals are poorly known. A mean of 16-28 years is likely, but may be too low (Baker and Ehle 2001, Baker and Shinneman 2004). Open woodland near Flagstaff, Arizona had a mean fire interval of 25 years (Despain and Mosley 1990).

Insects and Pathogens **Piñon-Juniper Vegetation** **Vegetation**

Disturbance by insects is poorly documented (Miller 2005), but appears extensive and interrelated with drought onset. Drought-insect interaction can change vegetation structure (Betancourt et al. 1993) and raise the upper-elevation ecotone of piñon-juniper vegetation through ponderosa pine mortality (Allen and Breshears 1998). Bark beetle (*Ips confuses*) outbreaks triggered by drought recently changed vegetation composition by causing extensive piñon mortality in piñon-juniper vegetation of the southern Colorado Plateau and elsewhere in the Southwest (Breshears et al. 2005).

Vegetation Dynamics **Piñon-Juniper Vegetation** **Vegetation**

In general, sites burned by crown fire are initially dominated by annual herbs, followed by perennial grasses and forbs, and later by shrubs then trees to form a woodland or forest in 200-300 years (Arnold et al. 1964, Erdman 1970, Barney and Frischknecht 1974, Tress and Klopatek 1987, Dick-Peddie 1993, Paysen et al. 2000, Miller and Tausch 2001). The few studies in GRCA indicate that sagebrush (*Artemisia tridentada*) is the primary shrub species in this successional sequence, and the shrub-dominated stage persists for decades, even as piñon pine and, to a lesser degree, Utah juniper invade (Schmutz et al. 1967, Jameson et al. 1962, Brian et al. 1999, Rowlands and Brian 2001).

Other vegetation dynamics include expansion of piñon-juniper vegetation, especially into grasslands. Changes in at least piñon-juniper forest are unrelated to fire suppression and other direct human influence (Floyd et al. 2004). Recent widespread dieback of piñon pine in the Southwest is related to contemporary climate change (Breshears et al. 2005).

Vegetation Structure and Composition **Piñon-Juniper Vegetation** **Vegetation**

A clear presentation of differences among piñon-juniper savanna, woodland, and forest subtypes is that of Romme et al. (2003), who synthesized information from previous studies and developed hypotheses. Their synthesis provides the basis for much of this section, except where other studies are cited.

Piñon-juniper savanna is sometimes considered a lower elevation, drier woodland variant (Moir and Carleton 1987) that often has more junipers than piñon. However, savanna can also be found at higher elevations. Savanna occurs on deep, fine-textured soils on gentle plains and broad valley bottoms, where there are few barriers to fire spread. Stands are often adjacent to vegetation that burned frequently, such as grasslands and ponderosa pine forest. Before the 20th century, savanna had an open tree canopy (5-30% cover) above a dense herb layer dominated by grasses and an open shrub layer. The herb layer is thought to have carried frequent, low-severity surface fires (see above). Changes over the last century include increased tree density, decreased herb biomass, decreased fire frequency, and increased fire severity. Many stands are outside the natural range of variability.

Piñon-juniper woodland has a tree cover of 30-50% above an open to very dense shrub layer and an open to moderately dense herb layer. Densities of the three layers depend on time since fire. Stands occur on similar soils and topographic sites as savanna. The fire regime is thought to have consisted of moderately frequent, high-severity crown fires carried by shrubs and trees (see above). Over the last century, tree density increased and shrub and herb cover decreased. Accordingly, there has been a small increase in fire severity. Many stands are outside the natural range of variability. Research in and near GRCA has focused on this type of piñon-juniper vegetation (Arnold et al. 1964, Jameson et al. 1962, Schmutz et al. 1967, Brian et al. 1999, Rowlands and Brian 2001), but has included only two park areas (Fishtail Mesa and Boysag Point). Sagebrush is the dominant shrub reported by these studies. Species composition is related to gradients in moisture and soil texture and shows little change over decades (Rowlands and Brian 2001). Piñon-juniper forest is sometimes considered an upper-elevation, moister woodland variant (Moir and Carleton 1987, Dick-Peddie 1993). It has a dense tree layer (50-80% cover), an open to moderately dense shrub layer, and an open herb layer. Stands occur on shallow, rocky, or coarse-textured soils on rugged hillsides, canyons, and mesas, where there are barriers to fire spread. The fire regime consists of very infrequent, very high-severity crown fires carried by trees (see above). Post-fire succession is very slow, so stands remain stationary for long, fire-free periods. Stand structure and fire regime appear to have changed little since the 19th century; therefore, stands are thought to be in the natural range of variability.

An important component of piñon-juniper vegetation is biological soil crust on and slightly below the soil surface (Belnap and Lange 2001). Crust consists of mosses, lichens, fungi, algae, and cyanobacteria, which form below open plant canopies where thick litter is absent. Crusts have several ecological functions (Miller 2005) and are sensitive to disturbance. They also occur in other GRCA vegetation types at higher and lower elevations (Beymer and Klopatek 1992).

Piñon-juniper (and other arid vegetation types) may share four degraded states that have altered ecosystem processes: invaded, annualized, woody dominated, and severely eroded (Miller 2005). The invaded state has functionally important invasive exotic plant species, but ecosystem processes (fire regime, etc.) are relatively little changed. The annualized state occurs with dominance by weedy annuals such that vegetation structure and ecosystem processes are greatly altered. Cheatgrass may occur in either of these states and has potential to alter fire regimes (West 1999, Miller and Tausch 2001, Harper et al. 2003, Romme et al. 2003, Miller 2005). Forest areas burned by crown fires may be especially susceptible to exotic invasion (Floyd et al. 2004). The woody dominated degraded state has persistent increased abundance of woody plants, and ecosystem processes such as fire regimes may be affected. The severely eroded state occurs with soil erosion and resultant resource changes.

Fire management activities of the last two decades had few impacts on GRCA's piñon-juniper vegetation.

3.1.1.6 Montane-Subalpine Grassland Vegetation

Montane-subalpine grassland dominated by herbs and shrubs forms small meadows (parks) in GRCA. This vegetation type covers little land in the Southwest, and GRCA stands have been protected from livestock grazing for several decades. Therefore, GRCA's montane-subalpine grassland has state and regional significance.

There are regional differences in montane-subalpine grassland (Turner and Paulsen 1976, Peet 2000); however, little research has been published for GRCA and the Southwest (limiting the depth of this description). Some authors separate Southwestern grasslands based on montane vs. subalpine elevational zones (e.g., Brown 1994b); however, others combine the two (e.g., Dick-Peddie 1993), because grasslands of both elevational zones are similar and intergrade where differences occur. Grasslands can also be divided into valley bottom and slope grasslands because of apparent differences in ecological processes involved in development and maintenance (Vankat, in review), but GRCA has only valley bottom grasslands. This section combines montane and subalpine grasslands and focuses on valley bottom grasslands, using literature from the Southwest and nearby areas.

GRCA's montane-subalpine grassland occurs on valley bottom sites throughout the coniferous forest elevational range and extends downslope into piñon-juniper vegetation, giving an elevational range of about 5,905-9,022 feet (Figure 3-1). Most stands are less than100 ha in GRCA and elsewhere (Rasmussen 1941, Dick-Peddie 1993, Brown 1994a, 1994b, Peet 2000).

There are no climate data for montane-subalpine grassland in GRCA or elsewhere in the Southwest. Presumably climate is similar to that of surrounding forests (see above), except that microclimates of valley bottom sites have generally cooler minimum and maximum temperatures, at least in summer and early fall (Rasmussen 1941, Brown 1994a). In addition, grasslands likely have higher potential evaporation rates than forests, and these rates are higher at lower elevations (Brown 1994a).

In general, summers are warm to cool and winters cold. Mean annual precipitation has been estimated as 14.17-45.27 inches for grassland in the subalpine zone (Brown 1994a) and near the lower end of this range in the montane zone. The precipitation percentage falling as snow increases with higher elevation, with grassland in the subalpine zone receiving 50-75% as snow, which builds up to depths of 5.9 feet and covers sites October through May (Turner and Paulsen 1976). The growing season is short, especially in the subalpine zone where it is often less than 100 days (Brown 1994a), and summer frosts occur occasionally (Turner and Paulsen 1976).

Soils are variable, but most are deep, well developed, and well- to poorly drained (Warren et al. 1982, Brown 1994a,c). The deep snow pack maintains soil temperatures at or above freezing during winter and saturates the soil in spring (Turner and Paulsen 1976). Soils resemble prairie soils with a deep, dark, organic A horizon (Moir 1967, Turner and Paulsen 1976). In comparison to surrounding forests, soils tend to be finer textured, deeper, and less well drained (Turner and Paulsen 1976), as well as more moist in summer (Merkle 1953). Fine texture is likely an important factor in distribution of valley bottom grasslands, especially in montane zones, but less important in subalpine zones where excessive soil moisture may be critical, along with cold-air drainage, frost pockets, deep snow, etc. (Peet 2000). Moir and Ludwig (1979) considered meadows dominated by Thurber fescue (*Festuca thurberi*) to be dependent on fine-textured soils (and possible relicts of warmer or drier post-glacial climates).

Little is known about fire regime and fire effects (Turner and Paulsen 1976). Although these grasslands probably were not fire caused (Rasmussen 1941), fires likely formerly restricted tree invasion into grasslands (Moore 1994) and were especially important in stands at low elevation (Dick-Peddie 1993). Fires possibly affected species composition, especially shrub abundance (Turner and Paulsen 1976).

Montane-subalpine grassland is grazed by deer and burrowing animals such as pocket gophers (Turner and Paulsen 1976). Heavy grazing reduces palatable species and increases less palatable species (Wolters 1996). Excessive deer grazing in GRCA is likely to have dramatically reduced the ability of quaking aspen to invade meadows in the 1920s and early 1930s (Moore 1994). In addition, burrowing animals aerate dense soil (Turner and Paulsen 1976) and provide mineral soil sites where competition is low. Grazing appears to increase soil temperatures and decrease soil moisture and fertility (Turner and Paulsen 1976). Historic livestock grazing may have facilitated erosion, causing incised drainages in some grasslands.

Vegetation Dynamics Montane-Subalpine Grassland Vegetation

No literature was found on succession or other vegetation dynamics following natural disturbance. In addition, little is known about stand recovery after livestock grazing, because, a) information on species composition before grazing is lacking and, b) grazing likely was so disruptive (including possibly facilitating exotic species establishment) that full recovery may be impossible.

Vegetation Structure and Composition Montane-Subalpine Grassland Vegetation

Little is known about montane-subalpine grassland on the Colorado Plateau prior to Euro-American influence, other than stands were present in areas where they occur today. For example, valley bottom grasslands were abundant on the Kaibab Plateau in the 19th century (Dutton 1882): "There is a constant succession of parks and glades—dreamy avenues of grass and flowers winding between sylvan walls, or spreading out in broad open meadows."
Livestock grazing and reduced fire frequency beginning in the 1870s likely had large impacts on montane-subalpine grassland. Long-lived, fire-scarred trees adjacent to grasslands have potential to reveal fire regime (Allen 1984, Moore 1994), but reconstructions of past grassland vegetation composition rely on observation of current livestock grazing effects. After reviewing the literature, Turner and Paulsen (1976) speculated that Thurber fescue, a bunchgrass, had dominated stand vegetation in the subalpine zone, with forbs abundant in disturbed sites and at higher elevations, and shrubs abundant at lower elevations.

Today's stands, at least where protected from livestock grazing, are generally dominated by a mix of grasses and forbs (broad-leaved herbs), accompanied by shrubs (see species lists in Turner and Paulsen 1976, Dick-Peddie 1993, Brown 1994a,c). Low-elevation sites in the montane zone tend to be dominated by Arizona fescue (*Festuca arizonica*). High-elevation sites in the subalpine zone continue to be dominated by Thurber fescue. The dominant native grasses include bunchgrasses less than 3.2 feet in height. Valley bottom grasslands in GRCA had 35-100% cover and variable species composition, with some species restricted to one or a few sites (Warren et al. 1982). In addition, today's stands have exotic species such as Kentucky bluegrass, whose abundance is linked to livestock grazing. Although stands appear to recover in a few years when grazing is reduced, recovery is incomplete (Dick-Peddie 1993, Wolters 1996). Many valley bottom grasslands in the Jemez Mountains of northern New Mexico are dominated by exotics (Allen 1989). Research is needed on GRCA's past and present vegetation composition and exotic species.

Species' distributions appear influenced primarily by soil texture, soil moisture, elevation, site exposure (e.g., ridges), and disturbance (Merkle 1953, Turner and Paulsen 1976, Warren et al. 1982, Dick-Peddie 1993, Brown 1994a). For example, wetter sites have sedges (*Carex* spp.) (Warren et al. 1982, Dick-Peddie 1993, Brown 1994a) and are often referred to as a wet meadow community (Turner and Paulsen 1976).

Stands are subject to tree invasion (Moir 1967, Turner and Paulsen 1976, Allen 1984, Dick-Peddie 1993, Brown 1994a, Moore 1994). Prior to Euro-American influence, tree invasion was less frequent. However, at least low- and mid-elevation grasslands were fringed by open, savanna-like forest, and these trees were likely invasion seed sources (Allen 1984). Tree invasion on North Rim involved all canopy tree species of surrounding forests except Douglas fir, but the most common invaders were quaking aspen (58%), Engelmann spruce (18%), and white fir (10%) (Moore 1994). Tree ages indicated that invasions had been continuous or episodic (depending on species) since grazing began. The mean encroachment rate was 1.11 inches per year, with a high of 1.47 feet per year for quaking aspen. Early encroachment likely occurred because of fire exclusion. Seasonal drought and other factors influenced encroachment at the local scale, but climate events (i.e., El Niño-Southern Oscillation; see Overview) and fire exclusion were keys at the landscape scale. There is much conjecture on what factors limit tree establishment, and therefore what has caused meadows and parks to shrink in size with tree invasion (Moore 1994). Possible limiting factors include poor drainage, fine-textured soil, frost heaving, absence of necessary mycorrhizae, seasonal drought, long-term precipitation patterns, frost, fire, animal activity, and competition from herbs

(Merkle 1962, Moir 1967, Turner and Paulsen 1976, Allen 1989, Moore 1994). Additional research involving experimental testing is needed.

Fire management activities of the last two decades appear to have had little effect on GRCA's montane-subalpine grassland, but research is needed to test this hypothesis

3.1.2 Special Status Plant Species

Special status plant species are grouped by vegetation type for sake of presentation and comprehension. Since fire impacts various vegetation types differently (based on fuel type and continuity, etc.), species are grouped and discussed by habitat preference. Since ground surveys were not conducted for this FMP FEIS/AEF, individual species' habitat is assumed occupied. The following information provides special status plant species grouping by vegetation type (habitat) used in the Chapter 4 analysis (some species exist in multiple vegetation types).

One species, Grand Canyon goldenbush (*Ericameria arizonica*), listed as a GRCA Species of Concern, was recently found in GRCA. A shrub which bears yellow flowers September through October, Grand Canyon goldenbush's complete GRCA distribution is unknown. Preliminary surveys along the rim provided sight records along South Rim from Hermits Rest to Grandview Point and in the Kaibab Limestone above and along South Kaibab Trail. Known habitat is limited to hard limestone outcrops and rock face cracks along (and below) the rim in Grand Canyon. This species has not been thoroughly surveyed and its rarity is unknown. Grand Canyon goldenbush was published as a new species in 2005 (Roberts et al. 2005). To date, the species is thought to be endemic to the Grand Canyon system, and is proposed for listing by the Navajo Nation as NESL Group 4[1], where it is known from two locations along the rim of the Little Colorado River Gorge.

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.

3.1.2.1 Ponderosa Pine Forest Special Status Plant Species

Ponderosa pine forest habitat comprises almost 60,000 GRCA acres, of that approximately 75% is at a low level of departure from its natural fire regime. Special status plant species known to occur in this habitat are

- Flagstaff rockcress (*Arabis gracilipes*)
- Mt. Dellenbaugh sandwort (*Arenaria aberrants*)
- Arizona clematis (*Clematis hirsutissima* var. *arizonica*)
- Rough whitlowgrass (*Draba asprella* var. *stelligera*) (GRCA endemic)
- Arizona rubberweed (*Hymenoxys subintegra*)
- Kaibab Plateau beardtongue (*Penstemon pseudoputus*)
- Grand Canyon goldenbush (*Ericameria arizonica*) (GRCA endemic)
- Tusayan flameflower (*Phemeranthus validulus* syn. Talinum validulum)

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[1] NESL Group 4. **Navajo Endangered Species List Group 4:** Any species or subspecies for which the Navajo Nation Department of Fish and Wildlife (NNDFWL) does not currently have sufficient information to support listing as G2 or G3 but has reason to consider the species. The NNDFWL will actively seek information on these species to determine if they warrant inclusion in a different group or removal from the list. http://nnhp.navajofishandwildlife .org/docs_reps/nesl_update08.pdf Accessed July 16, 2008.

Arizona rabbitbrush (*Chrysothamnus molestus*) is an additional special status species not known to occur in GRCA boundaries, but which could occur based on proximity and presence of potential habitat.

3.1.2.2 Mixed-Conifer Forest — Special Status Plant Species

Mixed-conifer forest habitat comprises approximately 38,000 GRCA acres occupying an elevational range between 6,600-7,800 feet. Mixed-conifer habitat has become relatively homogonous in forest structure with heavy fuel loads in fire's absence. No Federally listed plant species is known in this habitat type though Kaibab whitlowgrass (*Draba asprella* var. *kaibabensis*) and Kaibab Indian paintbrush (*Castilleja kaibabensis*) are special status plant species known to occur. Macdougal Indian parsley (*Aletes macdougalii* ssp. *Macdougallii*) is not known to occur in GRCA but is occasionally found in this habitat.

3.1.2.3 Spruce-Fir Forest — Special Status Plant Species

Spruce-fir forest habitat comprises a small GRCA area (18,000 acres), characterized at elevations of 7,500 to 8,400 feet. Spruce-fir forests tend to be fire intolerant. No Federally listed plant species is known in this habitat in GRCA. Special status plant species known in this habitat type are

- Spiked ipomopsis (*Ipomopsis spicata* ssp. *Tridactyla*)
- Kaibab Plateau beardtongue (*Penstemon pseudoputus*)
- Kaibab whitlowgrass (*Draba asprella* var. *kaibabensis*)
- Arizona rubberweed or bitterweed (*Hymenoxys subintegra*)

3.1.2.4 Piñon-Juniper Vegetation — Special Status Plant Species

Piñon-juniper forest habitat accounts for approximately 26% of GRCA (approximately 306,600 acres). For comprising such a large park area, minimal treatment is proposed in this forest type for all alternatives due to lack of information regarding historical fire regime and concern for cheat grass (invasive exotic plant species) spread. The four special status plant species known to occur in this habitat type also occur in other habitat types and are discussed above.

- Macdougal Indian parsley (*Aletes macdouglaii* ssp. *macdouglaii*)
- Flagstaff rockcress (*Arabis gracilipes*)
- Mt. Dellenbaugh sandwort (*Arenaria aberrants*)
- Grand Canyon goldenbush (*Ericameria arizonica*)

An additional species, *Astragalus septentriorema*, is located in the piñon-juniper at Cape Final. This population was previously thought to be 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.

Also known species specific to piñon-juniper are the Federally listed endangered species

- Sentry milk-vetch (*Astragalus cremnophylax* var. *cremnophylax*) (GRCA endemic)

and the special status plant species

- Kaibab agave (*Agave utahensis* ssp. *kaibabensis*)
- Tusayan flameflower (*Phemeranthus validulus* syn. Talinum validulum)
- Grand Canyon rose (*Rosa stellata* ssp. *stellata*)

3.1.3 Exotic Plant Species

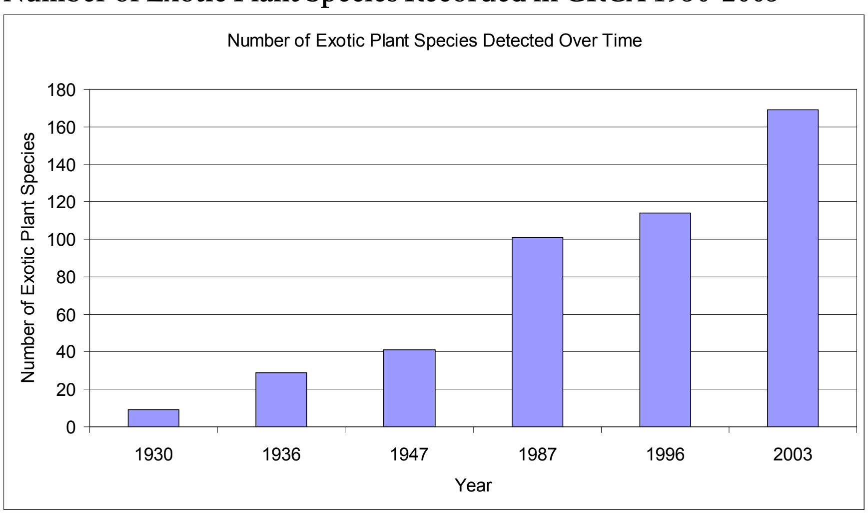
NPS Management Policies 2006 define native species as "all species that have occurred, now occur, or may occur as a result of natural processes on lands designated as units of the national park system. Native species in a place are evolving in concert with each other."

Exotic species are defined as "those species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities. Exotic species are also commonly referred to as nonnative, alien, or invasive species. Because an exotic species did not evolve in concert with the species native to the place, the exotic species is not a natural component of the natural ecosystem at that place."

Exotic plants are commonly early successional species of disturbed areas; however, they can also be aggressive, replacing late-successional native species in habitats relatively free of disturbance (Stohlgren et al., 1999). Although roughly 10% of exotic species pose a threat to ecosystems (Williamson, 1996), such species can displace native vegetation by robbing moisture, nutrients, and sunlight from surrounding plants resulting in native habitat loss and increased soil erosion. These species, also known as invasives, create long-term changes in plant community composition and structure, affecting entire populations of plants and animals (Cronk and Fuller, 2001; NPS, 2006; Vitousek et al., 1996). Exotics are considered the biggest threat to biodiversity after habitat destruction (Chornesky & Randall, 2003; Randall, 1996).

Worldwide, in the last few centuries both numbers of exotic plant species and their abundance has increased dramatically, and national parks are no exception. Exotic plant species are considered one of the most serious threats national parks face, infesting over 2.6 million acres (1,052,182.67 hectares) in the system (NPS, 2002a). At GRCA, historical floristic surveys reveal, and Figure 3-2 illustrates, a steady increase in the number of exotic plant species from 9 in 1930, to 29 in 1936, and 41 in 1947 (Hawbecker, 1936; McDougall, 1947; Mead, 1930). Today, 187 exotic plant species have been found inside park boundaries with more expected (see Appendix I for a list of exotic plant species). It is estimated that roughly 50% of the park's total area currently contains exotic plant species; however, the entire park is at risk. Of these, many species are considered invasive and are of particular concern to managers because they could displace native vegetation. Arizona's administrative code regarding regulated, restricted, and prohibited noxious weeds mandates control of seventeen of these species (Table 3-1).

Figure 3-2 Number of Exotic Plant Species Recorded in GRCA 1930-2003



NPS Management Policies 2006 state that all non-native plant species (not maintained to meet an identified park purpose, such as cultural landscape component) will be managed, up to and including eradication, if 1) control is prudent and feasible and 2) the exotic species

- interferes with natural processes and perpetuation of natural features, native species, or natural habitats, or
- disrupts genetic integrity of native species, or
- disrupts accurate presentation of a cultural landscape, or
- damages cultural resources, or
- significantly hampers management of park or adjacent lands, or
- poses a public health hazard as advised by the U.S. Public Health Service, or
- creates a hazard to public safety

A goal of GRCA's exotic plant management program is to preserve or restore natural environmental conditions by preventing, containing, significantly reducing, or controlling exotic plant species infestations. This is modeled after and designed to expand on six management strategies put forth by the NPS Strategic Plan for Managing Invasive Nonnative Plants in National Parks (NPS 1996):

- Prevent invasion
- Increase public awareness
- Inventory and monitor nonnative plants
- Conduct research and transfer technology
- Integrate planning and evaluation
- Manage invasive non-native plants

Supplementary GRCA exotic plant management goals include

- Reduce or eliminate exotic plant ability to invade natural areas, or to re-invade previously treated areas
- Re-establish natural ecosystem function in areas previously impacted by exotic plants
- Accomplish overall goals while avoiding harm to wilderness character, natural resources, natural ecological communities and processes, cultural resources, or human health and safety
- Ensure visitor and employee safety during project implementation
- Implement project without significantly impacting visitor experience
- Conserve native seeds in areas adjacent to infestations to preserve genetic diversity and provide a seed source for future restoration

Table 3-1 Exotic Plant Species Found in GRCA and on the Arizona Noxious Plant List

Common Name	Scientific Name	Common Name	Scientific Name
Russian knapweed	*Acroptilon repens*	Canada thistle	*Cirsium arvense*
Jointed goatgrass	*Aegilops cylindrica*	Field bindweed	*Convolvulus arvensis*
Camelthorn	*Alhagi maurorum*	Quackgrass	*Elymus repens*
Whitetop	*Cardaria draba*	Dalmation toadflax	*Linaria dalmatica*
Field sandbur	*Cenchrus spinifex*	Scotch thistle	*Onopordum acanthium*
Diffuse knapweed	*Centaurea diffusa*	Little hogweed	*Portulaca oleracea L.*
Yellow starthistle	*Centaurea solstitialis*	Field sowthistle	*Sonchus arvensis L.*
Spotted knapweed	*Centaurea stoebe* ssp. *micranthos*	Puncturevine	*Tribulus terrestris*
Rush skeletonweed	*Chondrilla juncea*		

GRCA began controlling exotic plant species manually in the early 1990s when Ravenna grass (*Saccharum ravennae* (L.) L.) became a threat to Inner Canyon riparian areas. By 1993, similar control efforts were initiated for South Rim Dalmation toadflax (*Linaria dalmatica* (L.) P. Mill.) and Mediterranean sage (*Salvia aethiopis* L.) populations, and North Rim Dalmation toadflax and houndstongue (*Cynoglossum officinale* L.). By the mid-1990s, Himalayan blackberry (*Rubus armeniacus* Focke) populations at Indian Garden were added to the control list. In addition to manual and mechanical treatment, this was the first time chemical herbicides were used to control GRCA exotic plants. Current control efforts focus on 39 particularly aggressive species with techniques such as pulling, digging, and replanting native vegetation.

In the 1870s, the first plants considered exotic to GRCA were introduced to the region by early settlers who planted these grasses and herbs as forage for domestic livestock. Other exotics were introduced intentionally for erosion control or aesthetic purposes. Creation of roads, trails, campgrounds, visitor centers, and picnic areas further contributed to exotic plant species establishment as seeds were carried on machinery, in gravel, or in contaminated seed mixes. Visitors, too, have unknowingly introduced and transported seeds on vehicles, mules, hiking boots, and other means. People, machinery, vehicles, livestock, wildlife, wind, and water have contributed to establishment and spread of exotic plant species.

3.1.4 Wildlife

GRCA is a valuable resource for wildlife due to its size, elevation range, and associated habitat variety. The current park wildlife database includes over 90 mammals, 355 birds, and 56 amphibian and reptile species. GRCA's diverse range of vegetation associations provides suitable conditions for both habitat generalists and specialists. Some species occur only on North or South Rim or along the river corridor. Wildlife occurrence can generally be grouped in habitats defined by vegetation: mixed-conifer (spruce-fir and mixed-conifer types), ponderosa pine, piñon-juniper, shrub-grass, and riparian. Many wildlife species are habitat generalists, using ecosystems from desert scrub through coniferous forest to meet basic requirements. Some species are habitat specialists, requiring specific vegetation composition and structural components to supply their needs. Table 3-2 provides a habitat list with common species. The proposed Fire Management Plan includes planned projects on both North and South rims; no fire and/or fuel reduction projects are planned below the rims.

Table 3-2 Representative GRCA Animal Species by Habitat

Common Name	Scientific Name	Common Name	Scientific Name
Mixed Conifer (Spruce-Fir and Mixed-Conifer types)			
Birds		Mammals	
American Robin	*Turdus migratorius*	Big Brown Bat	*Eptesicus fuscus*
Blue grouse	*Dendragapus obscurus*	Bushy-tailed Woodrat	*Neotoma cinerea*
Clark's Nutcracker	*Nucifraga columbiana*	Coyote	*Canis latrans*
Dark-eyed junco	*Junco hyemalis*	Deer Mouse	*Peromyscus maniculatus*
Hairy Woodpecker	*Picoides villosus*	Least Chipmunk	*Eutamias minimus*
Hermit Thrush	*Catharus guttatus*	Long-tailed Vole	*Microtus longicaudus*
Mountain Chickadee	*Parus gambeli*	Mountain Cottontail	*Sylvilagus nuttallii*
Northern Flicker	*Colaptes auratus*	Mule Deer	*Odocoileus hemionus*
Steller's Jay	*Cyanocitta stelleri*	Porcupine	*Erethizon dorsatum*
Townsend's Solitaire	*Myadestes townsendi*	Red Squirrel	*Tamiasciurus hudsonicus*
Yellow-rumped Warbler	*Dendroica coronata*	Uinta Chipmunk	*Eutamias umbrinus*
Reptiles		Western Harvest Mouse	*Reithrodontom megalotis*
Mountain Short-horned Lizard	*Phrynosoma douglassi*		
Ponderosa Pine			
Birds		Mammals	
American Robin	*Turdus migratorius*	Abert Squirrel	*Sciurus aberti*
Common Raven	*Corvus corax*	Bobcat	*Lynx rufus*
Dark-eyed junco	*Junco hyemalis*	Coyote	*Canis latrans*
Flammulated owl	*Otus flammeolus*	Deer Mouse	*Peromyscus maniculatus*
Grace's Warbler	*Dendroica graciae*	Elk	*Cervus canadensis*
Great Horned Owl	*Bubo virginianus*	Golden-mantled Ground Squirrel	*Spermophilus lateralis*

Common Name	Scientific Name	Common Name	Scientific Name
Hairy Woodpecker	*Picoides villosus*	Gray Fox	*Urocyon cinereoargent*
Mountain Chickadee	*Parus gambeli*	Long-legged Myotis	*Myotis volans*
Northern Flicker	*Colaptes auratus*	Mexican Woodrat	*Neotoma mexicana*
Pygmy Nuthatch	*Sitta pygmaea*	Mountain lion	*Puma concolor*
Western Bluebird	*Sialia mexicana*	Mule Deer	*Odocoileus hemionus*
Western Tanager	*Piranga ludoviciana*	Porcupine	*Erethizon dorsatum*
Western Wood-Pewee	*Contopus sordidulus*	Striped Skunk	*Mephitis mephitis*
White-Breasted Nuthatch	*Sitta carolinensis*	Uinta Chipmunk	*Eutamias umbrinus*
Wild turkey	*Meleagris gallopavo*	Western Harvest Mouse	*Reithrodontom megalotis*
Yellow-rumped Warbler	*Dendroica coronata*	Western Pipistrelle	*Pipistrellus hesperus*
Reptiles			
Great Basin Gopher Snake	*Pituophis melanoleucus*	Northern Sagebrush Lizard	*Sceloporus graciosus*
Mountain Short-horned Lizard	*Phrynosoma douglassi*	Plateau Lizard	*Sceloporus undulates*
Piñon-Juniper			
Birds		**Mammals**	
Ash-throated Flycatcher	*Myiarchus cinerascens*	Big Brown Bat	*Eptesicus fuscus*
Black-throated Gray Warbler	*Dendroica nigrescens*	Black-tailed Jack Rabbit	*Lepus californicus*
Blue-gray Gnatcatcher	*Polioptila caerulae*	Bobcat	*Lynx rufus*
Common Poorwill	*Phalaenpotilu nuttallii*	Cliff Chipmunk	*Eutamias dorsalis*
Common Raven	*Corvus corax*	Coyote	*Canis latrans*
Plain Titmouse	*Parus inornatus*	Desert Cottontail	*Sylvilagus audubonii*
Pinyon Jay	*Gymnorhynus cyanocephalus*	Elk	*Cervus Canadensis*
Say's Phoebe	*Sayornis saya*	Gray Fox	*Urocyon cinereoargent*
Scott's Oriole	*Icterus parisorum*	Long-legged Myotis	*Myotis volans*
Spotted Towhee	*Pipilo maculatus*	Mountain lion	*Puma concolor*
Steller's Jay	*Cyanocitta stelleri*	Mule Deer	*Odocoileus hemionus*
Western Bluebird	*Sialia mexicana*	Pinyon Mouse	*Peromyscus truei*
Western Scrub Jay	*Aphelocoma californica*	Rock Squirrel	*Spermophilus variegates*
White-Breasted Nuthatch	*Sitta carolinensis*	Stephen's Woodrat	*Neotoma stephensi*
Reptiles		Western Harvest Mouse	*Reithrodontom megalotis*
Mountain Short-horned Lizard	*Phrynosoma douglassi*	White-tailed Antelope Squirrel	*Ammospermophi leucurus*
Plateau Lizard	*Sceloporus undulatus*	White-throated Woodrat	*Neotoma albigula*
Sonoran Gopher Snake	*Pituophis melanoleucus*		
Shrub-Grass			
Birds		**Mammals**	
Ash-throated Flycatcher	*Myiarchus cinerascens*	Black-tailed Jack Rabbit	*Lepus californicus*
Black-throated Sparrow	*Amphispiza bilineata*	Cactus mouse	*Peromyscus eremicus*
Blue-gray Gnatcatcher	*Polioptila caerulae*	Coyote	*Canis latrans*
Bushtit	*Psaltriparus minimus*	Deer Mouse	*Peromyscus maniculatus*
Common Poorwill	*Phalaenpotilu nuttallii*	Desert Cottontail	*Sylvilagus audubonii*
Common Raven	*Corvus corax*	Desert Woodrat	*Neotoma lepida*
Horned Lark	*Eremophila alpestris*	Gray Fox	*Urocyon cinereoargent*
Mountain Bluebird	*Sialia currucoides*	Botta's Pocket Gopher	*Thomomys bottae*
Mourning Dove	*Zenaida macroura*	Western Harvest Mouse	*Reithrodontom megalotis*
Plain Titmouse	*Parus inornatus*	White-tailed Antelope	*Ammospermophi leucurus*

Common Name	Scientific Name	Common Name	Scientific Name
		Squirrel	
Red-tailed Hawk	*Buteo jamaicensis*		
Western Meadowlark	*Sturnella neglecta*		
Reptiles			
Black Collared Lizard	*Crotaphytus insularis*	Northern Whiptail	*Cnemidophorus tigris*
California King Snake	*Lampropeltis getulus*	Plateau Lizard	*Sceloporus undulates*
Collared Lizard	*Crotaphytus collaris*	Side-blotched Lizard	*Uta stansburiana*
Desert Striped Whipsnake	*Masticophis taeniatus*	Sonoran Gopher Snake	*Pituophis melanoleucus*
Great Basin Gopher Snake	*Pituophis melanoleucus*	Yellow-backed Spiny Lizard	*Sceloporus magister*
Riparian			
Birds		**Mammals**	
White-throated Swift	*Aeronautes saxatalis*	Ringtail	*Bassariscus astutus*
Black-chinned Hummingbird	*Archilochus alexandri*	Beaver	*Castor Canadensis*
House Finch	*Carpodacus mexicanus*	Western Spotted Skunk	*Spilogale gracilis*
Canyon Wren	*Catherpes mexicanus*	Gray Fox	*Urocyon cinereoargent*
Black-throated Gray Warbler	*Dendroica nigrescens*	**Reptiles and Amphibians**	
Yellow Warbler	*Dendroica petechia*	Red Spotted Toad	*Bufo punctatus*
Common Yellowthroat	*Geothlypis trichas*	Rocky Mountain Toad	*Bufo woodhousei*
Scott's Oriole	*Icterus parisorum*	Northern Whiptail	*Cnemidophorus tigris*
Dark-eyed junco	*Junco hyemalis*	Collared Lizard	*Crotaphytus collaris*
Song Sparrow	*Melospiza melodia*	Black Collared Lizard	*Crotaphytus insularis*
Ash-throated Flycatcher	*Myiarchus cinerascens*	Canyon Tree Frog	*Hyla arenicolor*
Blue-gray Gnatcatcher	*Polioptila caerulae*	Desert Striped Whipsnake	*Masticophis taeniatus*
Say's Phoebe	*Sayornis saya*	Yellow-backed Spiny Lizard	*Sceloporus magister*
Broad-tailed Hummingbird	*Selasphorus platycerus*	Tree Lizard	*Urosaurus ornatus*
Violet-green Swallow	*Tachycineta thalassina*	Side-blotched Lizard	*Uta stansburiana*
Cassin's Kingbird	*Tyrannus vociferans*		
Lucy's Warbler	*Vermivora luciae*		
American dipper	*Cinclus mexicanus*		
Black phoebe	*Sayornis nigricans*		
common merganser	*Mergus merganser*		
great blue heron	*Ardea herodias*		
mallard	*Anas platyrhynchos*		

Brown et al. 1984; Butterfield et al. 1981; Dickson et al. 2000a, 2000b, 2001; Hoffmeister 1971; Miller et al. 1982; Miller and Young 1981

The following brief species accounts provide information on preferred habitat. Accounts for species listed as sensitive or special status by the USFWS, AGFD, Arizona Department of Agriculture, or Navajo Nation are discussed in the following section, Special Status Wildlife.

3.1.4.1 Invertebrates Wildlife

Forested communities provide habitat for a wide variety of insects (e.g., Coleopterans, Hymenopterans, and Lepidopterans) that, in turn, provide food for wildlife such as bats and birds. Flying insects provide the sole food source for special status species such as the spotted bat and greater western mastiff bat (see Special Status Wildlife below). Little is known about the ecology of GRCA moth species (Painter 2004).

Wood-boring insects provide an important food source for bark-gleaning birds such as woodpeckers, brown creepers (*Certhia americana*), nuthatches (*Sitta* spp.), titmice, and warblers. Bark-dwelling insects are a particularly important food source for over-wintering bird species when flying insects are scarce and ground is snow covered. In northern Arizona ponderosa pine forests, wintering hairy woodpeckers (*Picoides villosus*) have been shown to exploit the increased food base in moderately and severely burned areas. Severely burned areas (99% tree mortality) were used more intensively than moderately burned areas (10% tree mortality) until three years post-burn; use levels in both burn classes declined to those of unburned areas by seven years post-burn (Covert 2004).

3.1.4.2 Vertebrates Wildlife
Herpetofauna

Approximately 56 reptile and amphibian species reside in GRCA. The majority of species occur along the river corridor or in upland desert and riparian sites, with highest densities and diversity in riparian areas due to abundant vegetation and invertebrate food sources. Little is known, however, about herpetofauna that inhabit GRCA's forested communities. Herpetofauna use of forested communities is generalized to forest ecosystems, but local conditions including exposure, air movement, and water presence create suitable microhabitats in each habitat type.

A variety of lizards and snakes inhabit plateau coniferous forests especially in piñon-juniper woodlands and ponderosa pine forests. Especially abundant on North Rim, the greater short-horned lizard (*Phrynosoma hernandesi*) is the most abundant reptile found in ponderosa pine. It occurs throughout this forest type and into piñon-juniper woodlands and is most abundant in semi-open sunny areas with sandy or pebbly soil. Horned lizards burrow into soil or use unoccupied rodent burrows when inactive (Rasmussen 1941, Miller et al. 1982). The northern plateau lizard (*Sceloporus undulatus elongatus*) is common in piñon-juniper woodlands, ponderosa pine, and desert scrub or grassland areas (Bogert 1932, Miller and Young 1981, NatureServe 2002). They prefer more open, sunny areas and use downed woody debris and snags or soil burrows for cover when inactive. Egg laying occurs underground (NatureServe 2002). Also common on North Rim is the northern sagebrush lizard (*Sceloporus graciosus graciosus*). It is most abundant in sagebrush and piñon-juniper, but also common in open areas of ponderosa pine with low bushes (Miller and Young 1981, NatureServe 2002). Northern sagebrush lizards seek cover under rocks or fallen logs (Miller et al. 1982) and forage in woody debris and undergrowth for insects, spiders, ticks, mites, and aphids, their preferred food. The many-lined skink (*Eumeces multivirgatus*) is rare in the park and only found on South Rim. It is very secretive and hides beneath rocks or logs (Miller et al. 1982). The western skink (*Eumeces skiltonianus*) is rare in habitats from grasslands to forests on both rims and is usually associated with rocky areas. Rocks, logs, and leaf litter are important habitat components as cover. Skinks lay eggs in soil burrows or in areas excavated by the female under rocks (NatureServe 2002).

The Great Basin gopher snake (*Pituophis catenifer deserticola)* is common in ponderosa pine forests, piñon-juniper woodlands, and desert scrub (Miller and Young 1981). It is most common on North Rim but also occurs on South Rim (Miller et al. 1982). This snake takes refuge in mammal burrows or under large rocks and logs and feeds primarily on rodents. The Great Basin rattlesnake (*Crotalus viridis lutosus*) is uncommon and prefers thinly forested rocky areas in ponderosa pine, piñon-juniper, or arid grasslands (Miller and Young 1981). Found on North Rim plateaus, it has been reported at elevations up to 8,000 feet. It uses rock crevices and rodent burrows for cover or hibernation (Miller et al. 1982). Primarily found on South Rim, the Sonoran gopher snake (*Pituophis catenifer affinis*) occurs in habitats from desert scrub to piñon-juniper woodlands, possibly extending into ponderosa pine. The Utah mountain kingsnake (*Lampropeltis pyromelana infralabialis*) is rare and found in ponderosa pine on North Rim (Miller and Young 1981, Miller et al. 1982). They inhabit thickly vegetated ravines in ponderosa pine forests, spending much time beneath rocks and forest floor litter or in deep boulder crevices (Miller et al. 1982). The wandering garter snake (*Thamnophis elegans vagrans*) is uncommon in riparian areas or moist habitats of North Rim and rarely occurs on South Rim (Miller and Young 1982, Miller et al. 1982).

Few amphibians inhabit plateaus and are restricted to the most mesic areas. Tiger salamanders (*Ambystoma tigrinum*) inhabit areas around pools, marshes, and water tanks in meadows in North Rim ponderosa pine to spruce-fir forests. It is common in larvae form, but less common in adult form (Miller and Young 1981). The Arizona tiger salamander (*Ambystoma tigrinum nebulosum*) is apparently limited to South Rim moist areas around marshes and water tanks. It is rare and highly secretive as an adult (Miller et al. 1982). Tiger salamanders require soil suitable for burrowing and a body of water suitable for breeding. Outside breeding season, adults generally remain underground in self-made burrows, abandoned rodent burrows, or under logs or rocks (Miller et al. 1982, NatureServe 2002). The Great Plains toad (*Bufo cognatus*) is also rare in rim riparian areas or in ponderosa pine forests (Miller and Young 1981). They typically occur in lower, damper areas of grasslands and breed in shallow pools, ponds, or flooded areas. These toads burrow underground when inactive (NatureServe 2002). The Great Basin spadefoot toad (*Spea intermontana*) occurs from ponderosa pine to spruce-fir forests on North Rim. They are also secretive amphibians, spending most time in burrows except during heavy rains and the breeding season (Miller et al. 1982). Breeding occurs in marshes, lakes, or temporary rain pools.

Fire suppression has altered herpetofauna habitat by fragmenting historically more open forests and resulting in large contiguous areas of higher density stands (Greenburg et al. 1994 in Russell et al. 1999). Higher density ponderosa pine forests inhibit sunlight from reaching the forest floor, reducing sunlight accessibility for ectothermic animals that rely on solar heat for metabolic processes and mobility. However, species have different thermoregulatory demands and should be examined on a species-specific basis (Knox et al. 2001).

Birds Vertebrates Wildlife

Grand Canyon's striking elevation and topographic diversity creates complex mosaics of vegetation types, providing diverse habitat for bird species (Brown et al. 1984). Pockets of Gambel oak in ponderosa pine, and inclusions of meadows and aspen in mixed-conifer and spruce-fir also provide essential diversity across the landscape.

A number of bird species are generalists and occupy a variety of habitats. Using point-count inventories, of 45 species in all GRCA habitat types (ponderosa pine, ponderosa-mixed conifer transition, mixed conifer, and meadow), Dickson and others (2000a) found 23 species common to all habitat types, 11 species present in only 1 habitat, and an additional 11 species present in 2 or 3 habitats. More generalist forest species such as the broad-tailed hummingbird, plumbeus vireo, brown creeper, and evening grosbeak were found in all forest types from ponderosa pine to spruce-fir forests (Dickson et al. 2000a). Ponderosa pine forests contain one dominant tree species, ponderosa pine, historically found in open park-like stands. This homogeneity generally decreases forest habitat variation and results in relatively low species diversity (Rasmussen, 1941). However, Gambel oak grows in dense, isolated patches in some areas of ponderosa pine forests, adding greatly to forest diversity and acting as important nesting sites or foraging sources for several bird species (Brown et al. 1984). Most birds found in ponderosa pine do not reach their highest densities there, but are more abundant in piñon-juniper woodlands below or higher mixed-conifer or spruce-fir forests. For example, three-fourths of birds found in ponderosa pine also occur in higher mixed-conifer and spruce-fir forests (Brown et al. 1984).

However, Greer (1982) found that North Kaibab ponderosa pine forests had the highest bird densities of all forested habitats for all seasons (usually twice as great), except for summer when densities were slightly higher in spruce-fir forests. Density of all bird species (individuals per 40 hectares) in ponderosa pine forests were estimated at 290 birds/40 ha in fall, 80 birds/40 hectares in winter, 320 birds/40 ha in spring, and 220 birds/40 ha in summer. Density of all bird species in mixed-conifer forests were estimated at 60 birds/40 ha in fall, 50 birds/40 hectares in winter, 110 birds/40 ha in spring, and 100 birds/40 ha in summer. Density of all bird species in spruce-fir forests were estimated at 90 birds/40 ha in fall, 25 birds/40 hectares in winter, 150 birds/40 ha in spring, and 225 birds/40 ha in summer. Greer (1982) sampled aspen stands as a separate forest type and found an average of 75 birds/40 ha in fall, 5 birds/40 hectares in winter, 160 birds/40 ha in spring, and 160 birds/40 ha in summer.

Ponderosa pine forests also had the greatest species richness during all seasons except summer, when richness was slightly higher in mixed-conifer and spruce-fir forests (Greer 1982). Species richness (number of species per 40 hectares) in ponderosa pine forests was estimated at 19 species/40 ha in fall, 14 species/40 hectares in winter, 32 species/40 ha in spring, and 23 species/40 ha in summer. Species richness in mixed-conifer forests was estimated at 14 species/40 ha in fall, 9 species/40 hectares in winter, 28 species/40 ha in spring, and 24 species/40 ha in summer. Species richness in spruce-fir forests was estimated at 13 species/40 ha in fall, 9 species/40 hectares in winter, 24 species/40 ha in spring, and 24 species/40 ha in summer. Greer (1982) sampled aspen stands as a separate forest type and found an average of 11 species/40 ha in fall, 2 species/40 hectares in winter, 16 species/40 ha in spring, and 16 species/40 ha in summer.

Breeding warbler diversity in ponderosa pine is second only to the Colorado River corridor, which has four breeding species. Yellow-rumped, Grace's, and Virginia warblers nest in ponderosa pine forests (Brown et al. 1984). The yellow-rumped warbler is one of the most abundant birds in ponderosa pine forests, but also forages in tree crowns and terminal branches (Rasmussen 1941).

Secondary cavity nesters (e.g. violet-green swallow, pygmy nuthatch, western bluebird, brown creeper, white-breasted nuthatch) are an important ponderosa pine forest bird community component. An average of six secondary cavity nesting species have been found on study plots, comprising 26-30% of all breeding species in ponderosa pine forests (Balda 1975, Cunningham et al. 1980). Studies show secondary cavity nesters contribute 56-108 breeding pairs per 100 acres of ponderosa pine forests; between 32 and 45% of all breeding pairs (Balda 1975). Number of suitable nesting cavities is the primary limiting factor for secondary cavity nesters. Relative proportion of total population of secondary cavity nesters increases as snag density increases (increasing from 20 breeding pairs per 40 hectares on sites with less than 10 snags per 40 hectares to 200 breeding pairs/40 ha on sites with 225 snags/40 ha) (Cunningham et al. 1980). To maintain a natural level of species diversity and density of secondary cavity nesters, Balda (1975) estimates that an average of 221 snags/100 acres is required in ponderosa pine forests. In addition to influencing overall density, snag removal will affect avian community composition depending on the sensitivity level of various secondary cavity nesting species (i.e. the species' dependency on snags for nests and food) (Balda 1975).

Secondary cavity nesters importance to bird communities in Arizona mixed-conifer forests is similar to that of ponderosa pine forests. Balda (1975) found an average of 30 to 178 breeding pairs per 100 acres, contributing 17 to 47% of all breeding pairs in mixed-conifer forests. In addition, four to eight species of secondary cavity nesters were 25 to 30% of all breeding species. Secondary cavity nesters require about the same number of snags in mixed-conifer forests as ponderosa pine forests, but some species seem especially attracted to aspen's soft wood for excavating (Balda 1975).

Brawn et al. (1987) found 24 insectivorous bird species in untreated ponderosa pine forests with an oak component. Breeding pair density varied from 65 to 215 pairs/40 ha over four years prior to experimental plot treatment. After experimental plot treatment, the control plot contained an average of 180 breeding pairs/40 ha over four years.

Several raptors are closely associated with ponderosa pine. The rare northern goshawk is the keystone bird of ponderosa pine forests, and is discussed in the Special Status Species section below. Red-tailed hawks are permanent residents and occupy ponderosa pine and mixed-conifer forests in summer, foraging in meadows and open park-like areas (Rasmussen 1941, Dickson et al. 2000a). The Cooper's hawk, a winter visitor and summer resident, breeds in forested areas throughout the region but has the highest nesting density in ponderosa pine (Brown et al. 1984). The great horned owl, active at night, uses ponderosa pine and mixed-conifer as it forages in meadows and open park-like areas (Rasmussen 1941, Brown et al. 1984). The northern pygmy-owl also occurs in ponderosa pine, but hunts during the day or at dusk (Brown et al. 1984).

Flammulated owls are migratory and occur in dry, montane coniferous forests in central and western North America. They are found in the yellow-pine belt from lower elevations mixed with oak (*Quercus* spp) or piñon pine (*Pinus monophylla*) to the higher elevations where pine is mixed with firs (*Abies* spp), Douglas fir, or quaking aspen (Reynolds and Linkhart 1992). Flammulated owls are obligate secondary cavity nesters that generally prefer older forests containing an abundance of snags and lightning-damaged trees with cavities. In a literature review, Reynolds and Linkhart (1992) found that all flammulated owl nests were in or adjacent to mature or old-growth stands. These owls are entirely insectivorous, gleaning arthropods from needle bunches or the bark of limbs and trunks of large conifers, and occasionally hawking for insects. Old yellow-pine forests (mixed or pure) typically form open stands with well-developed grass or shrub understories that support an abundance of arthropods (Reynolds and Linkhart 1992). However, increased tree densities and conversion of some forests to mixed-conifer or fir forests decreases flammulated owl habitat viability.

The majority of birds found in mixed-conifer forests also inhabit lower ponderosa pine or higher spruce-fir and aspen forests. Northern flickers, hairy woodpeckers, three-toed woodpeckers, yellow-rumped warblers and mountain chickadees reach highest densities in mixed-conifer, spruce-fir and aspen stands, but also occupy ponderosa pine in smaller numbers (Brown et al. 1984). The Williamson's sapsucker and three-toed woodpecker act more as indicator species for mixed-conifer and spruce-fir, as they seldom occur in ponderosa pine (Brown et al. 1984). The common Williamson's sapsucker usually nests in aspen but feeds on the cambium layer of smaller yellow pines (Rasmussen 1941).

Blue grouse are year-round residents of montane conifer forests. Males hold territories in spring and perform vocal and visual displays to attract females. Females rear broods alone and lay eggs in shallow depressions usually concealed under vegetation or beside a fallen log (Ehrlich et al. 1988). Young are precocial and feed primarily on insects. Adult blue grouse forage primarily on leaves, but also eat flowers, fruit, and insects. Conifer needles provide most of their winter diet.

Blue grouse occur on North Rim in mixed-conifer forest. They generally breed in relatively open areas such as aspen and sagebrush communities and migrate up in elevation to winter in dense conifer habitat (Zwickel 1992). Blue grouse populations may increase temporarily following fire or logging practices that create canopy openings, and decrease as canopies close. Fires may also cause direct mortality, particularly of eggs and young, and adult displacement.

Spruce-fir forest contains many of the birds found in ponderosa pine and mixed-conifer forests. Aspen and meadow inclusions enhance diversity of spruce-fir, and account for a good portion of birds that select for spruce-fir forests (Rasmussen 1941). Some birds use spruce-fir seasonally during summer and occur in other forested regions the rest of the year (Rasmussen 1941).

Snag density and spatial arrangement often determines bird use for foraging and nesting. Size, spatial arrangement, and presence of broken tops also influence usefulness to wildlife. Some species prefer clumps of snags (Saab and Dudley 1998), and trees with broken tops are usually partially decayed and thus easier to excavate for some species (Caton 1996). Nesting use is often concentrated in large snags (Scott 1978, Cunningham et al. 1980, Horton and Mannan 1988, Caton 1996). Larger snags tend to persist longer than smaller snags, adding to their advantageous use by many species (Raphael et al. 1987).

Preferential snag usage also changes over time. Snags experience heaviest use for foraging and nesting in a certain time period, depending on tree species. In northern Arizona, most nesting occurred in five- to twenty-year-old snags; most foraging occurred on one- to five-year-old snags (Cunningham et al 1980). Insects generally colonize these snags rapidly and their numbers decrease over time (Bock and Lynch 1970, Cunningham et al. 1980).

Breeding bird communities are naturally dynamic, exhibiting a high degree of natural variability in density, richness, and composition. Rosenstock (1996) found that breeding bird communities in individual stands had considerable annual species composition turnover. Fluctuation in some areas was due to irruptive species like the pine siskin and red crossbill, which respond to flushes of conifer seed production (Rosenstock 1996). Climatic factors can also influence breeding bird communities in ponderosa pine forests and may contribute to species turnover (Rosenstock 1996). Szaro and Balda (1986) found that bird density was lower in breeding seasons preceded by a harsh winter and spring weather, perhaps due to effects on prey insect emergence and abundance. However, weather effects are typically short-term and had less influence on avian communities than habitat conditions (Rosenstock 1996).

Bats Vertebrates Wildlife

GRCA provides a variety of roosting and feeding areas for bat species. Two species, western red bat (*Lasionycteris borealis*) and Yuma myotis (*Myotis yumanensis*), occur primarily along the river corridor, roost in cliffs or trees, and forage in riparian areas, though western red bats have also been detected on the rim between Grand Canyon Village and Desert View. A third species, Mexican long-tongued bat (*Choeronycteris mexicana*), was captured along the Colorado River in 1997 (one individual) and at springs on North Rim in 2001 (two individuals) (Leslie 2001). This species has also been detected throughout GRCA, from both rims to the river, though most records occur in Lower Gorge and on the Esplanade. Bat species that occur primarily below the rims are unlikely to be affected by fire management activities in forested areas.

Bats that typically roost in caves or cliff crevices are less likely than forest-dwelling bats to be affected by fire management activities. Roost sites are often limiting for bat populations, but canyon-wall roosts are unlikely to be affected by fire. Species that typically roost in caves or cliff crevices include the pallid bat (*Antrozous pallidus*), western pipistrelle (*Pipistrellus hesperus*), pocket free-tail (*Nyctinomops femorosaccus*), big free-tail (*Nyctinomops macrotis*), Mexican free-tail (*Tadarida brasiliensis*), California myotis (*Myotis californicus*), small-footed myotis (*Myotis lebii*), Yuma myotis (*Myotis yumanensis*), spotted bat (*Euderma maculatum*), greater western mastiff bat (*Eumops perotis*), Allen's big-eared bat (*Idionycteris phyllotis*), and Townsend's big-eared bat (*Corynorhinus townsendii*) (Hoffmeister 1986, Siders et al. 1999, BCI 2002). Allen's big-eared bat and Mexican free-tail bats may also roost in large snags, and the California myotis has been recorded roosting in South Rim ponderosa snags (Ward 2005).

Known GRCA forest-dwelling bats include big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), southwestern myotis (*Myotis auriculus*), long-eared myotis (*Myotis evotis*), long-legged myotis (*Myotis volans*), fringed myotis (*Myotis thysanodes*), and silver-haired bat (*Lasionycteris noctivagans*). These bats roost in dense foliage, beneath exfoliating bark, or in tree cavities. Big brown bat colonies have been documented using South Rim old-growth aspen stands (Ward 2005). Western red bats have been detected using the rim between Grand Canyon Village and Desert View. Roost sites for forest-dwelling bats could be affected by fire management activities.

A variety of bats use ponderosa pine forests and forest openings, but little is known about their habits. The small-footed myotis (*Myotis leibii*) is an uncommon resident of South Rim's eastern portion. Little is known about its habits, but it has been found in piñon-juniper and ponderosa pine with long-legged myotis (*Myotis volans*) and western pipistrelles (*Pipistrellus hesperus*). Western pipistrelles are a common GRCA bat, especially in the canyon and along the rim. They usually live in cliffs and walls and are found at the canyon bottom and over rim coniferous forests. The little brown bat (*Myotis lucifugus*) is very rare in GRCA. It forages in openings from ponderosa pine to spruce-fir forests. Long-legged myotis occur on both rims, but are more common among South Rim pines and piñon-juniper. They are South Rim's most common bat, along with the western pipistrelle, and are especially evident foraging over pine forests and water. Little is known about the silver-haired bat (*Lasionycteris noctivagans*) in GRCA. They are rare in habitats of piñon-juniper, ponderosa pine, and into spruce-fir forests, and could occur on both rims while migrating in spring or fall. The big brown bat (*Eptesicus fuscus*) is the largest bat commonly found in North and South Rim coniferous forests. They occur along the river corridor and in forested areas from piñon-juniper into mixed-conifer, foraging over water and among pines. The fringed myotis (*Myotis thysanodes*) occurs on both rims, but is uncommon on South Rim and rare on North Rim. They roost in trees, canyon cliffs, or buildings and feed over coniferous forests openings or water sources. Spotted bats (*Euderma* *maculatum*) also roost in rocky cliffs and canyons and use ponderosa pine as foraging area. Except for the Mexican long-tongued bat, bats that regularly roost and feed in GRCA are insectivorous.

The spotted bat, western red bat, pale Townsend's big-eared bat, Allen's big-eared bat, long-legged myotis, and greater western mastiff bat are special status species and discussed in more detail below.

Small Mammals Vertebrates Wildlife

A number of small mammals are habitat generalists, using ecosystems from desert scrub into coniferous forests. Deer mice (*Peromyscus maniculatus*) and western harvest mice (*Reithrodontomys megalotis*) are common throughout the park, and serve as important prey species for many predators. They live in habitats from Inner Canyon's hot, desert conditions to North Rim's cool coniferous forests. Deer mouse density has been positively correlated with amount of slash and downed logs available for hiding and nesting (Goodwin and Hungerford 1979). In ponderosa pine forests of varying densities above 6,500 feet, deer mice density ranged from two mice per acre to 19 mice per acre (as debris ranged from 25 square feet to 335 square feet per acre) (Goodwin and Hungerford 1979).

Botta's pocket gophers (*Thomomys bottae*) inhabit South Rim and North Rim's warmer west end. They use desert scrub, piñon-juniper and ponderosa pine forests wherever suitable soil exists for digging. Pocket gophers rely on deep soil for digging and abundant grasses and forbs for food; habitat quality considerably influences population density. Pocket gophers have been found at a density of 0.04 to 0.22 gophers per acre in ponderosa pine forests 30 miles south of Flagstaff, Arizona (Goodwin and Hungerford 1979). However, other studies have found pocket gopher populations could reach eight to ten gophers per acre (Ingles et al. 1949).

The brush mouse (*Peromyscus boylii*) uses a variety of park habitats, preferring piñon-juniper forests, riparian areas, rocky slopes, and shrublands, and sometimes spruce-fir forests. The Mexican woodrat (*Neotoma mexicana*), the bushy-tailed woodrat (*Neotoma cinerea*) and the Mexican vole (*Microtus* mexicanus) are located only on South Rim. The bushy-tailed woodrat occurs in piñon-juniper woodlands or ponderosa pine forests, but is restricted to suitable rocky areas. The Mexican woodrat inhabits rocky areas in ponderosa pine, frequently along rim edges and sometimes into the piñon-juniper belt. They often use the same habitat as rock squirrels (*Spermophilus variegates*). Mexican voles prefer areas that tend to be drier with sparse grass.

Goodwin and Hungerford (1979) found brush mice, white-throated woodrats, and Mexican woodrats in high density along rock ledges and slides in ponderosa pine forests. Brush mice density ranged from six per acre after harsh winters to 20 per acre after milder years. Woodrat populations varied from two to ten individuals per acre. These species were almost exclusively captured within 60 feet of rock ledges, and no recaptures were made in open ponderosa pine stands more than 210 feet from rocky cover (Goodwin and Hungerford 1979).

The Uinta chipmunk (*Tamias umbrinus)*, least chipmunk (*Tamias minimus*), golden-mantled ground squirrel (*Spermophilus lateralis*), and Nuttall's cottontail (*Sylvilagus nuttallii*) are found only on North Rim. Uinta chipmunks prefer ponderosa pine forests but also occur in spruce-fir, grasslands, and at some places near rims in piñon-juniper and oak. They are especially evident in campgrounds and overlooks. Uinta chipmunks are often found in association with golden-mantled ground squirrels, which prefer upper edges of ponderosa pine type or aspen stands. Golden-mantled ground squirrels prefer the forest edge and more open stands but will also use denser forests. They burrow or make a nest under rocks or fallen trees (Rasmussen 1941). Golden-mantled ground squirrel density in ponderosa pine forests varies from 0.05 to 0.5 individuals per acre (Goodwin and Hungerford 1979). The least chipmunk and Colorado chipmunk (*Tamias quadrivittatu*) occur in piñon-juniper woodlands and throughout the ponderosa pine forest type, but are more abundant on the forest edge and in rocky areas. They forage in trees and bushes or on the forest floor, and the Colorado chipmunk appears to be more restricted to edge habitat (Rasmussen 1941). The least chipmunk also uses more open, grassy parts of mixed-conifer and spruce-fir forests. Chipmunks and ground squirrels appear to eat similar foods including herbaceous plant seeds, especially grasses and composites. They also eat some green vegetation and any available berries or tree seed (Rasmussen 1941). Nuttall's cottontails are uncommon North Rim residents found in ponderosa pine and mixed-conifer forests. They depend on available cover and prefer areas near the forest edge. They feed on grasses and other herbaceous vegetation, usually in or near cover (NatureServe 2002).

Two vole and two shrew species occur in GRCA. Merriam's shrew (*Sorex merriami*) inhabits cool, grassy areas near coniferous forests and has been captured on North and South Rims (Hoffmeister 1986). The dwarf shrew (*Sorex nanus*) is the smallest Arizona mammal and occurs in Kaibab Plateau talus areas and rocky slopes near spruce-fir forests. Shrews feed on small invertebrates such as insects, spiders, and earthworms. Female shrews bear offspring in summer in a small nest sheltered by a rock or log.

The long-tailed vole (*Microtus longicaudus baileyi*) occurs on Kaibab Plateau and prefers grassy areas near springs and swamps although it has been found in drier areas. The Mexican vole (*Microtus mexicanus navaho*) inhabits grassy areas near ponderosa pine forest on South Rim's Coconino Plateau. Mexican voles are often found in association with Merriam's shrew. Mexican voles may also be found in piñon-juniper and spruce-fir habitats. Voles feed on green vegetation, fungi, roots, and bark. Like shrews, voles bear young in nests sheltered by a log or rock.

A study conducted in 2005 and 2006 sampled small mammal population density and species diversity in various North and South Rim habitats. A mean of 4.5 species/hectare were found in piñon-juniper habitat, 3 species/ha in ponderosa pine, and 4.5 species/ha in mixed-conifer. In 2005, species composition varied by habitat with deer mice (*Peromyscus maniculatis*) the numerically dominant species in ponderosa pine; pinón mice in piñon-juniper; and long-tailed voles in mixed-conifer sites. In 2006, deer mice were the most common species observed in all habitat types. Between the years, density estimates ranged from 38.75 individuals/ha to 44.5 individuals/ha in piñon-juniper sites, and 33.25 individuals/ha to 41.5 individuals/ha in ponderosa pine. Density in mixed-conifer was estimated at 41.5 individuals/ha, and 11.5 individuals/ha in high elevation grasslands, both of which were only calculated for 2006 due to small sample size in 2005 (Lawes and Ward, 2006).

Carnivores Vertebrates Wildlife

Most predators are highly mobile, hunting from desert scrub to coniferous forests. Eleven terrestrial mammalian carnivore species occur in GRCA. These include mountain lion (*Puma concolor*), black bear (*Ursus americanus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), badger (*Taxidae taxus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), spotted skunk (*Spilogale gracilis*), ringtail (*Bassariscus astutus*), and long-tailed weasel (*Mustela frenata*). In 2003, six carnivore species were detected during surveys in North Rim ponderosa pine forests including mountain lion, coyote, bobcat, gray fox, badger, and spotted skunk (Reed and Leslie 2003).

Mountain lions (*Puma concolor*) occur throughout Arizona and are primarily active at dawn and dusk. They prey mostly on mule deer and elk (*Cervus elaphus*) and occasionally porcupine (*Erethizon dorsatum*), rabbits, and domestic livestock (Hoffmeister 1986). Adult mountain lions are territorial and solitary. Home ranges typically vary from 25 square miles to approximately 100 square miles, depending on gender, time of year, and prey availability. Males generally have larger home ranges than females. Female mountain lions can bear young at any time of year, but most births occur during spring and summer (Tesky 1995).

Focused mountain lion studies in GRCA began in 2000 and continue. Track transects, hair traps, fecal and tissue samples, remote cameras, and collaring and radio tracking have obtained information on mountain lion presence, identity, and behavior (Garding and Leslie 2004). Seventeen mountain lions were radio-tracked on South Rim, using GPS collars, between 2003 and 2007, although no data was collected for two lions due to collar malfunctions. Data collected from functioning collars of six mountain lions between November 2003 and August 2006 indicate home range sizes of 123 to 351 square miles (90% Adaptive

Kernal Method) (York 2006). This home-range size is consistent with New Mexico studies that yielded lion home-range sizes from 12 to 560 square miles (Logan and Sweanor 2001). Lions collared on South Rim have shown significant ability to travel long distances. One female lion traveled from South Rim across the Colorado River to North Rim, where her collar prematurely released. Another juvenile male traveled from South Rim to north of Flagstaff where he was eventually hunted (York 2006). Mountain lions are known to occur on North and South Rims, but population estimates in GRCA are not currently available. Collaring and tracking efforts will continue to collect data.

Black bears are thought to exist in very low densities on North and South Rim, and are reported sporadically on South Rim. Raccoons are likely restricted to lower elevations along the river and in more developed South Rim areas. Ringtails are primarily found along the canyon rims and in developed areas. Striped skunks are common in South Rim piñon-juniper and ponderosa pine forests, and are probably present on North Rim. However, no striped skunks were detected during recent North Rim studies (Reed and Leslie 2003).

Spotted skunks are usually found only in the canyon below 4,000 feet on the south, and 4,400 feet on the north, where they are reported to be the commonest carnivore below the rim. They prefer rocky crevices, caves, and piles of fallen rocks, and concentrate around water supplies (Hoffmeister 1971). Spotted skunks are occasionally seen on North or South Rim. In 2003, a camera produced the first detection of a spotted skunk on North Rim since a museum sample was collected in 1963 (Reed and Leslie 2003).

Carnivores are wide-ranging and territorial, and analysis of co-occurrence has suggested that interspecific factors may affect carnivore species distribution (Reed and Leslie 2003). Studies in North Rim ponderosa pine forests found significant disassociation of coyotes with bobcats and trends indicating limited co-occurrence between coyotes and foxes, and coyotes and badgers. Coyotes are common throughout the park and appear to be particularly common on South Rim. Bobcats are commonly found throughout the park in areas of desert and wooded areas, especially along the piñon-juniper belt. Bobcat home-range sizes have been estimated at 24-563 ha (Crooks 2002). Gray foxes are uncommon but distributed throughout the park. They use habitat from desert scrub to coniferous forest, including areas along the river and on plateaus. Badgers uncommonly occur in grasslands, piñon-juniper, and ponderosa pine forests on both rims.

In Arizona, long-tailed weasels occur from the Kaibab Plateau south along the Mogollon Rim and in scattered mountain ranges in eastern Arizona (Hoffmeister 1986). Long-tailed weasels prey primarily on small, ground-dwelling rodents, though they also consume rabbits (*Lepus* spp.), small birds, and reptiles. Long-tailed weasels are solitary except during the mid-summer mating season. Young are born the following spring and remain with the mother during summer. Long-tailed weasels are active year-round and primarily nocturnal (Davis and Schmidly 1994).

The status of the North Rim long-tailed weasel population is unknown. Long-tailed weasels were detected in North Rim meadows as recently as 2001, but surveys in ponderosa pine sites throughout North and South Rims during summer 2003 did not identify any individuals (Reed and Leslie 2003).

Ungulates Vertebrates Wildlife

Ungulates such as mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) occupy zones seasonally. Both elk and mule deer are found on South Rim and use piñon-juniper and ponderosa pine forests for food and shelter.

Mule deer (*Odocoileus hemionus*) occupy a variety of habitats from ponderosa pine forests to chaparral scrub, but tend to avoid large openings and mature forest with closed canopy. Mule deer occur on both North and South Rims and along the river corridor. Mule deer on South Rim and in the river corridor are less influenced by weather-related migration, where rim species such as cliffrose, fourwing saltbush, and sagebrush in piñon-juniper woodlands provide essential winter forage sources (Crocker-Bedford 1986).

On North Rim, mule deer depend on the piñon-juniper zone for essential winter forage, and move into ponderosa pine, mixed-conifer, and spruce-fir during spring, summer, and fall. Deer begin migrating into mixed-conifer forest in early May and remain there and into spruce-fir until late September (Rasmussen 1941). Evidence suggests forage quality and quantity available on summer range, such as North Rim's mixed-conifer forests, can directly influence deer-herd productivity by resulting in low fawn recruitment (Hungerford 1970, Thill et al. 1983). Vegetation structure also influences mushroom abundance which contributes significantly to late summer/early fall mule deer diets (Rasmussen 1941, Hungerford 1970).

Desert bighorn (*Ovis canadensis*) prefer rough, rocky, sparsely vegetated habitat characterized by steep slopes, canyons, and washes. They tend to stay within a few miles of perennial water, but also use ephemeral pools and moisture from succulent plants (Hoffmeister 1986). Breeding occurs between July and September and peaks in August. Lambing typically occurs February through early April.

Little is known about GRCA's desert bighorn population status. Bighorn are commonly seen on rocky cliffs along the Colorado River, and occasionally seen on plateaus in close proximity to the rims.

3.1.5 Special Status Wildlife Species

Table 3-3 presents special status wildlife species recorded or likely to occur in GRCA that might be affected by fire, fire monitoring, or fire-suppression activities. These species are considered sensitive by a Federal (primarily USFWS) or state agency, and/or the Navajo Nation due to declining populations. Various factors are causing decline of these species, but the most common is habitat loss or alteration, as many of these species are habitat specialists.

The following provides distributional data, habitat description, and current status of each species in GRCA. Desert bighorn are discussed in general Wildlife as they are considered a special interest species and do not have a Federal or state status.

Special status species that inhabit, forage, or have critical habitat in GRCA's forested plateaus are more likely to be affected by fire management activities. These species include northern goshawk, Mexican spotted owl, California condor, Kaibab squirrel, American peregrine falcon, bald eagle, and various bat and other raptor species.

3.1.5.1 Northern Goshawk — Special Status Wildlife

The northern goshawk is a Federal species of concern and an Arizona wildlife species of special concern. Threats to goshawk populations include historic timber management and wildfire habitat threats. The northern goshawk (*Accipiter gentilis*) is holarctic in distribution, occupying boreal and temperate forests of North America, Europe, and Asia (63 FR 35183–35184). The northern goshawk is found in coniferous forests in northern, north-central, and eastern Arizona (AGFD 2003b) and in pine-oak habitats in isolated mountain ranges in southeastern Arizona. Approximately 250 breeding territories, only part of which exhibit nesting in any one year, were known in 1996, half of which occurred on the North Kaibab Ranger District in northern Arizona. Goshawks in montane areas may winter on or near home ranges or descend to lower elevations into woodlands, riparian areas, or scrublands (Reynolds et al. 1992).

Northern goshawks generally nest in stands of mature trees with dense canopy. In the Southwest, goshawks most frequently occupy three forest types: ponderosa pine, mixed-conifer (primarily Douglas and white fir), and Englemann spruce-subalpine fir. Reynolds et al. (1992) reported that nest sites are typically on northerly slopes, though Crocker-Bedford and Chaney (1988) found an equal distribution of goshawk nests among northerly and southerly aspects of mixed-conifer forests of the Kaibab Plateau. Young hatch after approximately 38 days of incubation, fledge approximately 40 days later (generally in early- to mid-July), and disperse in mid- to late-August. Young are dependent on parents for 30 to 40 days after fledging (Ehrlich et al. 1988).

Although goshawks typically nest in mature tree stands, they use a variety of forest ages and types to meet life history requirements (Reynolds et al. 1992, 63 FR 35183–35184). Various studies have shown the mean size of a goshawk home range is around 2,023 ha (Reynolds et al. 1992), and home ranges generally contain a forest condition mosaic. Goshawks prey opportunistically on a variety of small to mid-sized mammalian and avian species. Many prey species use snags, downed logs, woody debris, large trees, openings, and herbaceous and woody understories. Because goshawks are visually limited in dense understories, an open understory enhances prey detection and capture (Reynolds et al. 1992). Beier and Drennan (1997) demonstrated that goshawk use of a location for hunting does not vary with prey density, at least above some relatively low threshold of prey density; however, goshawks do select stands having more large trees and fewer small trees and shrubs.

Goshawk surveys are conducted in Grand Canyon National Park prior to project implementation that may negatively affect goshawk habitat. South Rim surveys were conducted regularly in 1991, 1992, and from 1994 to 1996. Surveys have been completed in all suitable habitat located on North and South Rim in prescribed-fire burn units since 2000 prior to burn implementation. The primary potential goshawk habitat in GRCA is in North Rim mixed-conifer and ponderosa pine habitats. Northern goshawk territories and nest stands are identified and designated by the park wildlife program manager dependant on species surveys and monitoring results (Reynolds et al. 1992, NPS 2006a). As of 2007, eighteen northern goshawk territories are identified in North Rim forests, and four territories in South Rim forests.

3.1.5.2 Mexican Spotted Owl — Special Status Wildlife

The Mexican spotted owl (*Strix occidentalis lucida*), one of three spotted owl subspecies, has a disjunct breeding range extending from central Colorado and Utah south through Arizona, New Mexico, West Texas, and Mexico to the states of Michoacán and Puebla. The Mexican spotted owl (MSO)was listed as threatened in 1993 (58 FR 14248), and a recovery plan was issued in 1995 (USFWS 1995). MSO critical habitat was designated in February 2001 (66 FR 8530–8553) and includes approximately 27,100 acres of mixed-conifer habitat on North Rim and over 31,000 additional acres of designated Protected Activity Centers in GRCA canyon habitat. MSO are threatened primarily by habitat destruction and modification through timber harvest and wildfires. Other threats include increased interactions with predatory and competitive species resulting from habitat alteration (USFWS 1995). MSO can also be negatively impacted by human disturbance from activities such as recreation, overflights, and noise disturbance.

GRCA falls in the Colorado Plateau Recovery Unit. The Recovery Plan for the Mexican Spotted Owl (USFWS 1995) provides three levels of habitat management: protected areas, restricted areas, and other forest and woodland types. Protected habitat in the Colorado Plateau Recovery Unit includes any Protected Activity Center (PAC); mixed-conifer or pine-oak forest types with slopes over 40% where timber harvest has not occurred in the past 20 years; and all legally and administratively reserved lands. Outside PACs, GRCA contains approximately 10,430 acres of protected habitat, most of which occurs below the rim. Restricted habitat in the Colorado Plateau Recovery Unit includes mixed-conifer forest types or riparian habitats. Important MSO habitat components in these habitat types include high basal area uneven-aged tree structure, high percentage canopy cover, and high density of large trees, snags, and downed woody debris. Spotted owls in canyonland habitat typically roost and nest in deep, narrow canyons with rocky topography, often with vertical or near-vertical cliffs that provide cooler and more humid conditions. Canyon owls roost on cliff ledges, cliffs, in caves or potholes, or in trees (Rinkevich and Gutierrez 1996, Willey 1998). All protected and restricted park habitat is also critical habitat.

GRCA MSO presence was confirmed in 1992 field surveys. Additional survey results in subsequent years suggest that MSO occupy rugged canyonland terrain. MSO detections indicate they use side canyons and small Douglas fir stringers below the rim. Currently 41 draft PACs have been designated in the park for a total of 31,000 acres. No MSO nests are known to occur on GRCA plateaus, but MSO have infrequently been found to forage on North and South Rim plateaus in close proximity to the rim (Bowden 2006).

Courtship behavior between paired Mexican spotted owls generally begins in March. Eggs are laid near the end of March or early April, and young hatch after 30 days incubation. Owlets fledge at approximately 35 days of age (Ehrlich et al. 1988, USFWS 1995) but are dependent on parents for food for several weeks. Young disperse mid-September to early-October. Adult Mexican spotted owls may remain resident on territories throughout the year or may migrate short distances in winter to more open habitats at lower elevations (USFWS 1995).

MSO diet varies depending on location and habitat, but in canyonland habitat consists primarily of small and medium rodents such as woodrats (*Neotoma* spp.), peromyscid mice, and microtine voles (Ward and Block 1995). GRCA MSO have been found to hunt primarily below the rim in open desert scrub or piñon-juniper habitat, with minimal use of plateau forests close to the rim (Bowden 2006).

GRCA biologists conducted a three-year radio-tracking study from 2004 to 2006 to describe the breeding ecology of GRCA MSO and provide a foundation for a long-term nest monitoring program. Preliminary data analysis and field observations indicated that roost and nest sites were located toward heads of canyons and in the Redwall Limestone geologic layer. These areas were shady and generally included some tree and shrub vegetation. Further data analysis is pending. No roost or nest sites were found above the rim on North or South Rim's forested plateau. MSO were very rarely found foraging on the North Rim plateau within 0.25 miles of the rim. MSO were also very rarely called onto North and South Rims during surveys using standard USFWS protocols and territorial MSO calls (Bowden 2006, Sipe 2005).

3.1.5.3 California Condor — Special Status Wildlife

The California condor (*Gymnogyps californianus*), one of the world's largest flying birds, historically ranged along the U.S. west coast south to Baja California and Norte Mexico. Condor populations were decimated by shooting, egg collecting, power-line collisions, and lead poisoning. The species was listed as endangered in March 1967, and the last free-flying condors were taken into captivity in 1987. In 1996, the USFWS established a nonessential, experimental population in northern Arizona with the release in the Vermilion Cliffs area of Coconino County, Arizona, approximately 30 miles north of GRCA. Subsequent releases occurred in the same vicinity and in the Hurricane Cliffs, about 60 miles west of Vermilion Cliffs. By declaring the population nonessential, experimental, the USFWS can treat this population as threatened and develop less restrictive management regulations than the mandatory prohibitions covering endangered species. This designation facilitates efforts to return condors to the wild by providing increased opportunities to minimize conflict between condor management and other activities. In GRCA, condors have the full protection of a threatened species (USFWS 1996).

Condors are opportunistic scavengers and feed primarily on large mammal carcasses. Foraging behavior includes long-distance reconnaissance flights. Nesting habitat includes various rock formations (caves, crevices, overhung ledges, and potholes). Roost sites include cliffs and tall trees, including snags (61 FR 54043–54060). Condors are long-lived and do not breed until they are approximately six years old.

Table 3-3 Special Status Wildlife by GRCA Habitat

Common Name	Scientific Name	Status		
		Federal[1]	State[2]	Navajo Nation[3]
Spruce-Fir				
None		-	-	-
Mixed Conifer				
Northern goshawk	*Accipiter gentilis*	SC	WC	G4
Mexican spotted owl	*Strix occidentalis lucida*	T	WC	G3
Ponderosa Pine				
California condor	*Gymnogyps californianus*	E, EXPN	WC	-
Allen's big-eared bat	*Idionycteris phyllotis*	SC	-	-
Kaibab squirrel	*Sciurus aberti kaibabensis*	NNL	-	-

Common Name	Scientific Name	Status Federal[1]	Status State[2]	Status Navajo Nation[3]
Piñon-Juniper				
American peregrine falcon	*Falco peregrinus anatum*	-	WC	G4
Pale Townsend's big-eared bat	*Plecotus townsendii pallescens*	SC	-	G4
Spotted bat	*Euderma maculatum*	SC	WC	-
Long-legged myotis	*Myotis volans*	SC	-	-
Shrub-Grass				
Desert tortoise	*Gopherus agassizii*	T	WC	-
Golden eagle	*Aquila chrysaetos*	-	-	G3
Ferruginous hawk	*Buteo regalis*	SC	WC	G3
Swainson's hawk	*Buteo swainsoni*	-	WC	G2
Greater western mastiff bat	*Eumops perotis californicus*	-	WC	-
Desert bighorn sheep	*Ovis canadensis*	-	-	G3
Riparian/Wetland				
Relict leopard frog	*Rana onca*	C	WC	-
Northern leopard frog	*Rana pipiens*	-	WC	G2
American dipper	*Cinclus mexicanus*	-	-	G3
Belted kingfisher	*Ceryle alcyon*	-	WC	-
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	C	WC	G3
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	-	-
Bald eagle	*Haliaeetus leucocephalus*	T, AD	WC	-
Osprey	*Pandion haliaetus*	-	WC	-
Western red bat	*Lasiurus borealis*	-	WC	-
Kanab ambersnail	*Oxyloma haydeni kanabensis*	E	-	G4
Aquatic				
Humpback chub	*Gila cypha*	E	WC	G2
Razorback sucker	*Xyrauchen texanus*	E	-	G2

[1]*Federal Status (USFWS or Department of the Interior)*
E Endangered, in danger of extinction
T Threatened, severely depleted
C Candidate for listing as threatened or endangered
EXPN Experimental non-essential population
SC Species of Concern; Some information showing vulnerability or threat, but not enough to support listing
AD Proposed for delisting
NNL National Natural Landmark designated by the Secretary of the Interior as a significant natural area

[2]*State Status*
WC Wildlife Species of Special Concern
HS Highly safeguarded

[3]*Navajo Status*
G2 Endangered, survival or recruitment in jeopardy
G3 Endangered, survival or recruitment likely to be in jeopardy in the foreseeable future
G4 Not enough information to list as G2 or G3, but reason exists to consider listing

Courtship begins in December, and breeding pairs lay a single egg late January and early April. Eggs hatch after approximately 56 days, and young condors take their first flight at approximately six months of age. Young condors may be dependent on parents through the following breeding season (USFWS 1996).

Free-flying condors in Arizona totaled 59 free-flying and two chicks as of September 2007. All the California condors in northern Arizona are fitted with radio transmitters that allow field biologists to monitor movements. Condors have been observed as far away as Flaming Gorge, Wyoming (The Peregrine Fund, 2001). Monitoring data indicate condors use habitat throughout GRCA. In fall and winter months, most condors spend time near Vermilion Cliffs and Marble Canyon and also on Tonto Platform near South Rim's developed zone (The Peregrine Fund, 2001). During spring and summer, condors frequent North and South Rims as well as the Kaibab Plateau (Rogers 2004).

Potential nesting habitat exists on cliffs throughout GRCA. One nesting attempt was documented in the Marble Canyon area in 2001. Two South Rim nest sites were initiated in 2002. Both nests failed. In 2003, condors initiated nesting on South Rim and at Vermilion Cliffs. The Salt Creek drainage nest was successful, and the first wild-born chick in Arizona since reintroduction fledged in November 2003.

Unfortunately, the chick died in 2005; suspected cause of death was starvation. Two nestlings fledged in 2004, one on South Rim and one at Vermilion Cliffs; another chick fledged in Salt Creek in 2005.

3.1.5.4 Kaibab Squirrel — Special Status Wildlife

Tassel-eared squirrels are found primarily in ponderosa pine communities in parts of Wyoming, Colorado, New Mexico, Arizona, and Utah and in the Sierra Madre Occidental from Sonora and Chihuahua south to Durango in Mexico (Nash and Seaman 1977). The Kaibab squirrel (*Sciurus aberti kaibabensis*) is one of three subspecies of tassel-eared (Abert) squirrels (*S. aberti*) recognized in Arizona. The Kaibab squirrel was historically found only on the Kaibab Plateau in northern Arizona. In the 1940s, transplants of Abert squirrels occurred in mountain ranges throughout south and central Arizona. Between 1972 and 1977, Kaibab squirrels were transplanted from the Kaibab Plateau to Mt. Logan on the Arizona Strip. Kaibab squirrels now occur in the Sawmill Mountains, on Mt. Emma, and on Mt. Trumbull, in addition to the Kaibab Plateau. Kaibab Plateau Kaibab squirrel habitat has been designated a National Natural Landmark (boundary under revision). This designation directs Federal agencies to consider the unique properties of Natural Landmarks when assessing effects of actions on the environment.

The best habitat for tassel-eared squirrels is intermediate-aged forest interspersed with groups of large trees with interlocking crowns. Multiple studies have reported lower squirrel density, recruitment, and preferred food (hypogenous fungi) in areas of lower basal area, canopy closure, and tree density (Pederson et al. 1987, Patton et al. 1985, States and Gaud 1997). Larger trees (greater than 30 cm dbh) are particularly important for cover and forage (Patton et al 1985). Nests are typically built of small pine branches in a large pine tree. Nest trees are usually in closed stands and have a crown interlocked with those of several neighboring trees (Halloran and Bekoff 1994). Dodd et al. (1998) found a positive correlation between squirrel recruitment and number of interlocking canopy trees, and recommended clumps of at least five interlocking canopy trees greater than 15 cm in diameter be interspersed throughout stands to manage for better squirrel recruitment. Dense forest may be important for juvenile survival and recruitment, while more open habitat is associated with high pine cone production (reviewed in Chambers and Germaine 2003). Tassel-eared squirrel populations exhibit dramatic fluctuations between years and habitat conditions. These fluctuations are apparently influenced by food availability, weather, and forest structure. Dodd et al. (1998) estimated squirrel density at 0.16 squirrels/ha for ponderosa pine forests.

Tassle-eared squirrels consume seeds, inner bark, terminal buds, staminate flowers of ponderosa pines (Nash and Seaman 1977), fungi, mistletoe, antlers, acorns, and insects (Hoffmeister 1986). The squirrels are opportunistic feeders and consume readily accessible foods. During winter, ponderosa pine inner bark and terminal buds are the primary food source. Squirrel populations may fluctuate widely over space and time, possibly in response to variations in pine tree seed production (Mejia 1999).

Kaibab Squirrel National Natural Landmark — Special Status Wildlife

A large segment of Kaibab squirrel habitat north of Grand Canyon was designated a National Natural Landmark (NNL) by the Secretary of the Interior in 1965 (NPS 1965). Totaling an estimated 220,000 acres[2] of ponderosa pine habitat on the Kaibab Plateau, the Kaibab Squirrel NNL straddles the border between GRCA and the North Kaibab Ranger District of the Kaibab National Forest. Approximately 10% of the NNL is in GRCA. The remainder is on the KNF.

A National Natural Landmark is a nationally significant natural area that contains one of the best examples of a natural region's characteristic biotic or geologic features (NPS 2008). The National Natural Landmarks Program is administered by the NPS and based on the voluntary preservation, by individual

[2] The 1965 evaluation for NNL designation describes the area as encompassing 200,000 acres in the Kaibab National Forest (NPS 1965). GRCA is not included in the description; however, the evaluation does note that a small portion of Kaibab squirrel habitat (described as the climax ponderosa pine formation) does exist in the park. That habitat is considered part of the NNL, bringing the total landmark area to approximately 220,000 acres.

landowners, of designated areas. As the NPS does not mandate management of NNL, NPS responsibilities include nomination for initial designation, assistance to landowners on request, periodic evaluation reports, resource condition and recommendations to the Secretary of the Interior for designation removal if characteristics and values for which the NNL were listed are compromised. Federal agencies are required to consider potential impacts of their actions on NNL.

Kaibab Squirrel NNL was designated because it is inhabited by a rare subspecies, the Kaibab squirrel (*Sciurus aberti kaibabensis*), that exists nowhere else. The area illustrates an important principle of biological evolution: allotropic speciation or genetic differentiation in geographically isolated populations (NPS 1965). Its closest relative, the Abert's squirrel (*S. a. aberti*), is found in similar habitat on Grand Canyon's south side as far south as central Arizona, but not on North Rim. Biologists believe that these two subspecies once shared a common ancestor, but the Grand Canyon's geographic barrier isolated the northern population, and over time it developed unique characteristics sufficient to be a separate subspecies. Kaibab Squirrel NNL is also noteworthy as one of the nation's largest and best examples of a ponderosa pine climax community (NPS 1965).

The portion of the Kaibab Squirrel NNL in GRCA covers parts of the Peninsula, Plateau, and Kaibab Summit FMUs in the proposed FMP. The Kaibab Squirrel NNL is treated the same as recommended wilderness in regard to fire management. A reassessment of suitable Kaibab squirrel habitat, and a NNL boundary revision are currently underway, and Grand Canyon wildlife biologists will establish a long-term monitoring plan in coordination with the Regional NNL Coordinator (see the Special Status Wildlife section above for more information).

According to guidance provided in NPS RM-77, Natural Resource Management, any resource management actions must avoid damage to NNL site integrity, and development should not be permitted unless compatible with resources and necessary for interpretation or educational use of the landmark.

3.1.5.5 American Peregrine Falcon — Special Status Wildlife

The American peregrine falcon (*Falco peregrinus anatum*) breeds from central Alaska, central Yukon Territory, northern Alberta, and Saskatchewan east to the Maritimes and south to Baja California and the highlands of central Mexico (Johnsgard 1990; 64 FR 46542–46558). Peregrine falcons in subarctic areas are migratory while those in southern latitudes are generally resident.

Peregrine populations declined as the result of chlorinated pesticides, especially DDT and its metabolite DDE, which accumulated in peregrines as a result of feeding on contaminated prey. This interfered with calcium metabolism and caused a decline in reproductive success as the result of thin eggshells. The American peregrine falcon was listed as endangered in 1970 (35 FR 8491–8498). On August 25, 1999, the USFWS removed the peregrine falcon from the list of endangered and threatened wildlife as a result of its recovery and establishment of stable populations throughout its historic range (64 FR 46541–46558).

Peregrines nest in scrapes on inaccessible cliff ledges and occasionally tall buildings. Nest sites are often near open water, and the same nest site may be used for many years. Eggs are laid mid-March to mid-May. Chicks hatch after approximately 30 days, and young fledge from the nest 35 to 42 days after hatching. Peregrine falcons feed primarily on other birds, such as songbirds, shorebirds, and waterfowl.

Peregrines nest on cliffs below the rim or in side canyons throughout GRCA. Formal surveys for peregrines in GRCA were completed in 1988, 1989, 1998, and 1999 (Ward 2000). Approximately 75 peregrine eyries are known in the park.

3.1.5.6 Bald Eagle — Special Status Wildlife

The bald eagle, which was listed as endangered in 1967, was reclassified as threatened in the lower 48 states in 1995, and proposed for delisting in 1999. The bald eagle is now listed as a wildlife species of special concern in Arizona. Bald eagles are found in all Arizona counties, typically near lakes and rivers where they forage for fish (NPS 2005a).

A small, resident bald eagle population breeds at selective Arizona sites. Bald eagles have been documented breeding along the Salt, Verde, and Bill Williams Rivers, along Tonto Creek, and at Roosevelt Lake in central Arizona. Bald eagles are not known to nest in GRCA, but occur from fall until early spring as migrants and winter residents. Known winter roosts include Nankoweap Creek near its confluence with the Colorado River, Bright Angel Creek near Phantom Ranch, Twin Overlooks, and Pasture Wash (NPS 2003). In addition, bald eagles have been found along the Colorado River from River Mile 3 to River Mile 132, and on South Rim from Hermits Rest to Desert View. Bald eagles have also been sighted in North Rim forests and meadows near the entrance. In the 1980s and early 1990s many bald eagles congregated at the mouth of Nankoweap Creek to feed on spawning rainbow trout. Their numbers have been greatly reduced in recent years since changes in stream morphology have hampered trout movement into the creek and reduced eagle foraging opportunities. Despite the diminished use of Nankoweap Creek, bald eagles remain the most frequently seen raptor along the river in winter (NPS 2005a). Monitoring of wintering bald eagle populations in the canyon is ongoing.

3.1.5.7 Allen's Big-eared Bat — Special Status Wildlife

A Federal species of concern, Allen's big-eared bat (*Idionycteris phyllotis*) occupies mountainous regions at higher elevations in Arizona. Typical habitat includes ponderosa pine, piñon-juniper, and riparian areas with sycamore, cottonwood, and willow. Individuals have also been observed in Mohave desertscrub and white fir. Most collection sites have been near boulder piles, cliffs, rocky outcrops, and lava flows. These bats consume small moths, beetles, and flying ants, which are either gleaned from foliage or taken in the air (AGFD 2001d). Allen’s big-eared bats roost in caves, mine shafts, and trees. The status of Allen's big-eared bat populations in GRCA is unknown, but individuals have been observed and collected in the river corridor (NPS unpublished data).

3.1.5.8 Pale Townsend's Big-eared Bat — Special Status Wildlife

Pale Townsend's big-eared bat (*Plecotus townsendii pallescens*) is found in Arizona from Grand Canyon to the state’s southeastern portion (AGFD 2003c) and is considered a Federal species of concern. Habitat types used by this bat include desertscrub, oak woodland, oak-pine forests, piñon-juniper and coniferous forests. Caves are a preferred location for summer day roosts and winter hibernation. Small moths gleaned from leaves or taken in flight along forest edges are the primary food source. Pale Townsend’s big-eared bats may be threatened by human disturbance at maternity sites, loss of roost habitat (mine and cave closures), and loss of foraging habitat through deforestation (AGFD 2003c). Townsend’s big-eared bats roost at many sites in GRCA and have a maternity colony at Stanton’s Cave.

3.1.5.9 Spotted Bat — Special Status Wildlife

The spotted bat (*Euderma maculatum*) is patchily distributed from British Columbia to northern Mexico and considered a Federal species of concern and an Arizona wildlife species of special concern. Spotted bats are known to roost in cliff rock crevices and forage in forest openings such as meadows or open woodland. Their relatively low echolocation frequency does not permit them to forage within or below the forest canopy. Spotted bats forage almost exclusively on moths, but may eat other soft-bodied insects. Spotted bats are known to roost on cliffs in GRCA and to travel up to 27 miles from roost to forage in meadows on the north and south Kaibab Plateaus (Painter 2002). Spotted bats may migrate elevationally to winter at lower altitudes.

3.1.5.10 Long-legged Myotis — Special Status Wildlife

The range of the long-legged myotis (*Myotis volans*) extends from southeastern Alaska and western Canada to central Mexico (AGFD 1997). Preferred habitat is coniferous forest, but riparian and desert habitats are occasionally used. Typical roosting sites include abandoned buildings, ground cracks, cliff crevices, and exfoliating tree bark. Caves are used for winter hibernation. These bats are opportunistic foragers and consume aerial insects both over and under forest canopy. Long-legged myotis is found in Arizona's forested mountains, including the North Kaibab Plateau (Hoffmeister 1986). Long-legged myotis populations in Arizona are considered stable (AGFD 1997).

3.1.5.11 Greater Western Mastiff Bat — Special Status Wildlife

The greater western mastiff bat (*Eumops perotis californicus*), an Arizona wildlife species of concern, is the largest U.S. bat. This high-flying, insectivorous bat roosts in small colonies (typically less than 100 individuals) in cliffs and rock crevices. Arizona records of greater western mastiff bats range from Kingman southeast to Tucson and Morenci (Hoffmeister 1986), and the species is considered a year-round resident. Greater western mastiff bats regularly use roosts that allow a ten-foot vertical drop or more and are often found in lower and upper Sonoran desertscrub near rugged rocky canyons. They are known to forage at considerable heights of 100 to 1,000 feet or more and at considerable distances from roosts (over 15 miles) for long periods during night. Their preferred prey includes bees, wasps, ants, and sawflies. Greater western mastiff bats are vulnerable to disturbance at maternity colonies and may be limited by availability of water sources at least 100-feet long (AGFD 2002b). Individual greater western mastiff bats are known to roost in GRCA and forage on the Kaibab Plateau (Siders et al. 1999).

3.1.5.12 Golden Eagle — Special Status Wildlife

Golden eagles (*Aquila chrysaetos*) are widespread across mountainous regions of the northern hemisphere (listed as a G3 species; i.e., considered endangered by the Navajo Nation). Species habitat includes badlands, mountains, foothills, plains, and open grasslands associated with rock outcrops and cliff formations (Peterson 1990). These eagles typically nest on cliff tops or in large trees with a surrounding landscape view (Peterson 1990, Johnsgard 1990). Foraging habitat is open country with available perches and shrub-steppe vegetation that provides habitat for large prey populations, such as rabbits and rodents (Johnsgard 1990). They feed mainly on small and medium-sized mammals but also consume birds, reptiles, and fish (Johnsgard 1990).

Special Status Species Outside Potentially Affected Environment — Special Status Species

Several special status species have been observed in the park, but outside potentially affected environment. Special status species that occur exclusively outside potentially affected environment include Ferruginous Hawk (*Buteo regalis*), Swainson's hawks (*Buteo swainsoni*), desert tortoise (*Gopherus agassizii*), relict leopard frog (*Rana onca*), northern leopard frog (*Rana pipiens*), Western yellow-billed cuckoos (*Coccyzus americanus occidentalis*), southwestern willow flycatcher (*Empidonax traillii extimus*), California Brown Pelican, western red bat (*Lasiurus borealis*), Kanab ambersnail (*Oxyloma haydeni kanabensis*), humpback chub (*Gila cypha*), and razorback sucker (*Xyrauchen texanus*).

Special Status Species Outside Potentially Affected Environment — Special Status Wildlife
Ferruginous Hawk

Ferruginous hawks (*Buteo regalis*) are a Federal species of concern and an Arizona species of special concern. Breeding range is from southwestern Canada through the western United States, and winter range is in northern Mexico and the Southwest. Habitat consists of open plains, prairies, badlands, rolling desert grasslands, and desertscrub (Peterson 1990). Optimum habitat is unbroken prairie grassland that is, at most, slightly grazed. Nesting sites are often elevated on hills and ridge systems that separate broad, flat valleys (Johnsgard 1990). Nests typically occur on cliffs, rock pinnacles, small buttes, or in trees (Peterson 1990). The species feeds almost entirely on grassland rodents and rabbits (Johnsgard 1990).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
Swainson's Hawk

Swainson's hawks (*Buteo swainsoni*), an Arizona wildlife species of special concern, breed throughout North American western plains and grasslands and winter as far south as the Argentina pampas. These hawks arrive on their breeding grounds in March or April and often return to previous breeding sites. They typically build stick nests in isolated trees or bushes or in riparian groves, and may occasionally nest on banks or ledges. Swainson's hawks are opportunistic feeders and consume a variety of insects and small rodents, birds, and reptiles (BLM 2004). Swainson's hawks are known to nest and forage on North Rim, particularly in large meadows near the entrance station.

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
Desert Tortoise

The desert tortoise (*Gopherus agassizii*) is a large (up to 15 inches long) herbivorous reptile that inhabits the Mojave, Sonoran, Colorado, and Sinaloan Deserts of the Southwestern U.S. and adjacent Mexico (55 FR 12178–12191). Two distinct populations, the Sonoran and Mojave, are separated by the Colorado River. The Mojave population occurs north and west of the river; the Sonoran population south and east.

Sonoran desert tortoises are found on rocky slopes and bajadas of Mojave and Sonoran desertscrub (AGFD 2001c). Sonoran desert tortoises become active in spring; peak activity occurs after summer monsoons start. Sonoran desert tortoises are known to occur in GRCA in the vicinity of Grand Wash.

Mojave desert tortoises occur in creosote bush, cactus, and shadscale scrub and Joshua tree woodlands, primarily on bajadas or flats with sand or sandy-gravel soils (AGFD 2001c). Mojave desert tortoises are most active in spring and early summer when annual plants are abundant. Tortoises are threatened by habitat destruction from development, grazing, off-road vehicle use, illegal collecting, and an upper-respiratory tract illness.

The Mojave population is a Federally threatened species (April 1990; 55 FR 12178–12191) and an Arizona wildlife species of special concern. Critical habitat was designated in 1994 and includes areas adjacent to the park in Lake Mead National Recreation Area. In May 2004, biologists from Lake Mead National Recreational Area and GRCA discovered potential desert tortoise scat and a possible tortoise burrow in the Whitmore area on the river's north side (Ward 2005).
Special status species that inhabit the river corridor and inner canyon are unlikely to be directly affected by fire management activities and are discussed below.

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
Relict Leopard Frog

The relict leopard frog (*Rana onca*) is classified as a candidate for listing by the USFWS (67 FR 40657) and is considered an Arizona species of special concern. It was considered extinct until small populations were located in 1991. This species persists in Nevada near Lake Mead's Overton Arm and in Black Canyon below Hoover Dam (USFWS 2002). GRCA is not in the frog's known historical distribution which includes the Virgin and Muddy River drainages in Utah and Nevada, and the Colorado River from its confluence with the Virgin River downstream to Black Canyon. No records exist for this species in GRCA; however, potential habitat in the form of small streams, springs, and spring-fed wetlands between 1,214 and 2,494 feet exist in GRCA. In 2004, a survey was conducted by park biologists, and a leopard frog population was discovered in a small pool in a Lower Gorge side canyon. Initially thought to be relict leopard frog tadpoles, genetic analysis recently completed determined them to be more closely related to the lowland leopard frog (*Rana yavapaiensis*) (NPS 2005a). The NPS is continuing surveys to determine relict leopard frog status in GRCA. There are no known populations of relict leopard frog in the park at this time. One leopard frog specimen, presumed to be *Rana onca*, was documented on the Hualapai Reservation by tribal biologists, but genetic analysis has not been performed.

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**

Northern Leopard Frog

The northern leopard frog (*Rana pipiens*) is listed as an Arizona wildlife species of special concern and as a species in jeopardy by the Navajo Nation. This species occurs in northeastern and north-central Arizona in and near permanent water with rooted aquatic vegetation, generally at elevations from about 2,640 to 9,155 feet (AGFD 2002a). These frogs use springs, streams, and ponds as well as moist habitat in grass lands, brushlands, woodlands, and forests. Breeding takes place from March to May, and eggs are laid on submerged vegetation in shallow water. Tadpoles transform to frogs June through August (Miller et al. 1982). Leopard frogs (either adults or tadpoles) have been observed at one locality along the Colorado River in Grand Canyon (although no longer present) and in several tributaries (NPS 2005a p165-166). An extant population occurs along the river in Glen Canyon a few miles upstream of the GRCA boundary (Spence 1996). Frogs in the Inner Canyon have been identified as *R. pipiens* (Miller et al. 1982); however, the taxonomic status of specimens collected from GRCA is currently being reevaluated. At this time, population status of the northern leopard frog in the Colorado River corridor is uncertain. A survey to determine the status of northern leopard frog populations in the river corridor was recently completed; however, no northern leopard frogs were located during the two-year survey (Drost et al. 2008).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**

Western Yellow-billed Cuckoo

The western yellow-billed cuckoo is a Federal candidate species in the Western U.S., a wildlife species of special concern in Arizona, and a future jeopardy species for the Navajo Nation. Western yellow-billed cuckoos (*Coccyzus americanus occidentalis*) were historically locally common in Arizona, California, New Mexico, Oregon, and Washington; and local and uncommon in western Colorado, western Wyoming, Idaho, Nevada, Utah, and British Columbia (66 FR 38611–38626). Yellow-billed cuckoos are migratory and winter from northern South America south to eastern Peru, Bolivia, and northern Argentina (Ehrlich et al. 1988). Starting mid to late May, cuckoos arrive on their breeding grounds, which typically consist of large blocks of riparian habitat. Nests are placed in areas with dense understory foliage and are almost exclusively close to open water. Because of this tendency, humidity is believed to be a requirement for successful hatching and rearing of young (reviewed in 66 FR 38611–38626). Yellow-billed cuckoos are insectivorous, and the nesting cycle often coincides with outbreaks of tent caterpillars, katydids, or cicadas. Population declines are attributed to widespread riparian habitat fragmentation and loss resulting from impoundments, channelization, groundwater pumping, conversion of land to agricultural and urban uses, and invasion of non-native plants, such as salt cedar.

Potential habitat for the yellow-billed cuckoo in GRCA only occurs downstream of Diamond Creek in the western end of the river corridor (Ward 2005). In 2001, one individual was observed by personnel from San Bernardino College (NPS 2005a).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**

Southwestern Willow Flycatcher

Southwestern willow flycatchers were listed as endangered in 1995 (60 FR 10694–10715). Critical habitat was designated in 1997 (62 FR 39129–39147) and included the Colorado River from River Mile 39 to River Mile 71.5. The Tenth Circuit Court of Appeals rejected the critical habitat designation in 2001 as the result of a lawsuit filed by the New Mexico Cattle Growers Association that alleged designation did not take economic impacts into account. The USFWS is currently in the process of redesignating critical habitat. GRCA is in the Middle Colorado Management Unit of the Lower Colorado Recovery Unit, and the river reach from Spencer Canyon (River Mile 246) to the Lake Mead delta was identified in the Recovery Plan as an area where recovery efforts should focus (USFWS 2002a). However, potential willow flycatcher habitat in this area has changed dramatically as the result of a 88-foot drop in the level of Lake

Mead since 2000. Areas that were inundated in the late 1990s are now well above water level, and existing riparian vegetation in many of these areas is dead or dying (Koronkiewicz et al. 2004).

The southwestern willow flycatcher (*Empidonax traillii extimus*) is one of four subspecies of willow flycatcher (*Empidonax traillii*). Breeding range includes southern California, southern Nevada, southern Utah, Arizona, New Mexico, and southwestern Colorado. All subspecies winter in Mexico and Central America (Sogge et al. 1997). Southwestern willow flycatchers arrive on breeding grounds late April to mid-June (Sogge et al. 1997). Southwestern willow flycatchers breed exclusively in dense riparian vegetation from sea level to over 8,500 feet. Nests are typically near open water or saturated soil. Among sites, dominant plant species, vegetation structure, and vegetation height vary widely. Southwestern willow flycatchers are insectivorous, and catch prey in the air or glean it from foliage (Ehrlich et al. 1988).

Potential willow flycatcher habitat occurs in GRCA along the Colorado River. Ornithological surveys in June 2003 recorded two flycatchers pairs at different locations in upper Grand Canyon (NPS 2005a p168). A nest and one fledgling were observed at one site. A single flycatcher was recorded in lower Grand Canyon in July 2003 (Koronkiewicz et al. 2004). During the 2004 breeding season, a nesting flycatcher pair was observed in lower Grand Canyon. Surveys in 2005 failed to locate any flycatcher nests in upper Grand Canyon (NPS 2005a p168).

Brood parasitism by brown-headed cowbirds (*Molothrus ater)* represents a large threat to southwestern willow flycatcher populations. Increases in cowbird populations are associated with livestock grazing, agriculture, and forest cutting. Threats to southwestern willow flycatchers also include widespread riparian habitat loss throughout the Southwestern U.S. Fire has caused habitat loss at several breeding sites across the Southwestern U.S. and is considered a critical threat to occupied and potential flycatcher habitat (Finch and Stoleson 2000).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
California Brown Pelican

The Federally endangered brown pelican is a subspecies found mostly along the California and Mexico coasts (USFWS 2001); however, it has been observed in Arizona along the Colorado River, near Lake Mead, in Gila Valley, and near other water bodies. Until recently, the California brown pelican was considered an infrequent winter migrant, and winter sightings were only occasionally recorded. However, in June 2004, a number of pelicans occurred in the river corridor (NPS 2005a).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
Western Red Bat

The western red bat (*Lasiurus borealis*), an Arizona wildlife species of special concern, is an Arizona summer resident found primarily in riparian woodland habitats where it roosts in tree and shrub foliage. In GRCA it occurs along the river corridor, and has been observed from Bright Angel Creek to Diamond Creek (NPS 2005a p170). Western red bats have also been observed using East Rim areas. Western red bats are uncommon and may be limited by broadleaf deciduous riparian forest availability (AGFD 2003d).

Special Status Species Outside Potentially Affected Environment **Special Status Wildlife**
Kanab Ambersnail

The Kanab ambersnail (*Oxyloma haydeni kanabensis*) is a rare endemic snail restricted to permanently wet areas in small Colorado Plateau wetlands (USFWS 1995b). This snail was listed under an emergency rule on August 8, 1991 (56 FR 37671). A final rule listing the Kanab ambersnail as endangered was published on April 17, 1992 (57 FR 13657). Threats include habitat alteration or destruction from development and heavy grazing, high flows and flood releases from Glen Canyon Dam, recreational visitors, and flash flooding (USFWS 1995b, 2001a).

Kanab ambersnail is known from three populations: one in Kane County, Utah (a second population there appears extirpated) and one at Vaseys Paradise along the Colorado River in GRCA (USFWS 1995b). A population was introduced to Upper Elves Chasm in 1998 and is successfully reproducing (NPS 2005a).

Special Status Species Outside Potentially Affected Environment Special Status Wildlife Humpback Chub

The humpback chub (*Gila cypha*) was Federally listed as endangered by the USFWS in 1967 (32 FR 4001), with critical habitat designated in 1994 (59 FR 13374).GRCA critical habitat extends from approximately River Mile 35 to River Mile 209. Humpback chub are found in canyon-bound reaches of large rivers (Colorado, Little Colorado, Green, and Yampa) with turbulent flow (AGFD 2001e). Larvae and juvenile fish prefer shallow, low-velocity nearshore habitats. With increasing size and age, the fish move to deeper and faster current. Humpback chub populations have declined as the result of river impoundment and predation by, and competition with, nonnative fish species.

Of the ten park aggregations identified, the two largest are those found in the Little Colorado River and in the mainstem near the confluence. Spawning for both aggregations occurs in the Little Colorado River, commencing in late March, peaking in mid-April, and waning in mid-May (Valdez et al. 1998). The GRCA population has been monitored since 1990. The current spawning population is estimated at from 2,000 to 4,000 fish aged four and older, possibly a 50% decline since 1990 (NPS 2005a).

Special Status Species Outside Potentially Affected Environment Special Status Wildlife Razorback Sucker

The razorback sucker (*Xyrauchen texanus*) was listed as endangered in 1991 (56 FR 54957); critical habitat was designated in 1994 (59 FR 13374). GRCA critical habitat extends from about River Mile 0 (Paria River) to Hoover Dam. This species is also listed as WSCA[3] and NESL G2[4]. Razorback suckers prefer slower current and are found in backwaters, side channels, flooded bottomlands, pools, and lakes in the Colorado River drainage (AGFD 2002c). In the lower Colorado River basin, razorback suckers are now restricted to Lakes Mohave and Mead and possibly to the Colorado River and tributaries. This species is considered extremely rare in GRCA, with only ten specimens recorded between 1944 and 1990, all adults (Valdez et al. 1998). No wild razorback suckers have been recorded since 1990. In 1997, 15 hatchery-raised razorback suckers were released by the Hualapai Tribe into the Colorado River at three locations in lower Grand Canyon (Zimmerman and Leibfried 1999). Results are unknown.

3.2 Cultural Environment

This section considers five cultural resources classes present in the park that may be affected by the proposed action, including

- Archeological sites
- Ethnographic resources
- Historic structures
- Cultural landscapes

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[3] WSCA Wildlife of Special Concern in Arizona. Arizona Game and Fish Department. Species whose occurrence in Arizona is or may be in jeopardy, or with known or perceived threats or population declines, as described by the Arizona Game and Fish Department's listing of Wildlife of Special Concern in Arizona. Available online at: http://www.azgfd.com/w_c/edits/hdms_status_definitions.shtml (accessed July 2008)

[4] G2 "Endangered Any species or subspecies whose prospects of survival or recruitment within the Navajo Nation are in jeopardy or are likely within the foreseeable future to become so. G2: A species or subspecies whose prospects of survival or recruitment are in jeopardy." From: Navajo Nation, Division Of Natural Resources, Department Of Fish And Wildlife, Navajo Endangered Species List, Resources Committee Resolution No. Rcau-103-05, 2005. Available online at: http://nnhp.navajofishandwildlife.org/nnhp_nesl.pdf (accessed July 2008)

- Museum objects (Because the proposed action will not affect museum objects, they will not be considered in affected environment or in impact analysis)

GRCA cultural resources reflect the region's long history of human presence and reveal the changing human relationship with landscape. Archeologists generally divide the nearly 12,000 years of human history in the American Southwest into four broad periods—Paleoindian, Archaic, Formative, and Historic—all of which are represented in Grand Canyon (Coder 2000). This history is represented by archaeological sites, ethnographic resources, historic structures, and cultural landscapes.

Paleoindian presence is indicated by a single Folsom preform projectile point and partial Clovis point dating to over 10,500 before present (BP). Evidence of Archaic occupation is more abundant but still sparse, consisting primarily of rock art panels, temporary campsites, and split-twig figurines dating 3,000-4,000 BP. The majority of prehistoric sites in Grand Canyon's eastern section date from the Formative Period (beginning around AD 500) and typically include Puebloan characteristics. This phase of prehistoric occupation ended mostly by 1150, but some areas were inhabited until at least the early 1200s. Limited occupation may have continued after that, but this has not been confirmed by physical evidence. Some prehistoric inhabitants of Grand Canyon moved to locations east of the canyon and are ancestral to modern Puebloan people (Ahlstrom et al. 1993). Artifactual evidence of Pai (ancestors of the Hualapai and Havasupai Tribes), Paiute, and Cerbat occupation of Grand Canyon, particularly its western section, dates to at least A.D. 1300 (Euler 1979). Pai occupation of areas along the Colorado River downstream of Grand Canyon likely goes back many more centuries to at least AD 700 (Gilpin and Phillips 1998). For a summary of the Grand Canyon's prehistory see Coder (2000).

As documented by written records, GRCA's historic period (starting with European contact in 1540) witnessed the Navajo arrival and ongoing American Indian use, which included shelter, farming, hunting, plant and mineral resources gathering, ritual, and refuge. Navajo oral histories tell a more expansive story, including association with specific deities (Roberts, Begay and Kelley, 1995). Euro-American uses included exploration, mining, ranching, transportation, and tourism. All prehistoric and historic uses are represented by archaeological sites along the Colorado River, both the mainstem and side canyons.

Several American Indian tribes in the region have expressed or claimed cultural affiliation to Grand Canyon—the Havasupai, Hopi, Hualapai, Navajo, Kaibab Band of Paiute Indians, Paiute Indian Tribe of Utah (representing the Shivwits Paiute), Las Vegas Paiute, Moapa Band of Paiute Indians, San Juan Southern Paiute, Yavapai-Apache (representing the White Mountain, San Carlos, Yavapai, and Tonto Nations), and the Pueblo of Zuni.

Although systematic inventories to identify ethnographic resources on GRCA rims has not been done, project consultations and tribal studies of the Colorado River Corridor through Grand Canyon (summarized in Neal and Gilpin 2000) identified ethnographic resources outside the corridor and general types of ethnographic resources in GRCA: archaeological sites (including rock art sites, trails, and graves), sacred sites, places mentioned or described in traditional history, subsistence areas, boundary lines (with or without markers), natural landmarks, minerals, plants, animals, and water (including springs).

The park's List of Classified Structures (LCS) includes 880 structures, 336 buildings are listed on the National Register of Historic Places (NRHP), and 40 buildings are classified as National Register-eligible. The vast majority of historic buildings and structures are concentrated in GRCA's National Historic Landmark Districts. The buildings listed on the NRHP are primarily associated with tourism, park administration and operations, and mining enterprises. Cultural landscapes are settings humans have created in the natural world, expressions of human manipulation, and adaptation of the land.

3.2.1 Archaeological Sites — Cultural Resources

Although archaeological surveys have not been conducted at the same intensity in all fire-dependent ecosystems, it appears archaeological sites have a higher density in lower elevation forests and woodlands than upper elevations. Few sites have been identified in spruce-fir ecosystems. The mixed-conifer ecosystem has approximately one site per 111.2 acres. The ponderosa pine—mixed-conifer transition averages one site per 43.2 acres. On South Rim, the ponderosa pine ecosystem contains approximately one site per 18.1 acres. The piñon-juniper ecosystem has approximately one site per 12.3 acres. Consequently, fires and fire-management activity at lower elevations on canyon rims have a greater potential to impact archaeological sites.

Archaeological sites can be broadly categorized as prehistoric or historic, based on their dates. Prehistoric sites can be further categorized as undated prehistoric, Paleoindian, Archaic, and Formative; historic sites can be further categorized as Historic Native American and Historic Euro-American. Distribution of known archaeological sites for each of these temporal categories is presented in Table 3-4.

Archaeological sites are also categorized by function or site type. Distribution of site types for North Rim, South Rim, and Inner Canyon areas are summarized in Tables 3-9, 3-10, and 3-11.

3.2.2 Ethnographic Resources — Cultural Resources

Regional Native American groups recognize certain tangible properties as important in their traditional tribal histories. These properties, which may or may not be archaeological sites, are referred to as traditional cultural properties (TCP) in National Register Bulletin 38 (Parker and King 1990). Like archaeological sites, TCP are given consideration under the National Historic Preservation Act of 1966, as amended. Native Americans—the Hualapai, Havasupai, Southern Paiute (including Kaibab Paiute, Shivwits Paiute, and San Juan Southern Paiute), Navajo, Hopi, Zuni, and White Mountain Apache—continue to use Grand Canyon. All of these groups consider Grand Canyon sacred, and many tribal members continue traditional practices in the park. Tribal studies of the Colorado River Corridor through Grand Canyon, summarized in Neal and Gilpin (2000), focused on the river corridor, but some tribes identified ethnographic resources outside the corridor. The studies generally identified ethnographic resource types occurring in GRCA, including archaeological sites (including rock art sites, trails, and graves), sacred sites, places mentioned or described in traditional history, subsistence areas, boundary lines (with or without markers), natural landmarks, minerals, plants, animals, and water (including springs). Archaeological sites are considered ancestral by the tribes. Sacred sites, places mentioned or described in traditional history, subsistence areas, and boundary lines may or may not have archaeological manifestations. Landmarks, minerals, plants, animals, water, and springs are natural phenomena having cultural significance to the tribes. The Havasupai identified a TCP on one of South Rim's named points. The Havasupai did not explain exactly what this TCP was, nor give its exact location. The Navajo Nation has identified sweatlodges as TCP and sacred sites in written correspondence. The Havasupai have done so during verbal consultation.

In addition to specific canyon locations, the area's Native American people hold many broader Grand Canyon attributes of traditional, even sacred, importance. Elders express a traditional veneration for the canyon's water, minerals, plants, and animals, and their oral traditions reveal a strong spiritual relationship to Grand Canyon as a whole. The Havasupai and Hualapai revere the Colorado River as the backbone, or spine, of their lifeline. The Hopi and Zuni consider Grand Canyon the place of their emergence into the present world. To the Navajo, the Colorado and Little Colorado Rivers are sacred female and male entities, respectively, and these rivers, as well as the canyons that engulf them, provide protection to the Navajo people. To the Southern Paiute, the Colorado River is one of the most powerful of all natural resources in their traditional lands, and Grand Canyon has taken on special cultural significance as a place of refuge allowing their people to endure in the face of Euro-American encroachment (NPS 1995).

Table 3-4 Cultural Site Distribution by Time Period

Time Period	North Rim		South Rim		Inner Canyon		Total	
	# Sites	Percent	# Sites	Percent	# Sites	Percent	# Sites	Percent
Paleoindian	0	0 %	0	0 %	1	0 %	1	0 %
Archaic	26	3 %	33	3 %	25	2 %	84	2 %
Formative	591	57 %	361	32 %	565	38 %	1517	42 %
Protohistoric	4	< 1 %	4	< 1 %	24	2 %	32	1 %
Historic	91	9 %	258	23 %	115	8 %	464	13 %
Multi-component	85	8 %	211	18 %	227	15 %	523	14 %
Unknown	243	23 %	268	23 %	514	35 %	1025	28 %
Total	1040	100 %	1135	100 %	1471	100 %	3646	100 %

< means less than

3.2.3 Historic Structures — Cultural Resources

The vast majority of historic buildings and structures are concentrated in GRCA's National Historic Landmark Districts. In addition, 336 buildings are listed on the NRHP, and some 40 buildings are classified as National Register-eligible. GRCA's List of Classified Structures contains 880 structures. Buildings listed on the NRHP are primarily associated with tourism, park administration and operations, and mining enterprises.

On South Rim, the Grand Canyon Village National Historic Landmark Historic District has the largest and most diverse assemblage of park architecture in the national park system. The District consists of 257 buildings, including four designated National Historic Landmarks—El Tovar Hotel, the park operations building, the Grand Canyon powerhouse, and the Grand Canyon railroad station. El Tovar Hotel opened in 1905. The railroad station was completed in 1910. The powerhouse was built by the Santa Fe Railway to supply power to the railroad and nearby facilities. The park operations building was completed in 1929 and remodeled in 1938. Table 3-6 shows South Rim cultural site type distribution by FMUs on South Rim.

The Mary Jane Colter Historic District consists of four widely separated buildings, each designed by Mary Jane Colter. These are Hermits Rest, Hopi House, Desert View Watchtower, and Lookout Studio. Hopi House was completed in 1905, and Hermits Rest and the Lookout Studio opened in 1914. Desert View Watchtower was completed in 1932. Hopi House and Lookout Studio are also contributing properties to the Grand Canyon Village National Historic Landmark District.

National Register-listed Tusayan Ruins includes an ancestral Puebloan site, and an archaeological museum built in 1932.

The Orphan Mine Historic District is located between South Rim's Maricopa Point and Powell Memorial. This District includes resources from both turn-of-the-century copper mining operations and 1950s and 1960s uranium production. Between 1953 and 1969, the Orphan Mine was one of the leading producers of high-grade uranium on the Colorado Plateau (NPS 1995:147). This District is not listed on the NRHP, but has been determined eligible.

On North Rim, the Grand Canyon Lodge Historic District consists of the main lodge building, 23 deluxe cabins, and 91 standard cabins located on Bright Angel Point. The Grand Canyon North Rim Headquarters Historic District contains two structure groupings that include residences, a garage, a ranger station, maintenance buildings, a resource management office, and barn. The buildings and structures date between the late 1920s and early 1930s. The Grand Canyon Inn (North Rim Inn) and Campground Historic District includes a main building, 30 frame cabins, and 10 log cabins. An NPS campground was constructed nearby. The North Rim Inn was built in 1929. Some cabins were built in 1929, others in 1934. Table 3-5 shows North Rim cultural site type distribution by FMUs on North Rim. Inner Canyon cultural site type distribution is shown in Table 3-7.

Other National Register properties include the Cross Canyon Corridor Historic District and the Trans-Canyon Telephone Line Historic District. The Cross Canyon Corridor includes over 40 buildings and the Bright Angel, South Kaibab, North Kaibab Trails and connecting river trails. The District's principal structures are four trailside shelters and the Phantom Ranch complex. Five of the original Phantom Ranch stone buildings were designed by Mary Jane Colter and built in 1922. The Telephone Line crosses approximately 18 canyon miles from South Rim to Roaring Springs, and consists of metal poles with copper-weld wire installed in 1935 and modified 1938–1939.

3.2.4 Cultural Landscapes — Cultural Resources

As defined in the Cultural Resource Management Guideline (NPS 1998c), cultural landscapes are settings that humans create in the natural world. They are intertwined patterns of things both natural and constructed, expressions of human manipulation and adaptation of the land. The historic districts mentioned above are examples of human manipulation and adaptation of Grand Canyon. Cultural Landscape Reports commissioned by GRCA to assess the character of the natural world that includes and encompasses four of these historic districts include: Desert View (John Milner Associates/OCULUS 2004a), Grand Canyon Village (John Milner Associates 2004), Indian Garden (John Milner Associates 2005), North Rim Bright Angel Peninsula Developed Area (John Milner Associates 2004c), and West Rim Drive (John Milner Associates 2004b). Such reports describe a landscape's physical development as it evolved over time, and evaluate its significance and integrity. 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. Cultural Landscape Reports are complete, but Cultural Landscape Inventories are in various stages of completion.

Table 3-5 North Rim Cultural Site Type Distribution

	North Rim FMUs						
Site Types	Backcountry Uplands	Primary WUI	Fire Islands	Kaibab Summit	Peninsula	Plateau	Total Sites
Agricultural Structure	3	-	5	--	23	3	34
Artifact Scatter	166	1	8	5	54	46	280
Culturally Modified Trees	-	1	-	9	6	15	31
Extractive Site	4	-	--	-	1	-	5
Habitation	162	2	88	-	181	4	437
Hunting, Fishing, Gathering Feature	6	-	2	-	1	-	9
Multitype	-	-	-	1	2	1	4
Open Air Habitation	-	-	-	-	1	1	2
Other	4	-	2	-	5	3	14
Other Structure	71	1	5	1	8	1	87
Protected Habitation	32	-	-	1	1	2	36
Ranching Structure	-	-	1	1	7	3	12
Residential, Community Complex	1	-	2	-	3	--	6
Rock Art	7	-	-	-	1	-	8
Special Use Structure	17	2	7	1	16	4	47
Storage Structure	11	-	1	-	6	-	18
Transportation, Communication Structure	-	-	-	-	-	-	-
Unknown	3	-	1	-	6	-	10
Total Sites	487	7	122	19	322	83	1,040

3.2.5 Elements or Values at Risk — Cultural Resources

Historic properties (archaeological sites, ethnographic resources, in-use buildings and structures) may be considered eligible to the National Register of Historic Places under any of four criteria: A) the location of a historically significant event, B) associated with a historically significant person, C) an outstanding example of a type of architecture or the work of a master, and D) the potential to provide important information about the past. GRCA archaeological sites (as well as elsewhere) are usually considered eligible to the National Register of Historic Places under Criterion D. Ethnographic resources are usually considered eligible under Criteria A and D. Historic buildings and structures and historic landscapes are usually evaluated under Criterion C, although the other three criteria may apply.

To be considered eligible to the National Register of Historic Places, historic properties must retain integrity of location, design, setting, materials, workmanship, feeling, and association. It is not necessary for any given property to retain all of these qualities of integrity, but the qualities of integrity that are necessary to preserve the significance of the property must remain intact. For example, archaeological sites considered eligible to the National Register of Historic Places because of their research potential should retain integrity of location, design, materials, and workmanship. Ethnographic resources, historic buildings and structures, and historic landscapes may need to retain all of the qualities of integrity. Properties evaluated under Criteria A, B, and C are often informally subjected to the recognizability test; that is, would the property, in its current condition, be recognized by the participants of the historic event, the historically important person, or the architect? If the answer to this question is yes, the property has probably retained the qualities of integrity needed for eligibility to the National Register of Historic Places; if the answer is no, the property probably does not retain integrity. Qualities of integrity are values most likely at risk as a result of fire and fire management activities.

Table 3-6 South Rim Cultural Site Type Distribution

Site Types	South Rim FMUs			Total Sites
	Backcountry Uplands	WUI (Primary and Secondary)	Peninsula	
Agricultural Structure	6	32	3	41
Artifact Scatter	56	309	49	414
Culturally Modified Trees	-	1	1	2
Extractive Site	-	7	1	8
Habitation	53	171	42	266
Hunting, Fishing, Gathering Feature	6	7	-	13
Multitype	-	2	-	2
Open Air Habitation	3	16	3	22
Other	2	17	17	36
Other Structure	9	21	3	33
Protected Habitation	-	2	3	5
Ranching Structure	2	8	4	14
Residential, Community Complex	1	-	-	2
Rock Art	-	4	-	4
Special Use Structure	5	136	34	175
Storage Structure	2	1	1	4
Transportation, Communication Structure	1	12	1	14
Unknown	2	67	11	80
Total Sites	148	814	173	1,135

3.2.6 Archeological Site Densities and Distributions — Cultural Resources

The Archeological Site Management System, the comprehensive system for all national parks, lists over 4,000 GRCA sites. Currently, the principal data source for rim sites is the Grand Canyon Archaeological Database. This database contains 3,646 sites in FMUs, and was useful in calculating site distributions by date, cultural affiliation, and function.

To quantify site density in different park areas, and to get an understanding of constituent resources of each site type, survey records were considered as North Rim, South Rim, and Inner Canyon areas. Certain types of archaeological sites, features, and artifacts are considered fire sensitive and can be affected by fire. Historic Native American sites often contain partially preserved wooden, fire-sensitive 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 partially preserved wooden, fire-sensitive dwellings, corrals, fences, fence posts, tree towers, enclosures, wood-cutting areas, woodpiles, hitching posts, wooden gates, benches, and signposts. Structural habitation sites dating to the 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 and leather, fire-sensitive features, and materials that can melt, such as glass and solder. To date 422 fire-sensitive sites have been identified in the park. See Table 3-8 for a summary of types and distribution of fire sensitive sites by general Fire Management Unit.

Table 3-7 Inner Canyon Cultural Site Type Distribution

Site Types	Inner Canyon Campgrounds	Inner Canyon	Total Sites
Agricultural Structure	-	13	13
Artifact Scatter	2	139	141
Culturally Modified Trees	-	1	1
Extractive Site	-	25	25
Habitation	2	413	415
Hunting/Fishing/Gathering Feature	-	406	406
Multitype	-	3	3
Open Air Habitation	-	14	14
Other	-	88	88
Other Structure	1	36	37
Protected Habitation	-	129	129
Ranching Structure	-	3	3
Residential/Community Complex	-	9	9
Rock Art	-	72	72
Special Use Structure	-	47	47
Storage Structure	-	53	53
Transportation/ Communication Structure	-	10	10
Unknown	-	5	5
Total Sites	5	1,466	1,471

3.2.6.1 Archeological Site Densities and Distributions Cultural Resources South Rim

South Rim includes 70,360 acres, of which 19,148 acres (27%) have been surveyed for archaeological sites (Table 3-9). A total of 1,135 sites have been identified, including 33 Archaic, 361 Formative, 4 Proto-Historic, 258 Historic, 211 multi-component, and 268 sites of unknown temporal affiliation. Overall site density on South Rim is one site per 16.9 acres. Twenty-seven percent (304 of 1,135) of South Rim sites are considered fire-sensitive (Table 3-8).

3.2.6.2 Archeological Site Densities and Distributions Cultural Resources North Rim

North Rim includes 189,202 acres, of which 38,522 acres (20%) have been surveyed for archaeological sites (Table 3-10). A total of 1,040 sites have been identified, including 26 Archaic, 591 Formative, 4 Proto-Historic, 98 Historic, 85 multi-component, and 243 sites of unknown temporal affiliation. Overall site density on North Rim is one site per 37.0 acres. Ten percent (104 of 1,040) of North Rim sites are considered fire-sensitive (Table 3-8).

3.2.6.3 Archeological Site Densities and Distributions Cultural Resources Inner Canyon

The Inner Canyon includes 933,060 acres, of which 26,761 acres (3%) have been surveyed for archaeological sites (Table 3-10). A total of 1,471 sites have been identified, including one Paleo-Indian, 25 Archaic, 565 Formative, 24 Proto-Historic, 115 Historic, 227 multi-component, and 541 sites of unknown temporal affiliation. Inner Canyon site density is one site per 18.2 acres; one site per: 13.4 acres (campgrounds) and one site per 18.2 acres (Inner Canyon). Seventeen percent (244 of 1,471) of Inner Canyon sites are considered fire sensitive (Table 3-8).

Table 3-8 Fire-Sensitive Cultural Site Types by FMUs

Site Description	Back-country	Fire Island	Kaibab Summit	Peninsula North Rim	Peninsula South Rim	Plateau	Primary WUI South Rim	Secondary WUI South Rim	Total
Burial	1								1
Cabin				4	1	1	1	1	8
Dendro-glyphs			10	9		17	2		38
Fence	1		1	4	4	1	3	1	15
Fire Lookout	1		1						2
Granary								1	1
Historic Adminis-trative Area							1		1
Historic Camp	2			8	7	3	7	1	28
Historic Corral		1		3	1	1	1		7
Historic Artifact Scatter	8		1	7	42	7	65	25	155
Historic Dam					1		3		4
Historic Dump							6		6
Auto, complete or parts							1	1	2
Historic Native American Structures	17		1		11		57	4	90
Historic Structure					1	1	2	1	5
Phone Line							3		3
Prehistoric Structure	1				1	1			3
Ranger Station	1		1						2
Road or Trail					1		2		3
Rock art	2			4	18		1	1	26
Spring Improvement			1	1		2			4
Tree Tower			1	5	3	2	3	4	18
Total	34	1	17	45	91	36	158	40	422

Table 3-9 Acres Surveyed and Cultural Site Distributions for South Rim FMUs

Area/FMU	Acres	Acres Surveyed	Percent Surveyed	Site Total	Normalized Density
Backcountry Uplands	35,709	2,821	8%	148	19.0
Primary WUI FMU Desert View	4,112	407	10%	41	9.9
Developed	12,515	6,258	50%	531	11.8
Peninsula	6,948	4,346	63%	173	25.1
Primary WUI FMU Grand Canyon Village	11,076	5,316	48%	242	21.9
Total	70,360	19,148	27%	1,135	16.9

Table 3-10 Acres Surveyed and Cultural Site Distributions for North Rim FMUs

Area/FMU	Acres	Acres Surveyed	Percent Surveyed	Site Total	Normalized Density
Backcountry Uplands	83,593	6,242	7%	487	12.8
Primary WUI FMU North Rim Developed Area	441	420	95%	7	60.0
Fire Islands	13,456	2,258	17%	122	18.5
Kaibab Summit	16,232	3,490	22%	19	183.7
Peninsula	42,520	16,456	39%	322	51.5
Plateau	32,960	9,656	29%	83	116.3
Total	189,202	38,522	20%	1,040	37.0

Table 3-11 Acres Surveyed and Site Distributions for Inner Canyon FMUs

Area/FMU	Acres	Acres Surveyed	Percent Surveyed	Site Total	Normalized Density
Campground Area PrimaryWUI FMU	89	67	75%	5	13.4
Inner Canyon	932,971	26,694	3%	1,466	18.2
Total	933,060	26,761	3%	1,471	18.2

3.3 Physical Environment

GRCA's physical environment that may be affected by the proposed Fire Management Plan includes air quality, soils and watersheds, and soundscape. Effected environments of these topics are addressed, below.

3.3.1 Air Quality — Physical Environment

GRCA is a Federally mandated Class I Area under the Clean Air Act, a status requiring the most stringent protection against air pollution increases and further degradation of air quality-related values (AQRV), as well as restoration of natural visibility conditions. Fire creates smoke that may have undesirable effects on air quality, including impacts on both visibility and human health. Visibility is addressed in detail under Visual Resources; this first section focuses on air-quality health standards with respect to smoke emissions from fire-management operations, though there are occasional references to visibility.

Management fires, including wildland fire-use and prescribed fires, are intended to restore and maintain a historic range of forest structure to the extent possible. With restoration of pre-Euro-American forest-fuel regimes, smoke from these fires should mimic natural smoke production. The modern airshed has many pollution sources not present during pre-Euro-American settlement. Today, millions of people visit Grand Canyon to enjoy the scenery. Views are diminished by air pollution from many sources.

The following describes regulatory and management constraints (laws, regulations, standards, and policies) that apply to air quality, GRCA smoke emissions data, monitoring efforts, and smoke-sensitive areas near GRCA.

3.3.1.1 Air Quality Regulatory and Management Constraints Air Quality Federal Constraints

The primary Federal statute that regulates GRCA air quality is the Clean Air Act (CAA). One of the Act's purposes is "to preserve, protect, and enhance the air quality in national parks" and other areas of special national or regional natural, recreational, scenic or historic value. The CAA, as amended in 1990, also requires EPA to set National Ambient Air Quality Standards (NAAQS) to protect public health and welfare. These standards apply regardless of air pollution source, although source is considered in determining what, if any, remedial actions are needed when standards are violated. Standards are set for six criteria pollutants: ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter (PM), and lead (Pb). InMarch 2008, EPA tightened the NAAQS for ozone (see Table 3-12). In 2006, EPA revised the NAAQS for particulate matter less than 2.5 microns ($PM_{2.5}$) and changed the PM_{10} standard as well (EPA 2006a). Current NAAQS for the criteria pollutants are shown in Table 3-12 (EPA 2007b).

EPA set policies to deal with wildland fire smoke management in 1998 through its Interim Air Quality Policy on Wildland and Prescribed Fires (EPA 1998). In its policy, EPA balances fire's role in restoring and maintaining forest ecosystems with the need to protect human health through adherence to the NAAQS. When the NAAQS are violated by smoke, the policy calls for actions to reduce immediate impacts on public health, and steps to mitigate future impacts up to and including Federal enforcement of smoke management plans.

Air Quality Regulatory and Management Constraints Air Quality State Constraints

State authority for managing air quality in Arizona derives from the CAA and state statutes. Establishing and administering air quality standards as noted above is just one of the state's responsibilities. ADEQ's Air Quality Division implements a statewide smoke management program that works toward reducing smoke impacts due to controlled burning of agricultural, rangeland, and forest fuels. All private, state, and Federally managed lands in Arizona are under ADEQ jurisdiction in matters relating to air pollution from prescribed burning. GRCA's fire management program operates under regulations set by ADEQ (Arizona Administrative Code, Title 18, Chapter 2, Article 15). GRCA is responsible to ADEQ for registering projects; submitting burn plans, burn day requests, and burn accomplishment reports; using Emission Reduction Techniques and Smoke Management Techniques to reduce total emissions; and monitoring weather and smoke conditions. All fires not under full suppression must have an approved burn plan that carries the same responsibilities as permits issued to other air pollution sources. Actions set forth in burn plans are legally binding conditions and requirements of the permit. If the plan and reporting requirements are not followed, the state may require containment or mop-up of any active burns. It may also require, at the ADEQ Director's discretion, a five-day moratorium on ignitions by the park. Violations are subject to a civil penalty of not more than $10,000 per day per violation (Arizona Administrative Code R18-2-1513 (D)).

Air Quality Regulatory and Management Constraints Air Quality Compliance with Federal and State Air Quality Standards

GRCA air pollution levels are generally low and within Federal and state standards (EA Engineering, Science, and Technology 2002). The pollutant of greatest concern to GRCA fire managers is particulate matter, for reasons detailed below under the heading Emissions Related to Fire Management. Levels of O_3 monitored by the park on South Rim are relatively high and have been trending upward since the late

1980s, but are still below the NAAQS. Hourly averages have risen as high as 93 ppb, and daily maxima often exced 70 ppb/hr during the ozone season. EPA's current re-evaluation of NAAQS for ozone does include options that would place current GRCA O_3 levels above the standard. Other regulated pollutants, including volatile organic compounds (VOC), CO, NO_x, and particulates are not monitored at GRCA for compliance with NAAQS. However, both PM_{10} and $PM_{2.5}$ are routinely monitored for impacts on visibility under Interagency Monitoring of Protected Visual Environments (IMPROVE) protocols on South Rim and below the rim at Indian Garden. Portable particulate monitors may be used during wildland fires. These instruments do not have the precision necessary to verify compliance with NAAQS, but have indicated unhealthy $PM_{2.5}$ levels during heavy smoke episodes. Levels of airborne lead (as sampled through IMPROVE) are extremely low. Levels of CO and NO_x have been measured during special studies, and in 2001–2002 appeared to be far below the NAAQS on South Rim (Martin et al. 2002).

Air Quality Regulatory and Management Constraints **Air Quality**
Grand Canyon Visibility Transport Commission

1990 CAA amendments authorized EPA to establish visibility transport regions as a way to reduce regional haze. Congress specifically mandated creation of a Grand Canyon Visibility Transport Commission (GCVTC) to advise EPA on strategies for protecting visual air quality at national parks and wilderness areas on the Colorado Plateau. The Commission's final report, Recommendations for Improving Western Vistas (GCVTC 1996), included the following recommendation relating to wildland fire

> *The Commission recognizes that fire plays a significant role in visibility on the Plateau. In fact, land managers propose aggressive prescribed fire programs aimed at correcting the buildup of biomass due to decades of fire suppression. Therefore, prescribed fire and wildfire levels are projected to increase significantly during the studied period. The Commission recommends the implementation of programs to minimize emissions and visibility impacts from prescribed fire, as well as to educate the public.*

Many of the Commission's recommendations were adopted by the EPA in its Regional Haze Rule (40 CFR 51.308-309). Arizona submitted its regional haze plan under the Rule in December 2004. Changes to the EPA rule required a re-submission of the Arizona plan by December 2007. The state's plan follows the Commission's recommendations and EPA's Rule, particularly as they address wildland fire issues.

Arizona submitted its regional haze plan under the Rule in December 2003. Changes to the EPA rule required a re-submission of the Arizona plan by December 2007 require, and the revision process is underway.

Air Quality Regulatory and Management Constraints **Air Quality**
National Park Service Policy

The NPS has a responsibility to protect air quality under both the 1916 Organic Act and the CAA. NPS Management Policies 2006, provides direction to NPS units.

3.3.1.2 Emissions Related to Fire Management **Air Quality**
Smoke Emissions

Burning of wildland vegetation causes varying quantities and types of emissions, depending in part on the types (i.e., vegetation, live vs. dead), amounts, and moisture contents of fuel burned, and combustion temperature. More than 90% of the smoke mass emitted from wildland fires consists of carbon dioxide and water. Emissions of greatest concern to fire managers are particulate matter, carbon monoxide, and volatile organic compounds. CO is a health concern near the fire line and fire professionals are looking at ways to minimize fire fighters exposure. VOC are important in ozone formation, and with expected new standards VOC will become of increasing future concern. PM is important due to both visibility and human health concerns.

Particulate matter is the most important pollutant category for fire managers. In addition to human health effects, particulates reduce visibility. Particles vary in size and chemical composition, depending on fire intensity and fuel character. Proportionately larger particles are produced as fires increase in intensity (longer flame lengths), compared to low-intensity and smoldering combustion fires. Amount of smoke produced depends on total fuel consumed. In humans, particles less than about 10 micrometers in diameter are able to traverse the upper airways (nose and mouth) and enter lower airways starting with the trachea. As particle size decreases further, particles are able to penetrate to deeper airway parts prior to deposition. Studies have linked breathing PM to a series of health problems including coughing and difficult or painful breathing, aggravated asthma, chronic bronchitis, and decreased lung function (Dockery et al. 1993 cited in Hardy et al. 2001, EPA 2006b, Core & Peterson 2001).

Table 3-12 Current Federal Ambient Air Quality Standards

Pollutant Emission	Averaging Time[1]	Federal Standards		Purpose of Standard
		Primary	Secondary	
Ozone (O_3)	8 hours	0.075 ppm	0.075 ppm	Prevent breathing difficulties, eye irritation, and biological impacts to sensitive species
Carbon Monoxide (CO)	1 hour	35 ppm	None	Prevent carboxyhemoglobin levels greater than 2%
	8 hours	9 ppm	None	
Nitrogen Dioxide (NO_2)	Annual average	0.053 ppm	0.053 ppm	Prevent breathing difficulties, reduce smog formation, and improve visibility
Sulfur Oxides	3 hours	None	0.5 ppm	Prevent increased respiratory disease, acid rain, crop damage, odor nuisance and improve visibility
	24 hours	0.14 ppm	None	
	Annual average	0.03 ppm	None	
Respirable Particulate Matter (PM_{10})	24 hours	150 μg/m^3	150 μg/m^3	Prevent chronic respiratory tract diseases and improve visibility
Fine Particulate Matter ($PM_{2.5}$)	24 hours	35 μg/m^3	35 μg/m^3	
	Annual mean	15 μg/m^3 (arithmetic)	15 μg/m^3 (arithmetic)	
Lead (Pb)	Calendar quarter	1.5 μg/m^3	1.5 μg/m^3	Prevent neurological system damage

(ppm = parts per million; μg/m^3 = micrograms per cubic meter)

[1] **One Hour** To attain the standard, the daily maximum one-hour average concentration measured by a continuous ambient air monitor must not exceed the listed standard more than once per year, averaged over three consecutive years

Eight Hour To attain this standard, the three-year average of the fourth-highest daily maximum eight-hour average of continuous ambient air-monitoring data over each year must not exceed listed standard

24 Hour To attain this standard, the 99th percentile of the distribution of the 24-hour concentrations for a period of one year, averaged over three years, must not exceed the listed standard

Annual To attain the standard, the 98th percentile of the distribution of the 24-hour concentrations for a period of one year, averaged over three years, must not exceed the listed standard

[2] The standards are attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (235 micrograms per cubic meter) is less than or equal to one

[3] Maximum three-hour concentration not to be exceeded more than once per year

3.3.1.3 Grand Canyon National Park Formal Agreements — Air Quality

GRCA maintains a formal agreement with the Kaibab National Forest that promotes coordination and cooperation in management of smoke that may impact Grand Canyon Village and Tusayan areas (USDA and USDI 2001). This coordination allows both GRCA and the Kaibab National Forest to accomplish fuel reduction projects while complying with air quality rules, policies, and permits.

Carbon monoxide can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues, particularly for those who suffer heart diseases like angina, clogged arteries, or congestive heart failure. Carbon monoxide is usually only a concern to those in close proximity to wildland fires (Core & Peterson 2001), but firefighters can be overexposed to carbon monoxide (Sharkey 1997).

Volatile organic compounds are a class of rapidly evaporating substances that contain carbon, hydrogen, and other elements such as oxygen. Included in this class are methane (CH_4), polynuclear aromatic hydrocarbons (PAH), aldehydes, benzene, and benzo-a-pyrene. Many of these compounds are potentially irritating, toxic and/or cancer-causing. VOCs also react with NO_x in sunlight to form ozone, a potentially harmful gas at ground level.

Ozone is not emitted directly into the atmosphere. Instead, it forms as sunlight drives chemical reactions between VOCs and NO_x. In sufficient concentrations (at and above NAAQS), ozone can irritate the respiratory system, reduce lung function, damage lungs, and aggravate asthma, emphysema, bronchitis and other lung diseases (AirNOW 2006a). At lower concentrations, ozone is still a potent toxin for many plants. Pollutants released by fires may react and increase ozone concentrations downwind, and can cause exceedences of NAAQS at considerable distances (Seitz 1998).

Nitrogen oxides, while a criteria pollutant, are not as important a concern for fire management as PM, CO, and VOCs because they are produced in only small amounts. However, NO_x is a contributor to ozone formation. Sulfur dioxide is produced in negligible amounts by wildland fires (EPA 1995).

3.3.1.4 Emissions Related to Fire Management — Air Quality

Other Emissions Sources

In addition to prescribed and wildland fires, park emissions originate from mobile, stationary, and area sources. Mobile sources include highway and non-road vehicles, trains, aircraft, and marine vessels. Stationary sources include space and water-heating equipment, generators, fuel-storage tanks, and wastewater treatment plants. Area sources include woodstoves, fireplaces, and campfires (EA Engineering, Science, and Technology 2002). In 2000, mobile sources produced 41.41 tons per year (tpy) of PM10, 0.70 tpy of SO2, 69.45 tpy of NOx, 664.00 tpy of CO, and 69.83 tpy of VOCs. This represented 20% of the park's total PM10, 26% of the SO2, 81% of the NOx, 28% of the CO, and 32% of the VOCs (EA Engineering, Science, and Technology 2002).

Most stationary and area sources are associated with NPS and concession contractors operations; however, most campfires are controlled by visitors. Emissions associated with visitor vehicles and tour buses constitute the largest mobile source emissions on South Rim and other seasonally visited areas such as North Rim.

Emissions, other than smoke associated with fire management, include aircraft, motor vehicles, and chainsaws.

3.3.1.5 Air Quality Monitoring — Air Quality

Air quality monitoring began at GRCA in 1959. The program has since grown with addition of increasingly sophisticated monitoring and sampling equipment. Monitoring for smoke impacts is an important component of this program for several purposes, including

- To assess potential human health effects in areas impacted by smoke
- For public information purposes (see Warning Messages below)
- For mitigating smoke impacts during fire management operations

- To evaluate smoke management efforts
- To evaluate compliance with state and Federal air quality laws and regulations
- To verify assumptions used in predicting impacts on a Class I airshed

Smoke impacts to GRCA air quality are generally monitored in two ways: using routine visibility monitoring to assess visibility degradation, and making fire-specific measurements of fine particle concentrations. The first method is described in the Visual Resources section below. The second method, which more directly assesses potential human health impacts from smoke, involves use of portable particulate monitors. Particle concentrations can be measured as either PM_{10} or $PM_{2.5}$. Because $PM_{2.5}$ has greater impacts on health and visibility, GRCA measures $PM_{2.5}$. Current monitors do not have the accuracy necessary to officially document particle concentrations to state or Federal NAAQS requirements. Their usefulness in smoke monitoring is a function of portability, which allows a reasonable estimation of particle concentrations where deployed.

Trigger Points **Air Quality Monitoring** **Air Quality**

In 1998, GRCA staff began developing smoke management protocols based on state and Federal policies and guidelines. These protocols were defined in GRCA's "Draft Smoke Management Program" (Bowman 2003), and identified trigger points to indicate when air quality conditions warrant action, including actions to reduce smoke from existing fire or fires. These trigger points, linked with EPA's Air Quality Index and Regional Haze Rule, form the basis for visibility and human health mitigation measures proposed in Chapter 4 of this FEIS/AEF. Trigger points based on visibility degradation are described in Visual Resources. Trigger points based on levels of particulate matter are described here.

GRCA has set its $PM_{2.5}$ goal of an Air Quality Index value of 100 or less. At indices above 100, air quality is considered unhealthy by EPA, beginning with sensitive individuals and at higher levels, for the general public. The Air Quality Index is based on a 24-hour average concentration, measured from midnight to midnight. With EPA's revision of particulate NAAQS in 2006, the Air Quality Index for $PM_{2.5}$ is under revision to determine what concentration of particulates (micrograms of $PM_{2.5}$ per cubic meter of air) will correspond with an index level of 100, and GRCA will follow these new index levels when issued. When $PM_{2.5}$ levels reach the trigger point of an Air Quality Index of 101, mitigation measures call for immediate action to protect public health, including options for notifying people in the affected area, closures, and/or control of smoke production (see Chapter 4). Table 3-13 lists current particulate concentrations and EPA's Air Quality Index standard for fine particulates ($PM_{2.5}$) and coarse respirable particles (PM_{10}) (from 40 CFR Part 58)

NPS Air Resources Division developed a set of warning messages linked to the Unhealthy for Sensitive Groups and Unhealthy categories in accordance with EPA guidance (EPA 2003b). These notices alert the public of dangers of high PM concentrations (Table 3-14). If particle monitor readings show or suggest concentrations in the unhealthy categories, a public advisory is issued. Such advisories include expected heavy smoke locations. Advisories have been issued through press releases and prominent postings at visitor centers, campgrounds, trailheads, and other public use areas. ADEQ and the NPS Air Resources Division are also notified (Bowman 2003).

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**

Smoke-sensitive areas, also called sensitive receptor sites, are special areas in and near GRCA where elevated concentrations of pollutants from smoke may cause human health or environmental impacts. NPS policies are aimed at minimizing smoke impacts on sensitive receptor sites which can include communities (especially hospitals, schools, and nursing homes), recreational areas, campgrounds, trails, scenic vistas, and Class I areas. Smoke-sensitive areas also include active California condor nest sites and designated Mexican spotted owl PACs. The sites listed below are considered susceptible to smoke impacts based on proximity to GRCA FMUs, local wind patterns, climatic conditions, potential smoke transmission, and fire behavior.

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**
Grand Canyon Village/Tusayan/Grand Canyon Airport

The following quotation describes a key airshed south of GRCA. Fire management in this airshed is shared by GRCA and Kaibab National Forest. The quote is taken from the "Smoke Management Plan for Tusayan and Grand Canyon Village" (USDA and USDI 2001).

> *The east side of the airshed identified in this plan is located east of Highway 64, Tusayan, Grand Canyon Village, and GC Airport. The area encompasses approximately 49,700 acres and is drained by Coconino Wash. This drainage runs westerly through Tusayan and GC Airport. Nighttime airflow typically carries smoke from burns on the east side down this wash into Tusayan and GC Airport and may cause impacts from late evening until the inversion lifts the next morning depending on weather conditions and smoke concentrations.*
>
> *The west side of the airshed lies west of Highway 64, Tusayan, Grand Canyon Village, and GC Airport. This area encompasses approximately 12,800 acres. Poor ventilation and prevailing winds from the west and southwest can cause daytime impacts to sensitive areas.*

Table 3-13 Particulate Concentrations and EPA Air Quality Index Standard for Fine Particulates ($PM_{2.5}$) and Coarse Respirable Particles (PM_{10})

			Current 24-hour Average Particulate Concentration (under revision)	
Level of Health Concern	Air Quality Index	Color	Fine Particle ($PM_{2.5}$)	Coarse Particle (PM_{10})
Good	0 – 50	Green	0 – 15.4 μg/m^3	0 – 54 μg/m^3
Moderate	51 – 100	Yellow	15.4 – 40.5 μg/m^3	55 – 154 μg/m^3
Unhealthy for Sensitive Groups	101 – 150	Orange	40.5 – 65.4 μg/m^3	155 – 254 μg/m^3
Unhealthy	151 – 200	Red	65.4 – 150.4 μg/m^3	255 – 354 μg/m^3
Very Unhealthy	201 – 300	Purple	150.5 – 350.4 μg/m3	355 – 504 μg/m^3
Hazardous	301 – 500	Maroon	350.5 – 500 μg/m^3	505 – 604 μg/m^3

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**
Desert View

Desert View is located on South Rim, approximately 26 miles east of Grand Canyon Village. Facilities include an NPS information center, concession-operated shops and snack bar, campground, and employee residential area. Smoke originating from fires on South Rim may directly impact Desert View. Although smoke from North Rim fires generally passes north of Desert View, impacts may still occur when smoke inversions in the canyon ventilate over Palisades of the Desert just north of Desert View.

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**
North Rim Developed Area

North Rim facilities and visitor-use areas include an NPS information center; concession-operated cabins, restaurant, shops and stables; a campground; and employee residential area. Emissions from nearby prescribed or wildland fires can move over this area or drain through it at night.

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**

Cross-Canyon Corridor Between Grand Canyon Village and North Rim Developed Area

The Cross-Canyon Corridor includes the Kaibab, Bright Angel, and River Trails; campgrounds at Indian Garden, Bright Angel, and Cottonwood; the lodge at Phantom Ranch; and infrastructure including power and water lines, communication equipment, and maintenance facilities. Although wildland fires on South Rim can affect the Corridor, impacts are most likely from North Rim fires in areas surrounding Bright Angel Canyon.

Table 3-14 Fine Particle Health Impacts and Messages GRCA

Level of Health Concern	Group Notified	Messages
Good	None	None
Moderate	None	None
Unhealthy for Sensitive Groups	Sensitive Individuals; those with respiratory disease, the elderly, and children are the groups most at risk	*Employees* Park $PM_{2.5}$ pollution conditions 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 (e.g., 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 (e.g., 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.
Unhealthy	General Public	*Employees* Park $PM_{2.5}$ pollution conditions 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 lung irritation 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.

Smoke-Sensitive Areas **Air Quality Monitoring** **Air Quality**

Areas Outside GRCA

Impacts to areas outside the park are generally the concern of ADEQ and the Interagency Smoke Coordinator. However, smoke impacts to the following areas are still a concern to park management.

- **Kanab, Utah; Fredonia, Arizona; and Small Communities along Arizona Highway 389**
  Smoke from short periods of high-intensity wildland fire has periodically reached these communities located approximately 35–45 miles north of GRCA's boundary. The north-south trending Kanab Creek

drainage occasionally funnels smoke northward, but smoke is normally well dispersed by the time it reaches these towns.

- **Tuba City and Page, Arizona, and Scattered Populations in the Western Navajo Nation and House Rock Valley**
  The Tuba City/Moenkopi area on the Navajo and Hopi Reservations is directly east of GRCA forested areas and has been affected by smoke from GRCA fires. Page is located 50 miles from North Rim forested areas; however, it lies northeast, in the path of summer prevailing winds. Smoke from the 2000 Outlet suppression fire on the North Rim was heavy enough to prompt ADEQ to issue a health advisory for Page and the Grand Canyon area (Arizona Department of Environmental Quality, 2000). Scattered residences and small communities on the Navajo Nation and House Rock Valley lie northeast and east and generally downwind of GRCA forested areas. Smoke impacts to Page indicate a similar potential for impacts in these areas.

Social Environment **Air Quality Monitoring** **Air Quality**

Scenic Resources

Grand Canyon was designated a national park in 1919 and a world heritage site in 1979, in large part because of its "exceptional natural beauty" and its "aesthetic importance."[5] Best known of the park's scenic qualities are expansive views of Grand Canyon from the rims. On clear days, depending on rim overlook orientation, a deeply eroded landscape of canyons, buttes, and cliffs may be visible for 160 miles or more. The Colorado River, flowing a mile below in its Inner Gorge, can be glimpsed from a few rim vantage points. For South Rim visitors looking directly across the canyon, the high, forested Kaibab Plateau caps North Rim 10–12 miles away. For visitors looking south from North Rim, a broad plain stretches beyond the canyon and past the San Francisco Peaks, some 65 miles distant.

Over the long term, fire management activities can enhance and protect GRCA's visual resources, primarily by clearing forests of overly dense stands of small trees and litter. Managed fire opens vistas, allows greater light penetration into the forest, promotes understory growth of grasses and forbs, allows remaining trees to grow to larger size, and creates and maintains meadows. By reducing fuels, managed fire also lessens risk of wildfires. In the short term, however, some fire management activities can and do detract from scenic values. Low- and moderate-intensity managed fire burns understory and tree trunks to varying degrees, resulting in some blackened conditions that may still be apparent a year or more after the fire. Higher-intensity fires have occurred both on South and North Rims from management activities in the past five years that have created an impact on scenic resources along roads and trails. Examples can be seen along Highway 64 on South Rim and along Cape Royal Road on North Rim.

Social Environment **Air Quality Monitoring** **Air Quality**

Visibility

Degradation of long-distance canyon views from fire-generated smoke is a serious concern. Because of the importance of good air quality to GRCA, Congress designated it a Class I area in 1977. This status requires the most stringent air quality protection under the CAA. While GRCA air quality is generally good, visibility is impaired to some degree by human-caused air pollution about 90% of the time (Bowman 2003). The primary problem is regional haze, a product of urban and industrial emissions mostly from metropolitan California, Nevada, Arizona, and northern Mexico. Haze is caused by fine particles suspended in the air, including sulfates, organics, dust, and soot. Sporadically, smoke from prescribed and wildland fires contribute to haze.

As part of a long-term GRCA air-quality monitoring program, the NPS routinely monitors visibility using a variety of instruments. The transmissometer consists of a light source (transmitter) and a light detector (receiver) separated by several miles. A beam of light projected by the transmitter is measured at the

[5] This language is used in Criterion No. 3 for designation as a natural heritage site under the World Heritage Convention (World Heritage Committee 2004).

receiver, and the amount of light lost in transit (called *light extinction*) is a measure of haze thickness in the light's path (Bowman 2003). The NPS maintains a transmissometer to measure light extinction in the canyon, including smoke impacts on canyon views. Raw transmissometer data is further calibrated and checked for errors before final reporting, but raw, real-time data are still a valuable measurement of current visibility conditions.

Nephelometers, which measure the amount of light scattered by airborne particles, are also used to monitor haze. Although raw nephelometer data are also available, they are less valuable for smoke monitoring since the measurement does not include light absorption, which also contributes to haze. The NPS operates two nephelometers, one on South Rim and one 3,200 feet below the rim at Indian Garden. Data gathered by the transmissometer and nephelometer may be converted to units called *deciviews* (dv). A change in visibility of one deciview represents a just-noticeable change to most observers under most conditions, although much smaller changes can be seen under some conditions. On a scale of 0–46, 0 deciviews indicate maximum clarity and 46 deciviews indicate virtually opaque conditions, so the higher the number, the hazier the conditions.

The best information about haze composition and trends comes from speciated particle samplers (not the portable particle samplers used for smoke monitoring discussed above). The NPS operates two particle samplers in Grand Canyon, one on South Rim and one at Indian Garden, and the state of Arizona recently installed one near the mouth of the canyon in Meadview, Arizona. These instruments capture 24-hour samples of airborne fine particulates every third day. The samples go to a number of laboratories for detailed analyses. Unfortunately, these filter samples are impractical for real-time smoke monitoring due to their sampling schedule and the months required for analysis. However, compositional data provided are invaluable in characterizing haze nature measured by the transmissometer and nephelometers.

Visibility tends to be best in winter (November–March) and worst in spring and summer (April–August). In winter, masses of clear, cold northwestern air generally sweep through the region every four to eight days, resulting in the clearest days experienced at GRCA. Between these cold fronts, air stagnates, and temperature inversions are common. Inversions trap pollutants (including smoke if present) in the canyon and can last several days. On these days, visibility may be poor. During spring and summer, prevailing winds from the southwest carry pollutants from industrial areas into the region, contributing to generalized haze throughout the Colorado Plateau. This seasonal pattern coincides with a high fire incidence in the dry months of May through mid-July, so smoke periodically compounds already hazy park conditions. Autumn is variable. In general, regional haze is less of a problem than summer, and days are clearer. Temperature inversions are more likely, however, with a consequent risk of trapping smoke in the canyon (Bowman 2003). Figure 3-3 shows how average haze levels peak in summer on both South Rim and inside the canyon at Indian Garden (particulate sampler data, 1990-2004).

Smoke impacts can be much greater than these average haze levels. From 1999 through 2004, the Indian Garden sampler captured 13 days where the 24-hour particle sample indicated visibility of 15 deciviews or more, the haziest 3% of the six-year period. Of these 13 episodes, fires on North Rim caused seven, and four others were caused by fires well upwind of the park, as shown in Table 3-15.

The range of visible conditions seen at GRCA is shown photographically in Figure 3-4. The first photos show the clearest and haziest 1% days. Haze is uniform in the second picture, but smoke is typically layered, as seen in the third photo, or forms plumes, as shown in the fourth photo.

Visibility Standards Social Environment Air Quality Monitoring

While standards to protect human health are clearly set forth in Federal and state regulations, standards to protect visibility are less clearly defined. In 1977, Congress established as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution" (Clean Air Act, Sec. 169A).

Figure 3-3 Yearly Visibility Trends GRCA

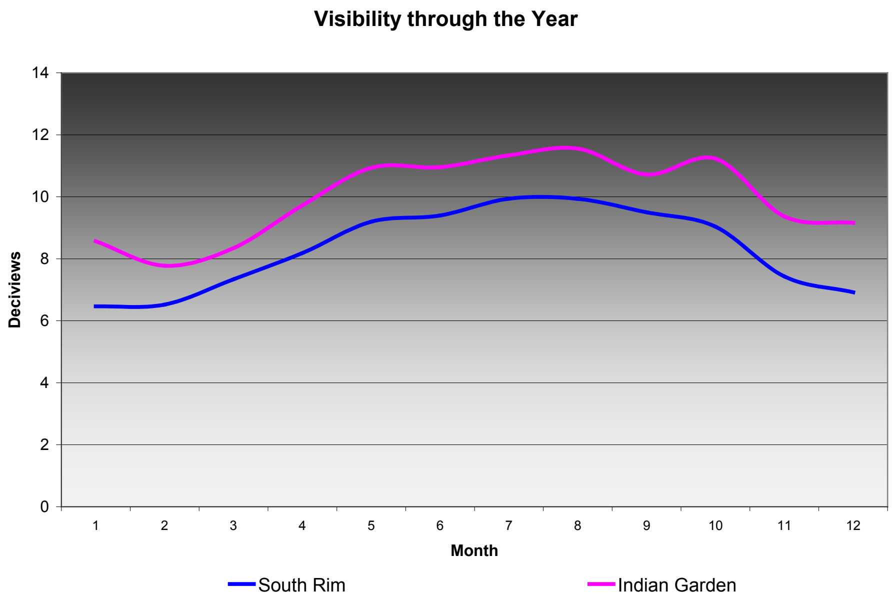
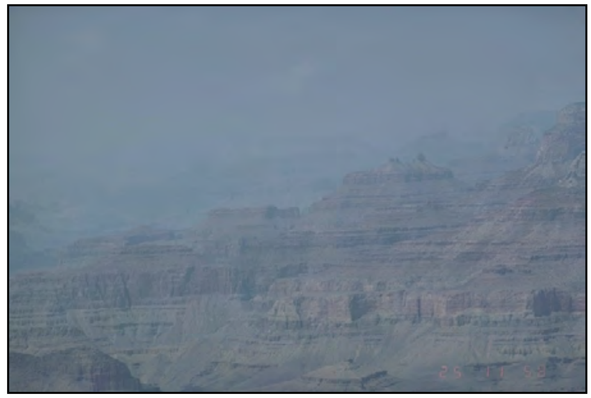


Table 3-15 Haziest Days, 1999-2004 GRCA

Haziest Days Recorded at Indian Garden, 1999-2004		
Date	Haze Level (deciviews)	Cause
October 24, 2003	26.64	GRCA Rose WFU
October 27, 2003	24.59	GRCA Rose WFU
October 30, 2003	23.33	California fires
September 28, 2001	20.88	GRCA Vista and Tower WFU
October 19, 2001	17.19	GRCA Tower WFU
October 13, 1999	16.49	GRCA Outlet Prescribed Fire
December 6, 2001	16.20	Unknown
September 22, 2001	15.93	GRCA Vista WFU
May 24, 2000	15.92	GRCA Outlet Suppression Fire
July 17, 2003	15.35	Regional haze (distant fires?)
August 2, 2000	15.33	Regional fires, CA and NV
September 5, 2002	15.31	Mogollon Rim fires
March 25, 2000	15.27	Regional haze

**Figure 3-4 Photographs Showing Air Quality Conditions GRCA
b) the haziest 1%, c) layered smoke in the canyon, d) smoke plume on North Rim**

a) 1% clearest days
Deciviews = 0; Range of Visibility = over 240 miles



b) 1% haziest days (uniform regional haze)
Deciviews = 22; Range of Visibility = 40 miles

c) Layered smoke in the canyon

d) Smoke plume on North Rim

GRCA is one of 258 such “mandatory class I Federal areas.” The national Regional Haze Rule sets a target of 2064 to return visibility to natural conditions (40 CFR §51.308(d)(1)(i) (B)). There are no actual monitoring data to define “natural conditions,” so EPA set out guidelines for their estimation (EPA 2003a). These reconstructed natural conditions include estimates for smoke from natural wildland fires. To reach natural visibility conditions, EPA recommended (and Arizona followed) a strategy to preserve the best 20% visibility days while improving the worst 20%. As seen in Table 3-16, the Haze Index in 2004 on Grand Canyon’s best days was already close to the natural conditions target. However, its average days are hazier, and its worst days are substantially hazier than EPA’s calculated natural conditions.

Table 3-16 GRCA Haze Index 2004

Grand Canyon Haze Index, measured in deciviews			
	Best 20% Average	Average	Worst 20% Average
Natural Conditions Default Target (EPA 2003a)	1.83	4.39	6.95
Actual Visibility Conditions in 2004 (VIEWS 2007)	1.98	6.44	11.17
Visibility is measured in deciviews, a unit in which perceived changes in visibility are constant across a wide range of visibility conditions – a change of one deciview is visible to most observers under most conditions regardless of the level of the haze			

Figure 3-5 Difference between Haziest 20% Conditions and Haziest Target Conditions

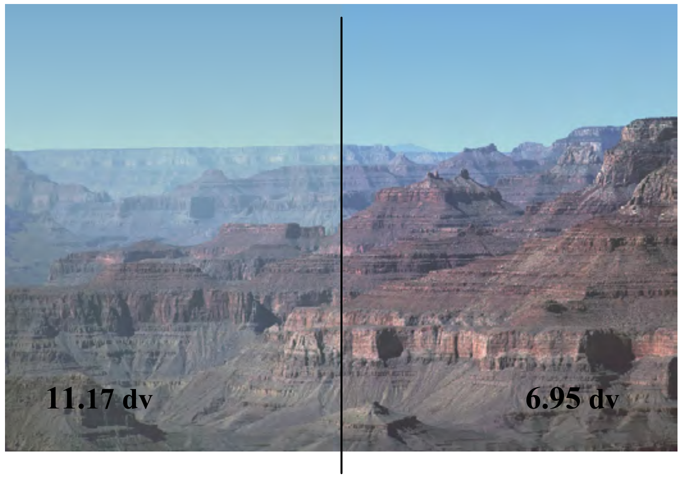
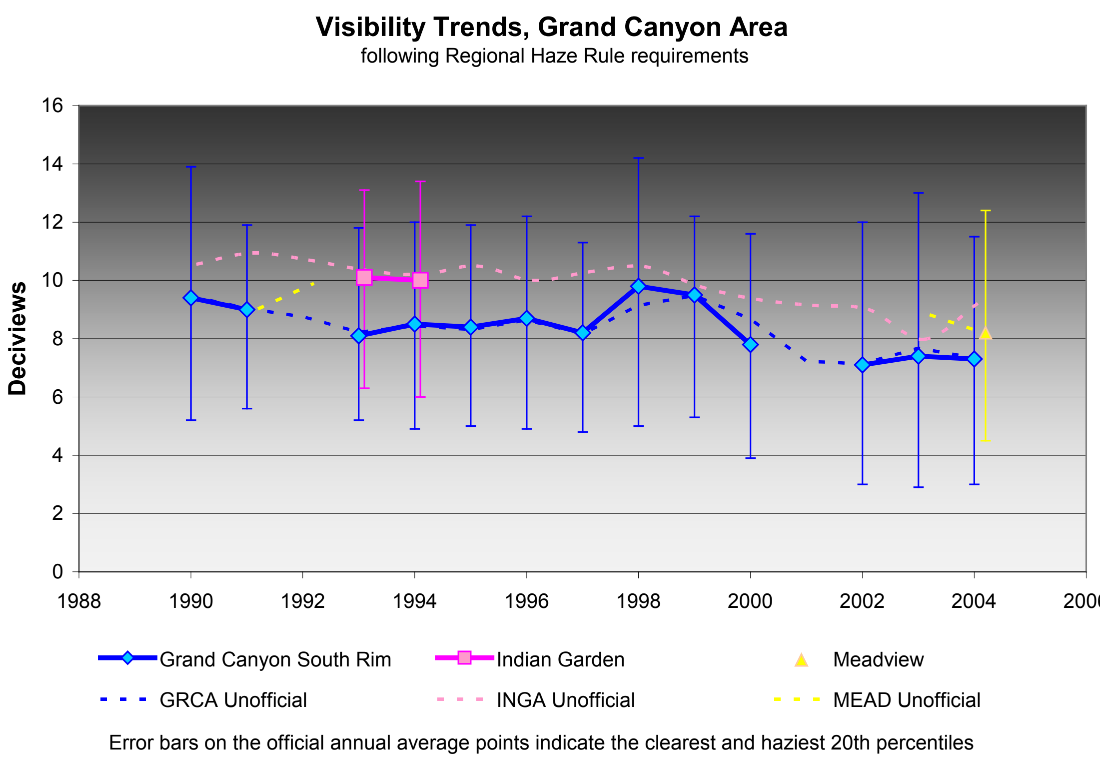


Figure 3-5 shows the difference between the haziest 20% in 2004 (on the left) and the haziest target conditions (on the right). This modeled image was made using Winhaze 2.9.0, from Air Resource Specialists Inc. Modeling produces a uniform haze rather than a plume as would be expected from a wildland fire.

Figure 3-6 shows park trends in visibility since 1990. Official values tabulated according to requirements of the Regional Haze Rule are solid lines, while unofficial trend lines (where some data samples are missing) are shown as dashes.

Figure 3-6 GRCA Visibility Trends Since 1990



For visibility impacts, the Regional Haze Rule provides some guidance. By measuring progress through improvements in the worst 20% of days, a potential strategy can be based on identifying those episodes when fire has cased smoke to exceed that level. Park and fire managers could then be made aware of these negative impacts to balance against resource benefits produced by the fire. Under the Draft Smoke Management Program (Bowman, 2003), analysis of the rolling 24-hour average visibility was used to determine unacceptable visibility. However, the methods were cumbersome, and did not relate directly to daily averages used to measure progress toward the national visibility goal. Based on past park experience characterizing visibility for fire management purposes, the following procedure is proposed to classify visibility conditions in GRCA to guide mitigation measures in Chapter 4.

1. The preferred instrument for assessing visibility is the In-Canyon Transmissometer (GRCW1). This instrument measures total light loss hourly along a light path from Phantom Ranch on the canyon floor to Yavapai Point on South Rim. This measurement is preferred because a) it measures visibility within the canyon, the park's prime visual attraction, b) its location near Grand Canyon Village represents the first (and often only) view seen by a majority of park visitors, and c) the canyon often acts as a haze trap or mixing chamber, and this instrument's readings tend to represent visibility through a long reach of the canyon, more or less from Grandview to Havasupai Point. Other real time instruments can be used if necessary, the nephelometers take point measurements of light scattering at either Indian Garden below South Rim or in the forest about a mile south of Grandview Point.

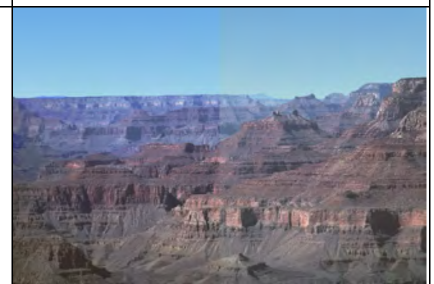
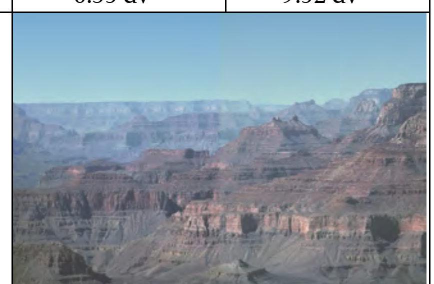
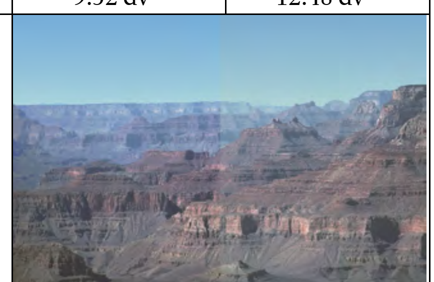
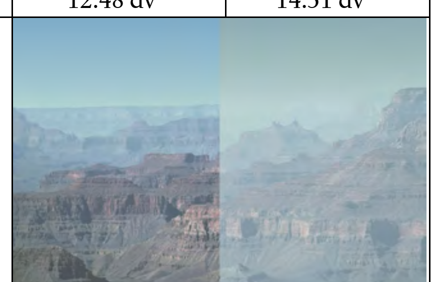
2. A 24-hour average haze index, measured in deciviews, will be calculated to evaluate visibility conditions. This index provides a real-time metric to assist GRCA in working toward the national visibility goal. Most visitors are viewing Grand Canyon during daylight, so including nighttime readings may deviate somewhat from the view they experience during their stay. There is generally a daily pattern of smoke drainage into the canyon during the night followed by morning ventilation (clearing). A 24-hour average combines smoky dawns and clearer sunsets typical of this pattern. Park staff will also track and report hourly readings. Hourly readings can be valuable in outreach (telling the public when the best views are expected), and in assessing how representative the 24-hour average is for management and regulatory purposes.

3. Severity of smoke impacts will be based on effect on visibility and potential to impede progress toward the national visibility goal. Therefore, a classification scheme is proposed using haze indices and percentiles drawn from EPA guidance in the Regional Haze Rule. EPA uses data from 2000 through 2004 to establish regional haze baseline conditions (EPA 2003a). Data from this same period collected by the preferred instrument (GRCW1) have been tabulated and analyzed following the EPA model.

4. Evaluation of the 24-hour haze index will be made against monthly visibility levels measured during the 2000 through 2004 baseline period for the Regional Haze Rule. EPA visibility goals are stated in terms of annual visibility measurements. However, GRCA visibility varies through the year, with winter having the clearest, and summer the haziest air. This variability must be considered in evaluating smoke impacts because conditions that would be judged excellent in summer (clearer than the average of the best 20th percentile) would be considered poor in winter. Evaluation against annual averages would virtually ensure "poor" visibility conditions from any fire in spring or fall. Yet, strong solar heating and wind patterns in hazier months usually provide good smoke dispersion. Conversely, stable air in clear winter months (and wet fuels from winter snows) would often allow smoke to be trapped in the canyon, thickening day after day. Consequently, percentiles developed by EPA to implement the Regional Haze Rule will be applied to monthly data from the 2000-2004 period to describe visibility impacts from smoke. The modeled photos in Table 3-17 use annual average percentiles, as examples only, to describe and depict various visibility levels for purposes of smoke impact monitoring and evaluation.

Arizona has followed the Regional Haze Rule's strategy of addressing those pollution sources that contribute to the haziest 20% of days. To support this strategy, the state requires fire managers to follow practices to reduce and manage wildland-fire produced smoke (Arizona Administrative Code, Title 18,

Table 3-17 GRCA Visibility Classification, Annual Average Examples

Visibility Classification for Grand Canyon Annual Average Examples			
Classification	Haze Index deciview	Justification	Modeled Visibility with Haze Index range
Excellent	less than 6.35 dv	The Regional Haze Rule goal is to preserve the best 20% of days. EPA calculated this to be less than 1.83 dv due to particles. During the baseline period, the best 10th percentile (the average of the best 20th percentile) measured by the GRCW1 was 6.35 dv. Haze this low (good) fosters attainment of the national visibility goal.	 0 (Rayleigh) / 6.35 dv
Good	6.35 – 9.52 dv	The upper limit for this classification is based on the average GRCA visibility. EPA predicts 4.39 dv due to particles. The 50th percentile measured GRCW1 during the baseline was 9.52 dv. Although not a specific Regional Haze Rule target, visibility this good will not impede attaining the national visibility goal.	 6.35 dv / 9.52 dv
Moderate	9.52 – 12.48 dv	The upper limit for this classification is the lowermost boundary of the worst 20% of days at Grand Canyon. EPA predicts 6.95 dv of haze due to particles at this level. Baseline measurements GRCW1 set this (the 80th percentile) at 12.48 dv.	 9.52 dv / 12.48 dv
Poor	12.48 – 14.31 dv	The upper limit for this classification is the average of the worst 20% of days at Grand Canyon. EPA anticipates 11.17 dv of particle haze at this level. During the baseline, the 90th percentile haze measured GRCW1 was 14.31 dv. Lowering haze levels in this range fosters meeting the national visibility goal.	 12.48 dv / 14.31 dv
Very Poor	greater than 14.31 dv	This classification includes days worse than the current average visibility at Grand Canyon on the worst 20% of days. The 90th percentile (average of the worst 20%) measured GRCW1 during the baseline was 14.31 dv (the 99th percentile of 24.93 dv is shown, the very worst visibility obscures the Canyon completely).	 14.31 dv / 24.93 dv

Chapter 2, Article 15). If a fire is not wanted, suppression actions taken also reduce smoke impacts as quickly as possible. For wildland fire-use and prescribed fires, Arizona has developed two sets of smoke management tools, Emission Reduction Techniques and Smoke Management Techniques. Emission Reduction Techniques are aimed at reducing smoke through methods such as ensuring fuels burned are the minimum necessary to achieve ecosystem goals. Smoke Management Techniques address ways to reduce fire-produced smoke impacts though types and timing of ignition and coordination with others. Grand Canyon fire managers are required to apply as many of both technique types as apply to a particular fire. Mitigation measures described in Chapter 2 include these techniques.

Smoke Management Managing smoke impacts from wildland fires begins as soon as a prescribed fire is planned or a natural fire discovered. The triggers first developed to protect visibility in response to North Rim Complex fires in 1998 were refined and expanded in response to subsequent fires to include particulate measurements, resulting in the Draft Smoke Management Program (Bowman 2003).This draft program guided fire managers in identifying and addressing unacceptable smoke impacts. Experience with the Draft Smoke Management Program and guidance from the Regional Haze Rule led to mitigation measures proposed in Chapter 2 to deal with visibility impacts of park wildland fires.

Based on the visibility monitoring strategy described above, if visibility is *very poor* for three days, the mitigations call for smoke reduction. *Very poor* visibility is defined as a 24-hour average visibility in the worst 10% of days for the particular month. Conditions this hazy would result in visibility degradation, rather than the improvement called for under the EPA's Regional Haze Rule. Smoke reduction actions for visibility impacts may not be necessary if weather conditions better suited to smoke dispersion are expected imminently, or if park management determines the fire's benefits to other park resources outweigh its visibility impacts. To control smoke, fire managers may elect to reduce smoke by actively burning out portions of the fire to reduce fuel loads during times of day when smoke will be dispersed (with prior approval of ADEQ); by cooling off the most active fire sections (hotspotting); by stopping fire spread in part or completely (containment); or by extinguishing all or part of the fire (mop-up). The specific action(s) taken may vary from fire to fire, depending on fire behavior, health and safety concerns, resources available, and other fire-specific variables.

3.4 Soils and Watersheds

Areas of concern are in GRCA in northwestern Arizona. Proposed treatment areas are FMUs shown on Maps 2-2 and 2-3. Planned fire management projects are located on North and South Rims; no planned fire management projects are located in the inner canyon or on fire islands.

3.4.1 Geology and Geomorphology

Grand Canyon was formed by the Colorado River and its tributaries cutting many layers of sedimentary and metamorphic rock that form the Colorado Plateau. Colorado Plateau soils are primarily derived from the uppermost bedrock formation, the Kaibab Limestone, a 250-million-year-old sandy limestone. Some drainages expose the underlying 260-million-year-old Toroweap Formation, composed of sandstone and limestone. Below this is the 270-million-year-old Coconino Sandstone formed from cross-bedded sand dunes, and exposed in one North Rim area.

Seven more major rock formations are exposed in canyon walls. All but the lowest are sedimentary, deposited during a series of advancing and retreating coastlines. Lower formations include highly metamorphosed one-to-two billion-year-old sedimentary rocks and granite.

The most extensive land forms are the Coconino and Colorado Plateaus in which the Colorado River and its tributaries have cut deep canyons. Near GRCA, flat-lying sedimentary formations rose into a dome. The river cut through the dome's southern slope, resulting in the higher Kaibab Plateau on the river's north side and the lower Coconino Plateau on the south (Price, 1999).

Plateau surfaces are relatively flat with drainages that trend generally south. Solution cavities in various limestone formations transmit groundwater, sometimes in large quantities, to canyon-wall springs. Sinkholes are also found on plateau surfaces.

3.4.1.1 Slope Stability Geology and Geomorphology Soils and Watersheds

Sedimentary layers are nearly flat and canyon walls form stair-stepping cliffs and flatter slopes, depending on hardness and resistance to slope failure. Layers harder and more resistant to slope failure tend to form nearly vertical cliffs, while softer units form debris-covered slopes. Slope failures and rock falls occur regularly due to steepness and effects of water and ice. Slope instability is a natural component of canyon walls. Canyon-wall slope failures contribute material of widely varying size to the canyon floor and stream channels. Sediment size ranges from clay-size particles to building-sized boulders. In contrast, plateau surfaces on North and South Rims have relatively gentle slopes and are very stable.

3.4.1.2 Soils Soils and Watersheds

Soil Classification

At least 62 soil-family complexes have been identified by the USDA National Resources Conservation Service in GRCA (USDA NRCS 2006). Soil-family complexes are soil types grouped on physical and chemical properties and other characteristics affecting management. Typically, soils are further grouped into orders based on soil formation, plant growth, and other pertinent properties. In GRCA, soils can be grouped into six orders including alfisols, aridisols, entisols, mollisols, inceptisols, and vertisols. The most common soil orders in GRCA FMUs are alfisols, aridisols, and entisols. Alfisols comprise 12%, aridisols 33%, and entisols 48% of FMU soils. Park and FMU soil orders are shown in Map 3-1. Acreages and percentages of soil orders in the park and FMUs are shown on Table 3-18.

Entisols and inceptisols are very young soils with little to no subsurface horizon development; other characteristics, such as moisture and porosity, can vary widely. Aridisols are relatively high in calcium carbonate and other salts and have some subsurface horizon development such as accumulations of clays, silica, and/or salts. They are dry most of the year. Alfisols and mollisols are more well-developed soils with clay and organic material subhorizon accumulation. They tend to have greater water holding capacity and aggregate soil structure than other soil types found in the project area (Merrill, 2006). These soils are generally more productive and support more plant growth.

Soil orders are divided into suborders based on soil formation and plant growth properties. Table 3-19 provides some characteristics of GRCA soil suborders including the percent organic matter, slope, runoff class, and surface soil textures. These characteristics are pertinent to soil erosion potential and productivity. The table shows that soil suborder characteristics vary widely. More specific data regarding soil types is not available due to GRCA's large size and inaccessibility. However, all major soil suborders include soil types that have potential for very high surface runoff.

GRCA soils are little affected by human activity except in developed areas such as Grand Canyon Village on South Rim and Bright Angel Point on North Rim, and along roadways. Logging, grazing, and farming have not occurred in GRCA in at least 75 years. Thus, current GRCA soil conditions are within or close to their natural state.

3.4.1.3 Soil Erosion Hazard Soils Soils and Watersheds

In addition to soil type, NRCS also groups soils by various characteristics to provide ratings of soil responses to different activities. For the purposes of this FEIS/AEF, NRCS soil ratings for potential off-road/off-trail erosion hazard, potential road/trail erosion hazard, and potential damage to soil by fire were used (USDA NRCS 1998). NRCS off-road/off-trail erosion hazard rates potential for increased erosion due to removal of cover due to fire or other activities, such as clearing for helipads or staging areas. This rating also applies to manual/mechanical treatments in WUI areas. The fire damage to soil rates potential for damage to soil's physical and biological characteristics. Thus, both are included to evaluate the full range of potential effects from fire and associated activities.

Table 3-18 Soil Orders in GRCA FMUs

	Soil Order											
	Alfisols		Aridisols		Entisols		Inceptisols		Mollisols		Vertisols	
FMU	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Backcountry Uplands	29,967	25	51,891	44	5,165	4	21,253	18	7,954	7	2,668	2
Fire Islands	4,182	31	2,275	17	4,073	30	2,917	<1	2,917	<1	<1	<1
Inner Canyon	5,630	<1	347,954	37	544,408	58	1,046	<1	19,766	2	1	<1
Kaibab Summit	14,733	91	<1	<1	958	6	<1	<1	510	3	<1	<1
Peninsulas	39,038	79	<1	<1	7,074	14	<1	<1	3,325	7	<1	<1
Plateaus	27,967	85	<1	<1	4,263	13	<1	<1	715	2	<1	<1
WUI	7,700	59	<1	<1	179	2	<1	<1	5,060	39	<1	<1
Secondary WUI	12,067	80	90	0.6	116	0.8	<1	<1	2,881	19	<1	<1
GRCA Total	141,341	12	402,234	33	566,316	48	22,349	2	43,171	4	8,082	<1
Soil Order Description	Moist part of the year; pH > 7; Hard, low-permeability horizons		Very little moisture and limited soil formation; May contain soluble salts		Few or no distinct soil horizons; Low organic matter content		Moist at least three months a year; Have a low-permeability layer; May not have distinct soil horizons		Thick, darkly colored, carbon-rich, and moist much of the year		Clay-rich, with strong shrink-swell characteristics	
< means less than; > means greater than												

These ratings do not predict amount of erosion or damage that may occur, only the likelihood that erosion or damage may occur under stated conditions. Weather patterns, fire severity, and mitigation measures can all change actual effects.

Potential off-road/off-trail erosion hazard ratings assess sheet and rill erosion from exposed soil surfaces created by fire or other activities. Fire or other activities are assumed to result in 50 to 75% bare ground in the affected area. Ratings include

- Slight — Erosion is unlikely under ordinary climatic conditions
- Moderate — Some erosion is likely; control measures may be needed
- Severe — Erosion is very likely; control measures for vegetation re-establishment on bare areas and structural measures are advised
- Very Severe — Significant erosion is expected; loss of soil productivity and off-site damages likely; control measures are costly and generally impractical

3.4.1.4 Biological Soil Crusts Soils Soils and Watersheds

Biological soil crusts are commonly found in arid and semi-arid regions, including limited portions of South Rim. Biological soil crusts are comprised of cyanobacteria, mosses, and lichens. These living organisms and their by-products bind soil particles, creating a living crust on the soil surface. Biological soil crusts generally cover much of areas not occupied by vascular plants. Biological soil crusts provide numerous benefits to soil and vascular plants by increasing soil nutrient content, soil stability, infiltration, seedling germination, and plant growth, and reducing erosion (USGS, 2006).

Biological soil crusts are easily damage or killed by compressional disturbances, such as trampling by humans, livestock, or off-road vehicles. The recovery rate for biological soil crusts may be slow, requiring years to regenerate; however, a study of trampling effects on biological soil crust in GRCA found the crust was nearly recovered within five years (Cole, 1990).

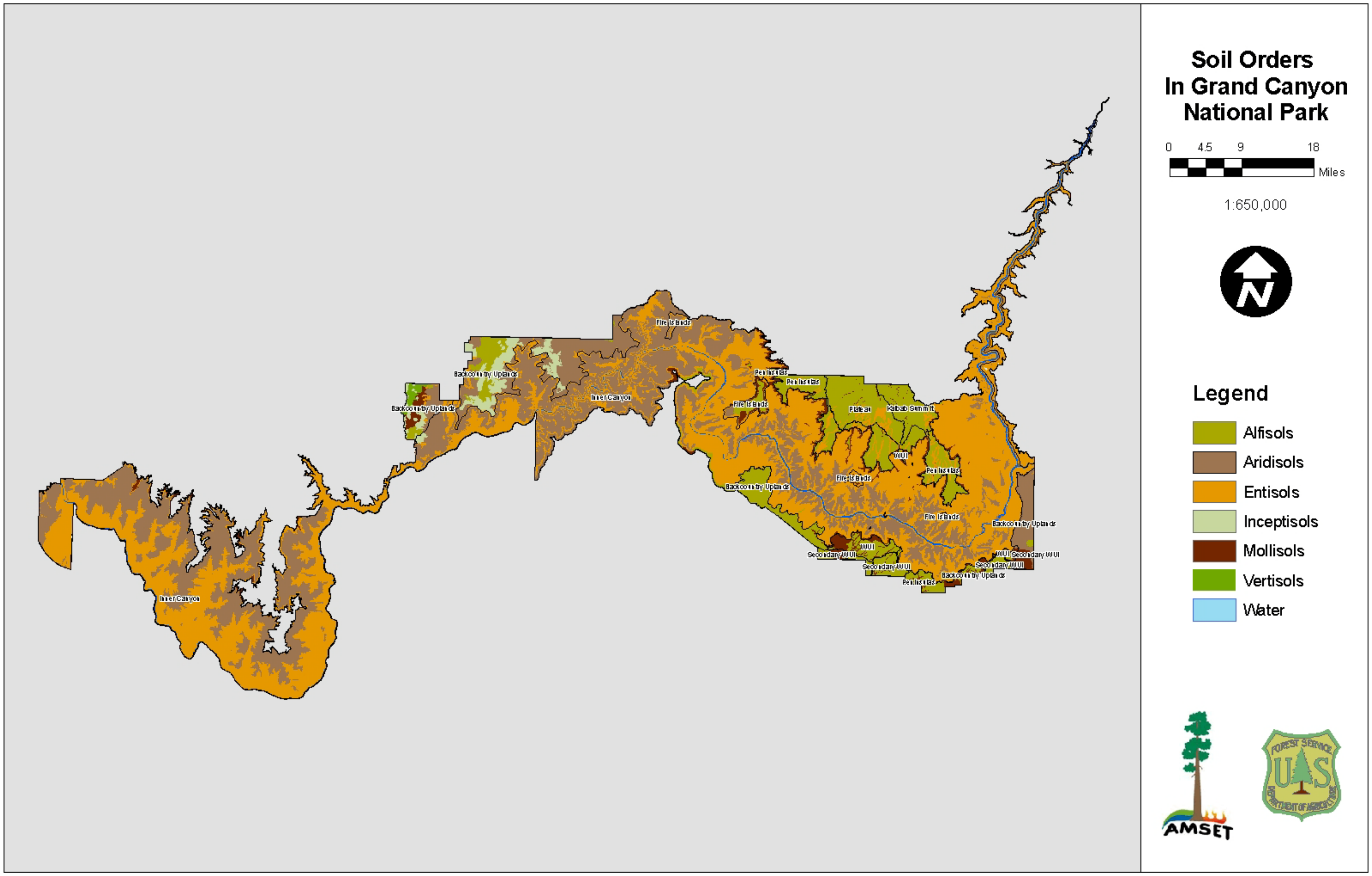
The extent of GRCA biological soil crust has not been mapped. Biological soil crust has not been observed in North Rim forested areas, but has been observed in North Rim's western portion, the Inner Canyon, and in at least one South Rim location (Rasmussen, personal communication, 2006).

The NPS considers biological soil crust an important GRCA resource.

Table 3-19 Soil Suborder Characteristics

Soil Order	Soil Suborder	Organic Matter (%)	Slope (%)	Runoff Class	Soil Textures
Alfisols	Ustalfs	0.0 to 6.0	1 to 65	Low to very high	Loam, sandy loam, sandy clay loam, gravelly loam, gravelly sandy loam, gravelly sandy clay loam, cobbly loam, clay, clay loam, gravelly silty clay, gravelly clay loam, gravelly clay, cobbly clay loam, silt loam, silty clay loam, gravelly silt loam, gravelly silty clay loam
Aridisols	Argids	0.1 to 2.0	2 to 35	Medium to very high	Loam, sandy loam, gravelly loam, gravelly sandy loam, cobbly loam, cobbly sandy loam, gravelly clay loam, cobbly clay loam
	Calcids	0.1 to 3.0	0 to 60	Very low to very high	Loam, sandy loam, gravelly loam, gravelly sandy loam, gravelly loamy sand, cobbly loam, gravelly silt loam, silty clay loam
	Cambids	Data not available	1 to 15	Data not available	Silt loam, gravelly sandy loam, gravelly loam
Entisols	Aquents	Data not available	2 to 6	Data not available	Stratified sand to silty clay
	Fluvents	0.1 to 6.0	2 to 15	Low	Silt loam, loamy sand
	Orthents	0.1 to 5.0	2 to 70	Very low to very high	Loam, silt loam, sandy loam, gravelly loam, gravelly sandy loam, gravelly loamy sand, cobbly loam, cobbly sandy loam, bouldery sandy loam, bouldery sandy clay
Inceptisols	Ustepts	0.0 to 3.0	2 to 60	Medium to very high	Loam, gravelly loam, gravelly sandy loam, gravelly loamy sand, cobbly loam
Mollisols	Ustolls	1.0 to 5.0	0 to 55	Negligible to very high	Loam, silt loam, silty clay loam, gravelly loam, gravelly sandy loam, gravelly sandy clay loam, gravelly silty clay, cobbly loam, cobbly silt loam, cobbly sandy loam, cobbly silty clay loam
Vertisols	Usterts	1.0 to 2.0	2 to 8	Very high	Cobbly silty clay loam

Note Many GRCA soil types are in remote or difficult to reach locations so specific data are unavailable. Runoff class is based primarily on slope and climate. Ground surface is assumed to be bare, such as might occur after a fire



Map 3-1 Soil Orders

3.4.5 Watersheds — Soils and Watersheds

The USGS (USGS 2006a) delineates U.S. watersheds into six hydrologic units based on size. These units are identified by a specific 2 to 11 digit hydrologic unit code (HUC). GRCA is delineated into six subbasins (HUC 4 level[6]), which range from approximately 940,000 to 1.9 million acres.

Subbasins cover extensive areas and are subject to a variety of uses under various jurisdictions. Portions of the subbasins are managed by the NPS, BLM, USFS, various Native American tribes, counties, cities, and/or private companies and individuals. This document focuses on land managed by GRCA.

3.4.5.1 Rivers and Streams — Soils and Watersheds

The major GRCA surface water feature is the Colorado River, which flows 1,450 miles from the Rocky Mountains in Colorado to the Gulf of California. Approximately 277 miles flow in GRCA boundaries. Prior to dam construction, river flows varied widely seasonally and annually, and the river transported large volumes of sediments into and through the canyon. Flows measured at Lees Ferry ranged from 5.6 to 24.0 acre-feet per year (GRCA, 1984).

The Colorado River is dammed both up and downstream. Downstream, Hoover Dam created Lake Mead, which backs up to the park's western end. Upstream, Glen Canyon Dam has regulated flow since 1966, significantly changing river temperature, moderating seasonal flows, and reducing sediment input.

A perennial stream flows year-round; intermittent streams flow seasonally; and ephemeral streams flow in response to rainfall or snowmelt. There are a number of side canyon perennial streams that drain to the Colorado River; most are spring fed and intermittent or ephemeral upstream of the springs. There are no perennial streams in any proposed treatment area.

After the Colorado River, the next largest perennial stream is the Little Colorado River, which enters the Colorado River near Chuar Butte near Desert View. There are 21 other perennial streams. The USGS maintains gauging stations on some of these streams. Perennial streams with annual range of discharge (if available) are listed below (Map 3-2 and Table 3-20).

There are numerous intermittent and ephemeral drainages and washes. The USGS maintains gages on a few of these streams. Some of the more significant intermittent streams, and discharge data from gauged streams, are shown in Table 3-21.

Two locations have short stream reaches composed of treated sewage effluent: an unnamed tributary of Coconino Wash on South Rim and Transept Canyon on North Rim (NPS 1984).

Current flow, turbidity, sediment transport, and temperature conditions on the Colorado River are different than historical conditions due to the dam, as stated above. Flows are regulated, and extremely high flows have been eliminated. Turbidity and sediment transport are reduced. Temperatures are generally lower, especially during summer and fall. Flow in Bright Angel Creek has been slightly reduced due to water use for domestic purposes on North and South Rims. Other perennial streams are closer to historic conditions.

A number of stock tanks and ephemeral ponds exist in the park. Stock tanks are being allowed to infill with sediments.

[6]See: http://geo-nsdi.er.usgs.gov/metadata/open-file/99-30/metadata.faq.html Accessed July 14, 2008; or http://pubs.usgs.gov/wsp/wsp2294/

3.4.5.2 Springs — Soils and Watersheds

The Grand Canyon area's sedimentary geologic formations contain many springs. Many springs occur in canyon walls, particularly in Redwall and Muav Limestones, although smaller springs occur in Coconino and Tapeats Sandstones as well (Monroe 2005; NPS 1984). Some GRCA springs are shown on Map 3-2.

Springs are generally found where a relatively more permeable formation overlies an impermeable one. The more permeable formations allow precipitation to percolate through solution channels, fractures, or joints until reaching a less permeable formation, which causes water to flow toward areas of lower pressure and emerge on the surface as spring flow. Spring discharge ranges from minor seeps—only visible due to plant growth—to torrents flowing at thousands of gallons per minute. Most park perennial stream reaches are fed by spring flow. Some of the park's named springs include

Angel Spring
Blue Spring
Boucher East Spring
Burro Spring
Cedar Spring
Cottonwood Spring (in Tuckup Canyon)
Cottonwood Spring (in Cottonwood Canyon)
Dragon Spring
Grapevine East Spring
Grapevine Main Spring
Haunted Spring
Hermit Spring
JT Spring
Lonetree Spring
Matkatamiba Spring
Miners Spring
Monument Spring
Pumphouse Spring
Red Canyon Spring
Roaring Springs
Royal Arch Spring
Salt Creek Spring
Santa Maria Spring
Shinumo Spring
Spring Canyon Spring
Tapeats Spring
Thunder Spring
Warm Springs

Surface and Ground Water Quality

GRCA water quality is variable. Except for the Colorado and Little Colorado Rivers, perennial and intermittent streams are fed by springs, supplemented by snowmelt or significant rainfall events. Streams fed by springs generally have good water quality, although some springs contain elevated levels of a few elements due to the bedrock that groundwater feeding the spring flows through. Groundwater migrating through various carbonate and marine sandstone layers pick up various constituents, including total dissolved solids, phosphate, bicarbonate, aluminum, sulfate, sodium, chloride, calcium, and/or magnesium. Thus, some springs may have concentrations of one or more of these constituents that are greater then state or Federal water quality standards.

Significant rainfall events can temporarily change spring and surface water quality due to increased run-off and stream flow that entrain sediments, increasing turbidity and total suspended solids. The Little Colorado River has generally higher turbidity and sediment load than spring fed streams. Prior to construction of Glen Canyon Dam, Colorado River water quality was similar to that of the Little Colorado River. Since the dam, water released from the reservoir is cooler and contains lower sediment levels than before the dam.

3.4.5.3 Groundwater — Soils and Watersheds

Groundwater occurs primarily in joints, faults, and solution cavities in limestone and sandstone formations (Huntoon, 1974; BOR 2002). In general, bedrock matrix has few or no interconnected pore spaces and so cannot transmit water. Thus, water moves through larger openings created as it dissolves rock. Groundwater recharge occurs when precipitation infiltrates surface soil and weathered bedrock and migrates to locations where subsurface cavities near or contact the surface, such as faults or sinkholes.

The main park water-bearing formation is the Redwall-Muav Aquifer. This aquifer is comprised of Redwall, Temple Butte, and Muav Limestones that overlie the relatively impermeable Bright Angel Shale. This aquifer lies approximately 3,000 feet below ground surface and is unconfined. Groundwater flows along cavities from higher to lower elevations until exiting at springs on North and South Rims.

Other water-bearing zones are present in other formations, but tend to be small and discontinuous due to separation by impermeable formations.

Table 3-20 GRCA Rivers and Perennial Streams

Rivers and Perennial Streams	Gauging Station Location*	Mean Annual Discharge/Range of Discharge (cfs**)	Period of Record
Colorado River	Lees Ferry, AZ	14,947 3,325 – 28,240	1922 - 2006
	Above Little Colorado River near Desert View, AZ	14,031 11,290 – 19,330	1990 – 2001
	Near Grand Canyon, AZ	15,346 3,756 – 28,590	1923 – 2006
	Above Diamond Creek near Peach Spring, AZ	14,183 12,190 – 20,010	1983 - 2006
Little Colorado River	Near Cameron, AZ	222 14 – 1,127	1948 - 2006
	Above mouth near Desert View, AZ	415 300 – 631	2004 – 2006
Boucher Creek	None	N/A	N/A
Bright Angel Creek	Near Grand Canyon, AZ	35.0 14.9 – 89.3	1924 - 1973
Clear Creek	None	N/A	N/A
Crystal Creek	None	N/A	N/A
Deer Creek	None	N/A	N/A
Garden Creek	None	N/A	N/A
Grapevine Creek	None	N/A	N/A
Hance Creek	None	N/A	N/A
Havasu Creek	Above mouth near Supai, AZ	74 70 - 89	1991 - 2006
Hermit Creek	None	N/A	N/A
Kanab Creek	Above mouth near Supai, AZ	13 4.32 – 26.4	1991 - 1993
Kwagunt Creek	None	N/A	N/A
Lava Creek	None	N/A	N/A
Nankoweap Creek	None	N/A	N/A
Phantom Creek	None	N/A	N/A
Pipe Creek	None	N/A	N/A
Shinumo Creek	None	N/A	N/A
Stone Creek	None	N/A	N/A
Tapeats Creek	None	N/A	N/A
Unkar Creek	None	N/A	N/A
White Creek	None	N/A	N/A

* USGS 2007
** cfs (cubic feet per second)

3.4.5.4 Water Use — Soils and Watersheds

Water used by GRCA is taken from Roaring Springs, located in Bright Angel Canyon below North Rim. Water is piped to facilities on North Rim and gravity fed to Phantom Ranch and other facilities near the

Colorado River. The remainder is then pumped across the river, up to Indian Garden, and then South Rim facilities (GRCA, 1984).

Groundwater is not currently used by GRCA. However, lack of surface water results in ground-water being heavily used as municipal, private, and agricultural water sources outside GRCA, particularly to the south. There is some concern by GRCA scientists and others that groundwater has potential of being overused and may affect GRCA spring flow (BOR 2002).

3.4.5.5 Public Water Supplies — Soils and Watersheds

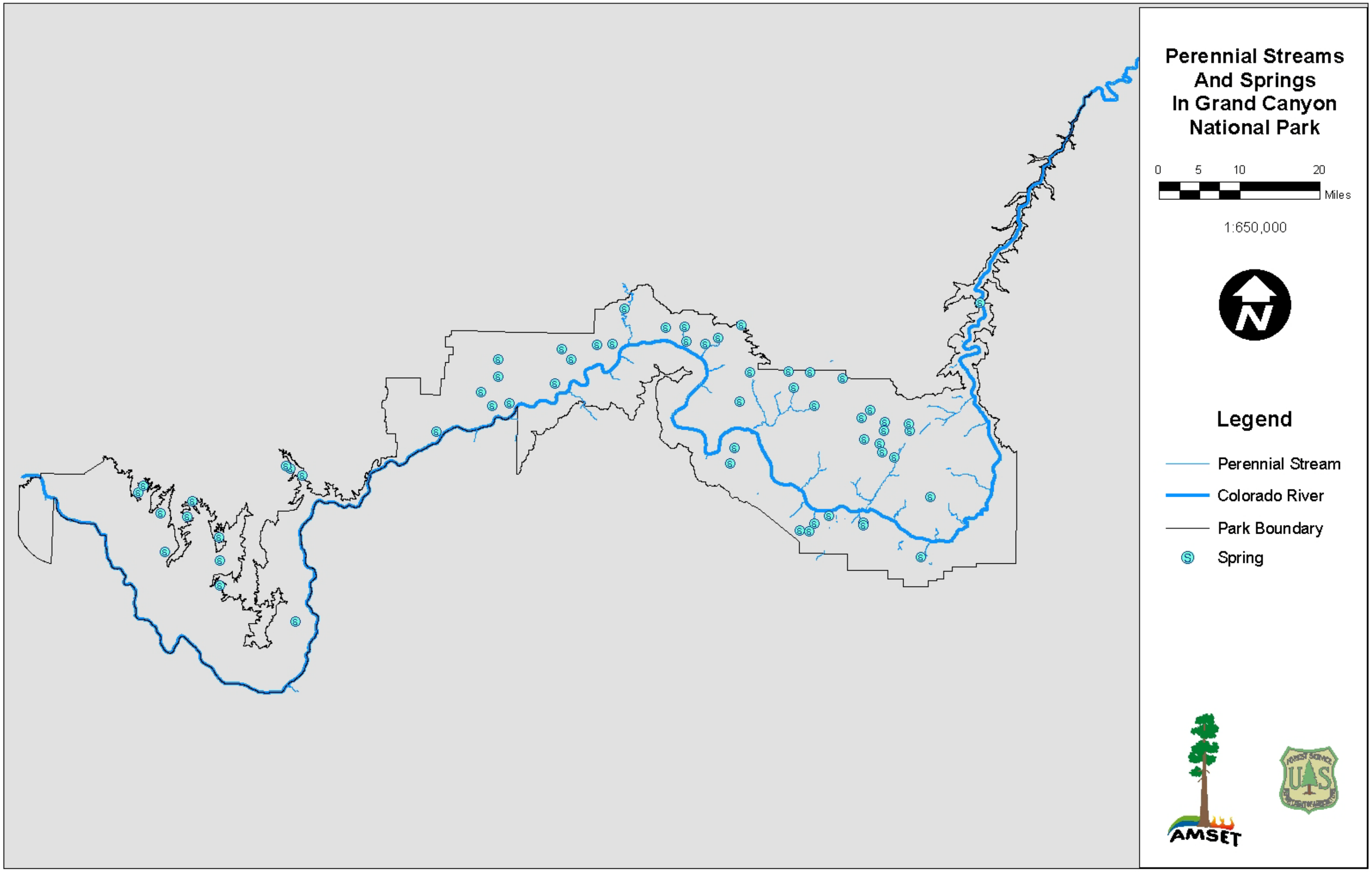
As of 2002, GRCA water use had increased to greater than 194 million gallons or 596 acre-feet per year (BOR, 2002). The NPS anticipates a continuing increase in water demand. Since 1928, water diverted from Roaring Springs, 3,000 feet below North Rim in Bright Angel Canyon, has been used for domestic and irrigation purposes at both North and South Rims (GRCA, 1984). Currently, the pipe carrying the flow is aging and subject to frequent failures. Several alternatives are being discussed, but a final decision has not been made.

Other water sources are limited, and there is concern that increased use of spring water or groundwater from wells, both in and outside GRCA, may affect GRCA springs (BLM, 2002).

Table 3-21 Partial List of Major GRCA Intermittent Streams

Major Intermittent Streams	Gauging Station Location*	Mean Annual Discharge/Range of Discharge (cfs**)	Period of Record
Dragon Creek	None	N/A	N/A
Slate Creek	None	N/A	N/A
Tuna Creek	None	N/A	N/A
House Rock Wash	None	N/A	N/A
North Canyon Wash	None	N/A	N/A
South Canyon	None	N/A	N/A
Sheep Spring Wash	None	N/A	N/A
Tatahasto Wash	None	N/A	N/A
Lee Canyon	None	N/A	N/A
Pasture Wash	None	N/A	N/A
Jump Up Canyon	None	N/A	N/A
Mohawk Canyon	None	N/A	N/A
Prospect Creek	None	N/A	N/A
Parashant Wash	None	N/A	N/A
Surprise Canyon	None	N/A	N/A
Diamond Creek	Near Peach Springs, AZ	4.9 2.9 – 10.9	1993 - 2006
Spencer Canyon	Near Peach Springs, AZ	6.3 1.1 – 28.4	1998 - 2006

* USGS 2007
** cfs (cubic feet per second)



Map 3-2 **Perennial Streams and Springs**

3.5 Soundscape

Natural sounds are intrinsic elements of the environment often associated with parks and park purposes. They are inherent components of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act. They are vital to the natural functioning of many parks and may be valuable indicators of ecosystem health.

The term *natural soundscape* is considered synonymous with the terms *natural ambient sound levels*, *natural ambient*, and *natural quiet*, although natural soundscape or natural ambient is more appropriate because nature is often not quiet (e.g., thunderstorms, river rapids, elk bugling, etc.). The natural soundscape is an important park resource specifically identified as requiring protection in the following legal and public documents

- 1975 Grand Canyon National Park Enlargement Act (Public Law 93-620)
- 1987 National Parks Overflights Act (Public Law 100-91)
- 1995 Grand Canyon National Park General Management Plan
- National Parks Air Tour Management Act of 2000 (Public Law 106-181)

A 1995 GMP management objective is to "protect the natural quiet and solitude of the park, and mitigate or eliminate effects of activities causing excessive or unnecessary noise in, over, or adjacent to the park."

In this context, *noise* is considered *unnatural sounds* (NPS Management Policies 2006); however, in many situations, noise is often defined as *unwanted sounds.* Whether a sound is natural or unnatural can usually be objectively determined, whereas *unwanted* is based on an individual's perception of sound as either wanted or unwanted, pleasant or unpleasant, which is the result of a complex series of factors, including but not limited to timing, location, context, duration, intensity, group size, the individual's physiology (hearing ability), and psychology (an individual's background and feelings toward various sound sources). For instance, noise would likely be tolerated more in Grand Canyon Village than in a remote backcountry setting. Also, "wilderness hikers may tolerate the noise of a helicopter flying a fire suppression operation more than they would aircraft noise that was thought to be less 'necessary'" (Gramann 1999).

3.5.1 Existing Soundscape Soundscape

Characterizing the natural soundscape is a complex task because natural ambient sound levels vary greatly over time and location throughout the park, depending on factors such as season, weather, vegetation type, terrain, wildlife, and proximity to running water. Natural ambient sounds along the rims where most fire management activities occur include sounds from wind through vegetation, wildlife, and intense thunderstorms (especially during monsoon season). Natural ambient winter sounds can be reduced due to muffling effects of snow cover and vegetation or amplified due to lack of snow or reduced vegetative cover. Natural ambient sounds in the canyon are sporadically influenced and locally dominated by running water from river rapids, waterfalls, streams, and springs. Canyon areas far from running water tend to have sparse desert vegetation and very low natural ambient sound levels.

Soundscape sensitivity is less in developed rim areas as compared to other park areas, consistent with park management zoning. The vast majority of park visitors limit their time to developed rim areas, especially South Rim. Human sounds include voices, personal and commercial vehicles, music, construction, maintenance activities, rescue operations, and aircraft overflights. Human-caused noise is typically far greater on South Rim (greatest visitation) and generally dissipates with distance from population centers such as Grand Canyon Village.

Unnatural sound levels caused by park recreational activities are usually temporary and random. Aircraft overflights are a significant noise source in many park areas year-round. The backcountry soundscape is more sensitive to such noise because it is more removed from human activity and generally has low natural ambient sound levels (see Table 3-22). Backcountry human sounds are commonly concentrated along established trails and campsites, and are usually low due to the low intensity of human backcountry activities (e.g., mechanized equipment is not allowed in most remote park areas). However, sound associated with fire management activities can be an exception, because it occurs wherever fire occurs. In the case of fire, use of mechanized equipment, vehicles, aircraft, and tools (such as chainsaws) must be consistent with the proposed Fire Management Plan, and a minimum requirement analysis must be prepared for such use in areas proposed for wilderness designation. Aircraft overflights typically represent the greatest backcountry noise intrusion.

Table 3-22 Average Natural Ambient Sound Levels by Park Vegetation Type

Vegetation Type	Percentage of Park in Vegetation Type	Average Daytime (0700-1900) Natural Ambient Sound (dbA) (Lnat)	Average Daily (0000-2400) Ambient Sound Level (dbA) (L90)
Piñon-Juniper	32.9	20.7	18.0
Warm Desert Scrub*	18.0	18.4	17.2
Cold Desert Scrub*	37.5	18.5	16.8
Ponderosa Pine	7.9	29.1	20.6

Source: NPS 2006b
*Warm and Cold Desert Scrub refer to vegetation consistent with Inner Canyon FMU vegetation.

Existing ambient sound varies daily, seasonally, hourly, and even minute-to-minute in all park areas. The soundscape is generally more sensitive to noise intrusions at times of lower human activity such as sunrise, sunset, night, and winter. During low recreational use seasons (winter, early spring or fall), existing ambient noise levels are typically lower, depending on visitor use and other factors that influence ambient sound level. Existing recreational noise levels are typically higher during daylight due to increased human activity and available recreational opportunities. Noise from aircraft and fire management operations is also typically greatest during daylight. In backcountry areas, high altitude commercial jet aircraft are often the dominant source of human noise, especially at night when other potential noise sources are absent.

Extensive park noise measurements have been gathered, and an ongoing effort measures sounds in many park areas. The decibel (dB) is a standard unit of sound measurement. Sound measurements are often weighted for human sensitivity in particular frequencies (i.e., A-weighted decibels expressed as dbA). Typical existing ambient levels in Grand Canyon Village are in the 50 to 60 dbA range (NPS 1995a). As a point of reference, a typical conversation between two people is about 60 dbA while busy street traffic is about 70 dbA (NPS 1995a).

A close representation of the natural soundscape (natural quiet) is the measured natural ambient sound condition that includes all natural sounds in a given area, excluding all mechanical, electrical and other human-caused sounds. Natural ambient data show that Grand Canyon is generally a very quiet place (NPS 1995a) with sound levels commonly in the range of 20 dbA.

For comparison purposes, dbA values of commonly experienced sounds (ADOT 2005) are

- 20 dbA whispering at five feet
- 50 dbA dishwasher in the next room
- 60 dbA normal conversation at three feet
- 80 dbA garbage disposal at three feet
- 100 dbA gas lawn mower at three feet

3.5.2 Noise Sources in Park Soundscapes — Soundscapes

Noise sources associated with fire management activities are described in detailed in Chapter 4. They include aircraft, manual tools such as chainsaws, pumps, vehicles including fire engines and all-terrain vehicles, and mechanical thinning machinery. Following are park noise sources not normally related to fire management activities.

3.5.2.1 Aircraft Noise Noise Sources in Park Soundscapes Soundscapes

Aircraft noise is a major park concern regarding impacts on natural quiet and visitor experience. As a consequence, several studies and/or regulations have occurred regarding noise associated with park aircraft overflights (e.g., FAA 2000, 2001; HMMH 1993, 2003). Park aircraft noise originates from overflights of high altitude commercial and military aircraft, general aviation aircraft, commercial air tour aircraft, helicopters associated with the Hualapai Indian Tribe adjacent to the Colorado River, and park administrative aircraft use. Park administrative flights include primarily helicopter use for such management activities as search and rescue, maintenance, visitor and resource protection, resource management, research, and fire management. Fixed-wing aircraft are also sometimes used for park administrative purposes. Recent regulations (e.g., FAA 1997, 2000) have resulted in establishment of flight-free zones, defined air tour corridors, commercial air tour curfews, and other regulations on use of airspace over Grand Canyon National Park. Currently, all fire management activities in the park average about 150 hours of helicopter flight time annually. In the event the park experiences a large suppression fire (usually greater than 500 acres), hours of flight time could increase substantially (greater than 60 additional hours) depending on resources availability, values at risk, and location.

In 1992, Harris Miller Miller and Hansen, Inc. quantified noise levels and audibility of observed air tour and air tour-related aircraft noise events in Grand Canyon (HMMH 1993). Aircraft were audible as much as 79% of the time at Hermit Basin, and 76% of the time at Point Sublime. Both of these locations are adjacent to or under the Dragon commercial air tour corridor and a General Aviation corridor.

All sound levels associated with aircraft are classified as *loud* in terms of human judgment, and can be considered major intrusions in the park's natural soundscape. A 1992 survey of 536 GRCA visitors found that 34% of those surveyed reported hearing aircraft during their park stay; 5% of those surveyed reported annoyance from aircraft noise; 5% stated the noise interfered with their enjoyment of the park; and 10% of people surveyed stated that aircraft noise interfered with the park's natural quiet (NPS 1995a). Interestingly, more fall respondents reported negative experiences associated with aircraft noise than did summer respondents. A study involving GRCA and two other national parks found that, in terms of psychological perception of aircraft noise, if "aircraft sound levels are no more than about 10 to 15 decibels higher than natural levels, and are audible less than about 30% of the time, fewer than one-quarter of visitors are likely to feel annoyed by the noise" (Miller 1999). Conversely, human noise can have negative impacts on wildlife even at relatively low sound levels, especially nesting birds or certain big-game species. This is discussed in more detail in the wildlife section.

3.5.2.2 Motor Vehicle Noise Noise Sources in Park Soundscapes Soundscapes

In park developed areas, motor vehicles such as buses, trucks, construction machinery, and automobiles are often the primary noise source. Motor vehicle noise can include sound from engines running, tires, doors opening and closing, backup safety beeps, and brakes. Trains and associated whistles or bells are also a noise source in South Rim's Grand Canyon Village. During high-use seasons and in popular locations, vehicle noise can be almost constant in some more congested park developed areas. Sirens from emergency vehicles can also sometimes be heard.

Some dirt roads are designated open to motor vehicles in the park's backcountry. While vehicle noise can be heard along these roads, it is usually sporadic, random, and at low levels.

3.5.2.3 Other Developed Area Noise Noise Sources in Park Soundscapes Soundscapes

Other noise sources in the park's developed areas include air conditioners, sounds from visitor voices and walking, and industrial sounds from concession operations and maintenance.

3.6 Wilderness Character

3.6.1 History of GRCA Wilderness Recommendation Wilderness Character

Approximately 94% (1,139,077 acres) of Grand Canyon National Park has been recommended for inclusion in the National Wilderness Preservation System. The Wilderness Act of 1964 required the Secretaries of Agriculture and Interior to evaluate land under their jurisdiction for possible wilderness classification. The Grand Canyon National Park Enlargement Act of January 3, 1975, as amended by the Act of June 10, 1975, required the Secretary of the Interior to prepare a wilderness recommendation. In 1970, GRCA released a Preliminary Wilderness Study for Grand Canyon National Park, Marble Canyon National Monument, and Grand Canyon National Monument. This was followed in 1973 by a FEIS for the Proposed Wilderness Classification, which recommended a wilderness area totaling 512,870 acres. In 1975, the Grand Canyon National Park Enlargement Act required submission of a wilderness recommendation reflecting an enlarged Grand Canyon National Park. This resulted in a revised wilderness recommendation issued in 1980 that identified 980,088 acres as recommended for immediate designation and 131,814 acres recommended for potential wilderness designation (NPS 1993). The revised recommendation was superseded in 1993 by the Final Wilderness Recommendation.

Grand Canyon's 1995 GMP addressed wilderness management and provided for development of a wilderness management plan. The GMP directed the fire management plan be revised consistent with wilderness policy and management objectives set forth in the GMP. A Draft Wilderness Management Plan was prepared in 1998 but not finalized. Following completion of this FMP, the NPS will begin the processes of updating the Backcountry Management Plan; both the proposed FMP and Backcountry Management Plan will be in compliance with GMP and NPS wilderness policy.

History of GRCA Wilderness Recommendation Wilderness Character
GRCA Final Wilderness Recommendation

GRCA's Final Wilderness Recommendation (NPS 1993) includes 1,109,257 acres proposed wilderness and 29,490 acres potential wilderness in the park's congressionally authorized boundary (as stated in the Grand Canyon National Park Enlargement Act of 1975, as amended). The authorized boundary encompasses 1,218,375 acres. Of this, 1,188,885 acres are owned by the U.S. Government and managed by the NPS as Grand Canyon National Park. The potential wilderness areas include the Colorado River corridor and various private and Navajo Nation in-holdings. Table 3-23 provides a breakdown of proposed and potential wilderness areas identified in the Grand Canyon National Park, Final Wilderness Recommendation, 1993 Update.

Approximately 79,298 acres have not been recommended for any wilderness status. Excluded areas include North and South Rim developed areas , major road corridors (600-feet wide), specified unpaved road corridors (300-feet wide), the Cross-Canyon Corridor (Bright Angel, South Kaibab, and North Kaibab Trails and associated development), and specific sites in proposed wilderness areas (incorporated into paragraphs below).

GRCA Final Wilderness Recommendation Wilderness Character
Grand Wash Cliffs Area

This area consists of the Grand Wash Cliffs escarpment on the Colorado River's southern side in extreme western Grand Canyon. The Grand Wash Area is bounded on the north by Lake Mead, and on the west, south, and east by the park boundary. The entire area, approximately 23,078 acres, is proposed for immediate wilderness designation.

GRCA Final Wilderness Recommendation **Wilderness Character**
Western Park Area

The Western Park Area encompasses most of the park, both inner canyon and rim lands, west of South Rim's developed area, and the North Rim area west of Highway 67. Approximately 857,471 acres in the area are proposed for immediate wilderness designation. Land excluded from the wilderness recommendation includes several minor road corridors that provide access to trailheads and overlooks, Tuweep ranger station and campground, Pasture Wash Ranger Station and South Bass Trailhead, the Kanabownits Fire Tower and cabin, a sanitary landfill on North Rim, and 7,447 acres in the Great Thumb area that allow mechanized access to Havasupai Reservation lands and a trailhead.

Table 3-23 GRCA Proposed Wilderness Acreage

Area	Proposed Wilderness (acres)	Potential Wilderness (acres)	Total
GRCA Wilderness Unit			
Grand Wash Cliffs	23,078	-	23,078
Western Park	857,471	-	857,471
Eastern Park	228,708	-	228,708
Colorado River Corridor	-	12,190	12,190
GRCA In-holdings			
Curtis Lee Tracts (Private)	-	67	67
Hearst Properties (Private)	-	326	326
Navajo Properties (Navajo Nation)	-	17,237	17,237
Total	**1,109,257**	**29,820**	**1,139,077**

NPS 1993

GRCA Final Wilderness Recommendation **Wilderness Character**
Eastern Park Area

This area includes Marble Canyon, North Rim east of Highway 67, Inner Canyon east of the Cross-Canyon Corridor, Palisades of the Desert, and adjacent South Rim lands. Approximately 228,708 acres in the area are proposed for immediate wilderness designation. Land excluded from the wilderness recommendation includes overlooks at Point Imperial and Cape Royal, and roads that lead to them.

GRCA Final Wilderness Recommendation **Wilderness Character**
Colorado River Corridor

The state of Arizona holds ownership rights to the Colorado River's bed, but approximately 330 acres along the riverbanks are owned by the U.S. Government and managed by the NPS. These 12,190 acres are proposed as potential wilderness rather than proposed for immediate designation because established motorized river boat use is a non-conforming use.

GRCA Final Wilderness Recommendation **Wilderness Character**
Grand Canyon In-Holdings

The Curtis Lee Tracts (private), the Hearst Properties (private), and the Navajo Properties (Navajo Nation) in-holdings are not proposed wilderness areas. These in-holdings (a total of 17,630 acres) are considered potential wilderness. These in-holdings would become eligible for wilderness only if they come under NPS ownership.

GRCA Final Wilderness Recommendation **Wilderness Character**
Accessibility

Approximately 58 miles of primitive roads in 300-foot-wide, non-wilderness corridors are open to mechanized travel and provide access to trailheads and scenic overlooks (NPS 1998b). All other unpaved roads or trails are not open to motorized vehicles or bicycles. Exceptions (e.g., for fire management) are governed by the minimum requirement decision process (see Appendix A). GRCA also has over 500 miles of established trails; approximately 93% of trail mileage is in proposed wilderness (NPS 1998b).

3.6.2 Law and Policy **Wilderness Character**

Section 4 of the Wilderness Act describes authorized uses of wilderness areas. Subsection 4(a) declares, with specific legislative references, that the Wilderness Act shall be supplemental to the purposes, for which the national forests, parks, and refuges have been established. Subsection 4(b) states in part, "Except as otherwise provided in this Act, each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character." Thus, except for specified provisions in the legislation, wilderness areas shall be devoted to recreational, scenic, scientific, educational, conservation, and historical uses. Subsection 4(c) prohibits certain uses (unless specifically provided elsewhere in the Act) that are inconsistent with wilderness preservation. With the exception of the minimum actions needed for administrative duties and emergency health and safety procedures, the Act prohibits temporary roads, motor vehicle use, motorized equipment or motorboats, landing of aircraft, mechanical transport, structures, and installations. Section 4 also addresses special provisions for certain wilderness uses. Subsection 4(d)(1) states in part: "Within wilderness areas designated by this Act the use of aircraft or motorboats, where these uses have already become established, may be permitted to continue…" These uses are subject to such restrictions as the administering federal official deems desirable. Subsection 4(d)(5) permits the performance of commercial services within wilderness "to the extent necessary for activities which are proper for realizing the recreational or other wilderness purposes of this act."

Proposed wilderness is land suitable for immediate wilderness designation. Potential wilderness is land that exhibits wilderness characteristics but may also contain non-conforming characteristics such as structures, roads, in-holdings, or mining claims. If and when the non-conforming issues are resolved, potential wilderness areas may then qualify as suitable for wilderness designation. As stated in NPS Reference Manual 41, Wilderness Preservation and Management, proposed wilderness and potential wilderness are to be managed in the same manner as designated wilderness. Wilderness is defined as including "the categories of suitable, study, proposed, recommended, and designated wilderness. Potential wilderness may be a subset of any of these five categories."

3.6.3 Defining Wilderness Character **Wilderness Character**

According to the Grand Canyon National Park's General Management Plan, areas proposed for wilderness offer visitors opportunities for solitude and primitive recreation. An important provision in the GMP states: "The management of these areas should preserve the wilderness values and character. Non-wilderness undeveloped areas should continue to serve primarily as primitive thresholds to wilderness."

Subsection 2(c) of the Wilderness Act defines wilderness as, "A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."
The same subsection 2(c) further defines wilderness as having the following characteristics.

- Undeveloped land retaining its primeval character in influence without permanent improvements or human habitation
- Generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable
- Has outstanding opportunities for solitude or a primitive and unconfined type of recreation
- May contain ecological, geological, scientific, educational, scenic, or historical value

This FEIS/AEF adopts the definitions and concepts developed through an interagency process to establish a framework for monitoring conditions related to wilderness character (Landres et al 2005). All wilderness areas, regardless of size, location, or any other feature, are unified by the statutory definition. These four qualities of wilderness are

- *Untrammeled* Wilderness is essentially unhindered and free from modern human control or manipulation. This quality pertains to actions that manipulate or control ecological systems
- *Natural* Wilderness ecological systems are substantially free from the effects of modern civilization. In the context of fire management activities, this quality pertains to the intended and unintended human-caused effects on natural and cultural resources conditions
- *Undeveloped* Wilderness is essentially without permanent improvements or modern human occupation. This quality pertains to the presence and development level of park trails, campsites and structures and facilities
- *Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation* Wilderness provides outstanding opportunities for people to experience solitude or primitive and unconfined recreation, including the values of inspiration and physical and mental challenge. This quality pertains to visitor opportunities to experience a primitive setting that may include solitude and adventure

3.7 Social Environment

3.7.1 Visitor Experience Social Environment

Visitors come to Grand Canyon, a World Heritage Site, from all over the world and experience the park in many different ways. According to the 1995 GMP, the first purpose for establishing and managing Grand Canyon National Park is to "preserve and protect its natural and cultural resources and ecological processes, as well as its scenic, aesthetic, and scientific values." The second purpose is to provide "opportunities for visitors to experience and understand the environmental interrelationships, resources, and values of the Grand Canyon without impairing the resources."

3.7.1.1 Visitor Experience Social Environment Visitor Use

Visitor use information, including statistics cited below, is available online at http://www.nps.gov/grca/park mgmt/statistics.htm. For the last decade, park visitation has been between 4.3 and 4.9 million annually. Approximately 40 percent of park visitors are from over 110 non-U.S. countries. During 2004, 3.75 million tourists visited South Rim; 307,000 visited North Rim; 8,066 visited the Tuweep area; in 2003, 22,500 rafted the Colorado River. In addition, air-tour operators estimate 642,000 tourists fly over Grand Canyon yearly. Visitation is heaviest March through September.

Acceptance of wildland fire as an ecosystem management tool has been the subject of many surveys. Abrams and Lowe (2005) summarized results for 13 surveys in the southwestern U.S. (Arizona, Colorado, New Mexico, and Utah) and stated that a majority (about 70 to 80%) of Southwesterners are aware of fire's role in forest ecosystems. 13.9% of Grand Canyon visitors come from the Southwest. Another 18.3% are from other western states (California, Idaho, Montana, Nevada, Oregon, Washington, and Wyoming) where there may be a similar familiarity with fire and smoke management (Cothran et. al. 2005). Different forest management strategies received varying degrees of public support. In general, less than 10% of

Southwesterners oppose mechanical thinning, and less than 15% oppose prescribed burning. However, there is disagreement on wildland fire-use, with about 40% approving and 47% not approving of allowing wildfires to burn "if no lives are threatened." Most Southwesterns (82-83%) felt smoke made breathing difficult, but half to three-quarters felt it an acceptable by-product of using fire as a management tool. Results for people from other areas not available.

Smoke was somewhat more acceptable to Southwestern wildland-urban interface residents than others (Abrams and Lowe, 2005). A summer 2001 GRCA survey found one-third of all South Rim Visitor Center visitors felt "all fires should be prevented" in national parks if possible (Muleady-Mecham 2004). During one survey (Cothran et. al., 2005), a prescribed fire was converted to suppression after jumping control lines. Very few survey respondents mentioned the fire in open-ended comments. Four merely noted it affected their visit, five had negative comments about air quality (difficulty breathing and poor visibility), and three proposed commercial timber harvest rather than burning (Hellmich-Bryan 2005).

Visitors engage in a wide variety of activities including sightseeing at view points, day hiking below the rim, overnight backpacking, bicycling along paved rim roads, riding mules into the canyon, rafting the Colorado River, and participating in commercial air tours. The majority of visitors arrive in cars, although more than 12% arrive on commercial buses, and approximately 5% come by train from Williams, Arizona.

Statistics for 2007 indicate the South Rim Shuttle System provided almost 4.8 million rides (a passenger who exits at a rim viewpoint and later reboards the shuttle counts as two rides). The backcountry office issued more than 11,067 backcountry permits for 87,100 user nights, with 48,648 user nights in campgrounds along the Cross-Canyon Corridor, and 38,452 user nights in other backcountry locations. Hiking and backpacking occur along 33 miles of maintained trails, approximately 470 miles of unmaintained trails, and numerous backcountry routes. Concession-operated mule trips from South Rim served 5,241 visitors on a day-long ride to Plateau Point, and 2,998 passengers on an overnight Phantom Ranch ride between approximately January and October 2007. Another approximate 7,000 visitors ride mules on North Rim each year. Statistics are not collected for day hiking; however, a 2005 study estimated 1,500 people daily take backcountry day hikes during peak use periods (Backlund 2006). Overnight visitors staying above the rim have a choice of 1,110 lodging units (907 on South Rim, 203 on North Rim), 80 recreational vehicle parking stalls, and 464 campsites (316 family, 7 group and 3 hiker/biker) at Mather Campground near Grand Canyon Village; 50 campsites at Desert View Campground; 83 family and 4 group sites on North Rim; and 10 family and 1 group site at Tuweep).

Although GRCA covers 1.2 million acres (over 1,900 square miles), most visitation is concentrated in a few developed areas and along paved roads leading to scenic overlooks. For many visitors, the primary means of experiencing the park is to drive Arizona Highway 64 along South Rim with occasional stops at rim overlooks and Grand Canyon Village. A paved road from Grand Canyon Village west to Hermits Rest is open to private vehicles in winter, but only accessible by foot, bicycle, or shuttle bus the rest of the year. Existing roads to Cape Solitude and along the park boundary to Pasture Wash are closed to private vehicles, but are occasionally used by hikers and backpackers seeking a more remote experience. Backpackers using the South Bass Trail generally access the trailhead on dirt roads that leave the park and travel through the Kaibab National Forest and Havasupai Indian Reservation.

On North Rim, most visitation occurs at the developed area near Bright Angel Point and along 23 miles of paved roads leading to overlooks at Point Imperial and Cape Royal. The Point Sublime overlook, North Bass trailhead, and other remote areas are accessed by primitive non-wilderness road corridors. Approximately 30 miles of primitive roads in proposed wilderness are closed to motorized and mechanized access, although backcountry users hike these areas. North Rim forested areas comprise approximately 80,000 acres of GRCA proposed wilderness. Similar to other backcountry areas, overnight use is permitted. In 2001, over 1,100 people had permits to camp in remote North Rim areas, including Walhalla Plateau and Swamp Ridge use areas. Other backcountry users access Inner Canyon backcountry areas by the Swamp Ridge Road and other USFS primitive roads.

3.8 Socioeconomics

Tourism is one industry widely considered to drive Arizona's economy. Northern Arizona's tourism industry is largely dependent on GRCA and other national parks, recreation areas, monuments, and forests. GRCA receives more than four million visitors annually that support park economic interests and surrounding communities. Fire and fire-management activities have potential to impact economic interests by dissuading visitors through park closures, access restrictions, or visibility loss from smoke.

The numbers below, attributed to the Arizona Department of Commerce (ADOC), may appear out-of-date. GRCA decided to retain these numbers as they were used in the analysis. Up-to-date figures can be found at: http://www. azcommerce.com.

3.8.1 In Grand Canyon National Park Socioeconomics

Grand Canyon National Park has developed a wide variety of tourist accommodations in the park.

3.8.1.1 In Grand Canyon National Park Socioeconomics Residents

Some NPS staff, concession employees, and their families reside in the park. South Rim developed areas (Grand Canyon Village and Desert View) are open and staffed year-round. North Rim's developed area is open and staffed mid-May through October with only a caretaker staff during the rest of the year. NPS personnel also live in park areas near ranger stations, and some live in surrounding communities.

According to the 2000 U.S. Census, Grand Canyon Village population totaled 1,509. Table 3-24 identifies number of employees by industry in the village.

3.8.1.2 In Grand Canyon National Park Socioeconomics Economics

Visitors may pay several types of fees for GRCA use, including entrance fees, and permit fees for campgrounds, backcountry camping, and river rafting. Demand for some permits exceeds use limits established for certain park areas. For example, GRCA received approximately three times the number of requests for backcountry permits in 2000 as were available, and applicants for a private river trip permit may have to wait up to 20 years (NPS 2005a). Use limits are based on visitor experience desired quality, and number of campground spaces, river-trip boat launches, and other park use characteristics.

Tourism-related jobs provide the major employment opportunities; however, employment industries are not all tourism based. Non-tourism industries support year-round residents and park facilities.

Visitation is generally concentrated in the park's developed areas. These areas provide lodging, food services, gift shops, campgrounds, laundries, lodges, an RV Park, general stores, service stations, a medical clinic, and a shuttle bus system. Xanterra Parks and Resorts is currently contracted by the NPS to provide most of these services in addition to mule rides, bus tours, and other services, and runs most facilities except bookstores, medical facilities, and campgrounds. Other park concessioners include river outfitters that operate rafting trips on the Colorado River, and a few small miscellaneous operations. Xanterra grosses an average of $70 million annually. In 2002, 22 concessioners grossed approximately $118.8 million and paid franchise and other fees of approximately $6.9 million (NPS 2005a).

Six lodges occupy South Rim and one on North Rim. North Rim's Grand Canyon Lodge is only open during North Rim's open season, mid-May to mid-October. Dormitories and cabins at Phantom Ranch in the Inner Canyon are available for lodging year-round. The GRCA website suggests Kaibab Lodge and Jacob Lake Inn as potential lodging outside the park near North Rim. Communities of Tusayan, Valle, Williams, and Flagstaff offer potential lodging areas outside the park on GRCA's south side.

Both Grand Canyon Village and North Rim accommodations are located in developed areas, where the majority of people visit, and in close proximity to the Cross-Canyon Corridor hiking trail. Grand Canyon Village is accessible from Flagstaff and Williams to the south and Cameron to the east by Arizona Highway 64. North Rim is located at the end of Arizona Highway 67. These routes offer visitors easy access to the park's developed areas. Numerous unmaintained roads access other park areas. Considering the park's size, access roads are few.

Table 3-24 Employees By Industry, Grand Canyon Village

Employment by Industry	Number Employed
Agriculture, Forestry, Fishing, and Hunting	7
Mining	0
Construction	44
Manufacturing	7
Wholesale Trade	2
Retail Trade	97
Transportation, Warehousing, and Utilities	43
Information	4
Finance	5
Professional, Scientific, Management, Administration, and Waste Management Services	30
Education, Health, and Social Services	92
Arts, Entertainment, and Recreation	188
Accommodation and Food Services	454
Other Services (except Public Administration)	26
Public Administration	77
U.S. Census Bureau 2004	

GRCA participates in the Fee Demonstration Program which allows the park to keep 80% of revenue from most fees charged, including entrance fees, backcountry/river permit fees, and commercial tour fees, to be used for in-park projects. The remaining 20% of fee money supports NPS projects in other park service areas.

3.8.1.3 In Grand Canyon National Park Socioeconomics Park Closures

Concessioners, the NPS, and adjacent gateway communities lose revenue when park areas, access roads, or trails are closed. Park closures are rare, while road and trail closures occur more often.

Since 2000, several fire suppression and planned activities in the park closed, restricted, or evacuated parts of the park. According to available data, GRCA has imposed visiting restrictions approximately 11 days in four out of five years. On average, either North or South Rim is closed a total of three days a year due to fire-management activities. North and South Rims have never been closed at the same time.

3.8.2 Outside Grand Canyon National Park Socioeconomics

Because northern Arizona and southern Utah have world-famous scenery and attract millions of tourists each year, communities developed businesses to accommodate visitors. Communities based economies on industries such as lodging, restaurants, service stations, and other service-related areas (Heffernon et al. 2000). Businesses are usually located along major roadway corridors used to access park areas.

Approximately 30,000 people live within 50 miles of GRCA. This population is scattered amongst small communities, many with populations less than 1,000 individuals. Most of these communities can be considered gateway communities that provide tourist services. These attractions may not necessarily have an associated town or city (Heffernon et al. 2000). The Grand Canyon can be approached by several routes on North and South Rim. Gateway communities along those routes are considered important in this analysis due to potential effects fire may have on economies or services provided to visitors.

3.8.2.1 Outside Grand Canyon National Park Socioeconomics Larger Surrounding Gateway Communities

Flagstaff, Arizona, located approximately 80 miles south, is the largest community in the GRCA area. Several smaller communities exist closer to the park including Cameron, Fredonia, Page, Peach Springs, Tusayan, and Williams, Arizona, and Kanab, Utah. Although these communities vary in population and income (Table 3-25), employment is generally consistent with tourism-based economies (Table 3-26). Populations vary from approximately 550 to over 53,000 people with median incomes ranging from approximately $18,000 to $47,000.

Cameron is a gateway community located approximately 30 miles east of South Rim's Desert View entrance. According to Census 2000, Cameron's population is 1,030. Construction, retail trade, education, health and social services, and food services have the largest employment. Retail trade, accommodations, and food services are directly related to tourism.

Flagstaff, Arizona (2000 population approximately 53,000), is the region's largest city. Flagstaff is 80 miles southeast of GRCA, and many visitors stop or stay in Flagstaff. The largest employee group in Flagstaff works in education, health, and social services industries (Northern Arizona University); the second and third largest by employee number are the retail trade, and accommodations and food service industries. The latter two relate directly to the Flagstaff tourism market.

Two main highway routes (U.S. 180 and 89) to GRCA pass through Flagstaff and connect to Interstates 40 and 17 in Flagstaff. This intersection gives the city opportunity to provide lodging, food, fuel, services, shopping, and entertainment to area visitors (Heffernon et al. 2000). Flagstaff is also in close to other northern Arizona attractions, including Arizona Snowbowl ski area and various national cultural and natural resource preservation sites. While GRCA is the primary draw, other attractions contribute to Flagstaff's tourism revenue.

According to the Arizona Department of Commerce (ADOC), Flagstaff has 4,679 rooms available for lodging. Based on a cursory overview of motel and hotel availability, Flagstaff has more than 100 hotel/motels, over 100 restaurants, and more than 35 gas/service stations.

In 1997, Flagstaff's retail trade industry recorded $784,611,000 in total sales, shipments, receipts, revenue, or business done; the largest amount of sales throughout all the industries (U.S. Census Bureau 1999). Accommodations and food services ranked fourth with $179,708,000 in the same category (U.S. Census Bureau 2000). The retail trade and accommodations and food services sections account for approximately 34% and 7.9%, respectively, of total sales, shipments, receipts, revenue, or business done in the town.

Table 3-25 Population Estimates (2000) and Median Income (1999) of Larger Gateway Communities, GRCA

Community	2000 Total Population	Median Income (1999)
Cameron	1,030	$24,773
Flagstaff	53,137	$37,146
Fredonia	1,036	$30,288
Page	6,809	$46,935
Peach Spring	786	$18,194
Tusayan	543	$34,917
Williams	2,864	$32,455
Kanab	3,510	$35,125
U.S. Census Bureau 2004		

Fredonia, Arizona, a community of 1,036 (2000), is located along U.S. 89A approximately 80 miles north of the GRCA boundary. Its four largest employers by industry are 1) education, health and social services, 2) retail trade, 3) construction, and 4) accommodation and food services.

Accommodation and food services account for just less than 12% of community employment. According to ADOC, Fredonia has 55 rooms. Based on a cursory overview of motel and hotel availability, Fredonia has three phone-directory listed hotel/motels, three listed restaurants, and two listed gas/service stations.

Page is located northeast of GRCA along U.S. 89. Although Page is a gateway community for GRCA, Page's main attraction is Lake Powell in Glen Canyon National Recreation Area, whose visitors come to boat, fish, and enjoy other water-related recreation. The four industries with the largest employment are: education, health and social services; transportation, warehousing, and utilities; retail trade; and accommodations and food services. According to ADOC, Page has 1,500 rooms and over 30 hotel/motels, over 30 restaurants, and approximately nine gas/service stations.

In 1997, the Page retail trade and accommodations and food service industries recorded the highest and second highest amount of total sales, shipments, receipts, revenue, or business done in the community. Retail trade reported $85,295,000 and accommodations and food services ranked second, with $29,431,000 in the same category (U.S. Census Bureau 1999, 2000). Of the industries surveyed and presented, the retail trade, and accommodations and food services sections account for approximately 64% and 22%, respectively, of total sales, shipments, receipts, revenue, or business done in the community; collectively approximately 86% of the sales economy.

Peach Springs, Arizona, is a small, rural community of 786 people located on historic U.S. 66 and Diamond Creek Road south of GRCA's western portion. Peach Springs is the Hualapai Tribe's headquarters. The three largest sources of employment in Peach Springs are education, health and social services; public administration; and accommodation and food services. Diamond Creek is a major take-out point for river-rafting trips on the Colorado River through Grand Canyon, and most of the Grand Canyon-related traffic through Peach Springs is involved with river running. Peach Springs has two listed (advertised) hotel/motels, a few restaurants, and few gas/service stations.

Tusayan is a gateway community of 543 people immediately south of GRCA's main entrance on Arizona Highway 64. Approximately 66 percent of community employment is in the accommodations and food services industry, catering to GRCA tourists. In 1998 Tusayan had almost 1,200 hotel/motel rooms with associated restaurants and service stations (USFS 1999) additional rooms have been added since then.

Grand Canyon Airport, which is located just south of Tusayan, is the third busiest in Arizona (NPS 1995). The airport supports several air-tour operations including helicopter and fixed-wing GRCA tours.

Williams, located at the intersection of Interstate 40 and Arizona Highway 64, is a South Rim gateway community located 55 miles south with a population of 2,864. Williams' largest industry (accommodation and food services) employs almost the same number as the three next largest industries (education, health and social services; retail trade; and transportation, warehousing, and utilities). According to ADOC, Williams has 1,410 rooms, over 40 hotel/motels, 25 restaurants, and approximately 14 gas/service stations.

In 1997, the retail trade and accommodations and food service industries in Williams recorded the highest and second highest total sales, shipments, receipts, revenue, or business done in the community. Retail trade reported $24,306,000 and accommodations and food services ranked second, with $19,164,000 in the same category (U.S. Census Bureau 1999, 2000). Of the industries surveyed and presented, the retail trade and accommodations and food services sections account for approximately 55% and 43%, respectively, of all the total sales, shipments, receipts, revenue, or business done in the community; collectively approximately 98% of the sales economy.

Kanab, Utah, a town of 3,564 people, is seven miles north of Fredonia, Arizona. Located at the intersection of U.S. 89 and 89A, Kanab is situated among several major attractions in southern Utah and northern Arizona such as Zion National Park (30 miles), Grand Staircase—Escalante National Monument (15 miles), Bryce Canyon National Park (70 miles), Glen Canyon National Recreation Area (70 miles), and GRCA (85 miles). Accommodation and food services ranks third in number employed (11 percent) following education, health and social services (16%) and retail trade (11%). Kanab has 14 lodging establishments and two camping/RV grounds.

3.8.2.2 Outside Grand Canyon National Park Socioeconomics Smaller Gateway Communities

Northern Arizona communities—Jacob Lake, Valle, and Marble Canyon—are not large enough to list separately in the U.S. Census (2000) or by ADOC. Coconino County was unable to provide information regarding these unincorporated communities.

GRCA's 1995 GMP did consider these gateway communities in its analysis, using 1990 Census data. However, the GMP did not make any population or employment growth estimates.

Jacob Lake, which consists of a convenience store, inn, restaurant, gas station and USFS Information Station, is located at the intersection of U.S. 89A and Arizona Highway 67, the road to North Rim. This community serves travelers to North Rim and surrounding public lands.

Valle, an unincorporated community about 30 miles south of GRCA's south entrance, is located at the junction of Arizona Highway 64 and U.S. 180. The community has a restaurant, two gas stations, a motel, a campground, gift shops, an airport, an aviation museum (commercial), a small theme park, and a convenience store.

Marble Canyon is a dispersed, unincorporated community located along U.S. 89A near GRCA's northeastern-most portion. The area serves as a service location for Colorado River rafting trips and angling in the tailwaters of Glen Canyon Dam. Three motels with restaurants and gas stations exist, as well as a small airport.

Table 3-26 Employment by Industry (2000), Larger Gateway Communities

	Cameron	Flagstaff	Fredonia	Page	Peach Springs	Tusayan	Williams	Kanab
Number Employed By Industry	236	29,223	396	3,396	178	362	1,328	1,500
Agriculture, Forestry, Fishing, and Hunting	14	276	15	0	5	15	51	58
Mining	0	50	0	29	0	0	4	7
Construction	72	1,574	57	187	11	0	96	121
Manufacturing	0	1,567	34	83	3	0	75	107
Wholesale Trade	0	448	2	43	0	0	28	20
Retail Trade	53	4,219	64	470	5	13	117	171
Transportation, Warehousing, and Utilities	0	952	20	601	7	37	113	129
Information	0	441	0	41	3	4	35	18
Finance	4	1,210	0	181	12	8	40	59
Professional, Scientific, Management, Admin., and Waste Management Services	7	2,000	15	104	9	5	66	73
Education, Health, and Social Services	38	9,136	70	713	57	15	157	241
Arts, Entertainment, and Recreation	0	751	7	192	4	12	18	50
Accommodation and Food Services	24	3,753	46	490	27	238	383	161
Other Services (except Public Administration)	7	1,053	40	115	2	0	49	160
Public Administration	17	1,793	26	147	33	15	96	125

U.S. Census Bureau 2004

3.9 Park Operations

Park operations refers to adequacy of staffing levels and quality and effectiveness of park infrastructure in protecting and preserving park resources and providing for effective visitor experience. It also refers to level and implications of park staff, budget, and time needed to accomplish proposed activities.

3.9.1 Staffing and Facilities Park Operations

GRCA's Superintendent is ultimately responsible for park management, including all park operations. In 2007 the park employed approximately 500 full-time staff to manage operations including visitor services and facilities, resource management and preservation, emergency medical services, law enforcement, search and rescue operations, fire management, air operations, maintenance, science and research, interpretation and education, public affairs, planning and compliance, and administrative duties. Park divisions primarily concerned with fire management are the Visitor and Resource Protection Division, Science and Resource Management Division, Office of Planning and Compliance, the Public Affairs Office, and the Division of Interpretation (Table 3-27).

Fire management activities have potential to affect park personnel and operations. Current NPS policy, as stated in DO-18, Wildland Fire Management, directs agency administrators to "...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."

Table 3-27 2007 Fire Management Activities and Responsible Park Divisions

Park Division	Fire Management Responsibilities	Staff/FTE*
Visitor and Resource Protection	**Branch of Fire and Aviation Management** Fire Planning and Compliance, Suppression, Wildland Fire Use, Prescribed Fire and Fuels Management, Aviation Management	24.5
Science and Resource Management	Cultural Resource Management, Air Quality, Wildlife, Vegetation, Soils, Water Quality, Wilderness, Visitor Use Management, Research	2-3
Office of Planning and Compliance	Planning and environmental compliance documents	2
Public Affairs Office	Public and stakeholder information, media relations	0.1

* This column indicates staff time associated with fire management activities measured in FTE (fulltime equivalent or 100% time allocated)

3.9.1.1 Fire and Aviation Management Organization and Responsibilities

Chief, Branch of Fire and Aviation (Fire Management Officer)

Current staffing is outlined below; GRCA anticipates staffing will remain similar in the future, but could change through the life of the plan. Program direction and management oversight lies with the Chief, Branch of Fire and Aviation, Division of Visitor and Resource Protection (i.e., Fire Management Officer). This position reports directly to the Division Chief (i.e., Chief Ranger). Duties include

- FMP implementation and overall program responsibility
- Preparedness
  - Fire and aviation facilities and inventory are up to date for both rim operations based on Preparedness and Aviation Operations Plans
  - Training, qualification, and certification policies are followed
  - Agreements are reviewed and maintained
  - Established and maintained procedures ensure preparedness levels respond to wildland fire severity

- Mobilization
  - Detection and dispatch operations according to established Standard Operating Procedures
- Suppression
  - All aspects of the wildland fire suppression function
- Prescribed Fire Planning and Implementation
  - Safe and effective implementation of FMP Prescribed Fire section
  - Implementation of the Long-Term Prescribed Fire Schedule (including coordination with outside-of-Branch entities), documentation, protecting sensitive park values, supervision of projects, budget and fiscal matters, project follow-up activities
- Wildland Fire Use
  - Manages all program aspects involving wildland fire use for resource benefits

The following general staff positions report directly to the Chief, Branch of Fire and Aviation

- Deputy Fire Management Officer
- Aviation Officer
- South Rim District Fire Management Officer
- North Zone Fire Management Officer (Co-supervised with the North Kaibab District Ranger).

Responsibilities, roles, and functions for key staff positions in the Branch of Fire and Aviation are briefly described in the following sections and shown in the organizational chart in Appendix E, Attachment A.

Fire and Aviation Management Organization and Responsibilities Park Operations
Deputy Fire Management Officer

The Deputy Fire Management Officer is responsible for

- Administration and Finance
  - Short- and long-term program and financial planning, along with fiscal responsibility
- Fire Ecology and Effects Monitoring
  - Ensures fire ecology knowledge is gained, trends in fire effects on plant communities are followed through literature review, monitoring program objectives are met through established field data collection techniques, and documentation and analysis of fire effects data are accomplished

The following staff positions report directly to the Deputy Fire Management Officer

- GIS Specialist
- Fire Ecologist
- Communication Center Manager (jointly supervised through an Operating Agreement with the Kaibab National Forest)

Fire and Aviation Management Organization and Responsibilities Park Operations
Fire Business Manager

The Fire Business Manager is responsible for all aspects of Branch administrative functions: budget preparation, purchasing, tracking budgets, maintaining personnel records, reporting requirements, supervising a Fire Program Assistant, and providing general administrative support.

Fire and Aviation Management Organization and Responsibilities Park Operations
Aviation Officer

The Aviation Officer manages the park's aviation program, and is responsible for safe and efficient aviation operations, overseeing aviation contracts, and staying current with aviation policy and procedural changes. The Helicopter Manager reports directly to the Aviation Officer.

Fire and Aviation Management Organization and Responsibilities **Park Operations**
District/Zone Fire Management Officers

North Zone and South Rim Fire Management Officers are responsible for implementing fire management programs in their respective districts/zones. District/Zone fire management personnel report directly to the District/Zone Fire Management Officer.

Fire and Aviation Management Organization and Responsibilities **Park Operations**
Archeologist and Wildlife Biologist

Fire and Aviation Management employs one archeologist and one wildland biologist. These employees coordinate closely with the Science and Resource Management Division to accomplish compliance and mitigation requirements in support of fire projects.

3.9.1.2 Other Visitor and Resource Protection Division Programs **Park Operations**

Other Visitor and Resource Protection Division Programs
Dispatch

Most fire-related communications are coordinated by the joint NPS-USFS Communications Center in Williams. However, most park communications are handled by the park Dispatch Center in Grand Canyon Village. Often the park Dispatch Center will be involved with communications in addition to the Williams Communication Center, especially when coordination of communications with park personnel outside the fire organization is involved.

Other Visitor and Resource Protection Division Programs **Park Operations**
Structural Fire

Although structural fire is not a component of the proposed FMP, there is potential for wildland fire to affect structures, and for structural fire to become wildland fire.

Other Visitor and Resource Protection Division Programs **Park Operations**
Emergency Services

Occasionally fire-related activities may require search-and-rescue or medical assistance from the park's Emergency Services personnel. In addition, if there is a need to evacuate visitors or residents due to a fire, emergency services personnel will be involved in implementing evacuation and public safety plans.

Other Visitor and Resource Protection Division Programs **Park Operations**
Law Enforcement

If there is any possibility that a person may have started a fire either intentionally or accidentally, trained park law enforcement personnel would conduct an investigation. In addition, although fire personnel are responsible for most traffic and visitor safety control during fire management activities, law enforcement personnel may occasionally need to assist. If a vehicle or other property in danger from a fire needs to be moved, or is damaged by fire, law enforcement personnel would handle movement or damage reports.

Other Visitor and Resource Protection Division Programs **Park Operations**
Permits Office

Permits are required for almost all overnight backcountry visitation. When a fire starts in a backcountry area, the permits office may be consulted to learn if visitors are in the area. If automobiles at trailheads may be in danger from a fire, the permits office will provide identity and itinerary information to help locate and remove people and property from danger. If a wildland fire or fire management activity may last for a considerable time in an area, the permits office may need to reschedule visitor trips or change itineraries that may be affected by the fire-related activity.

3.9.1.3 Other Divisions with Fire-Related Responsibilities Park Operations
Science and Resource Management Division

The Science and Resource Management Division (S&RM) is responsible for resource management, research, restoration and rehabilitation of disturbed lands. Most staff have parkwide responsibilities.

In addition to the Fire and Aviation Management wildlife biologist, S&RM wildlife and vegetation staff ensure protection of threatened, endangered, or sensitive species and habitat in consultation with the USFWS. Vegetation and earth science programs guide restoration or rehabilitation of lands disturbed as a result of fire management actions. The Air Quality Manager conducts smoke management and air quality monitoring to ensure compliance with state and Federal air quality standards.

S&RM cultural resource staff have responsibility for tribal consultations on park projects. In addition to the Fire and Aviation Management archeologist, S&RM archaeologists have responsibilities for responding to fire use and suppression activities to ensure impacts of ground-disturbing activities on archeological and other cultural resources are minimized. They have direct involvement in fire activity planning and implementation, conducting surveys and protection measures prior to, during, and following fires to ensure compliance with Sections 106 of NHPA.

The Wilderness Coordinator contributes to planned fire management activities in proposed wilderness. The Wilderness Coordinator offers advice for wilderness values management and compliance with applicable laws and policies.

Other Divisions with Fire-Related Responsibilities Park Operations
Office of Planning and Compliance

Organizationally located in the Superintendent's Office, the park's Office of Planning and Compliance (OPAC) works with other park divisions to develop plans (including the Fire Management Plan), and ensures compliance with applicable laws and policies, including but not limited to NEPA, NHPA (including Section 106 consultation), ESA, and the Wilderness Act. OPAC is responsible for ensuring applicable procedures are followed for planning and implementation, all necessary documentation and consultation is successfully completed, and that any site-specific environmental and/or cultural compliance is completed in a timely manner. OPAC staff members are not usually subject-matter experts on projects, but primarily ensure that applicable processes are followed.

Other Divisions with Fire-Related Responsibilities Park Operations
Public Affairs Office

Also located organizationally in the Superintendent's Office, the Public Affairs Office is responsible for ensuring that information about park plans and management activities is delivered in a timely and effective manner to interested parties such as public, media, stakeholders, other agencies, and Congress. The Public Affairs Office is responsible for disseminating information about fire management activities, for example distributing press releases about prescribed fires and fire suppression activities.

Other Divisions with Fire-Related Responsibilities Park Operations
Facilities

Fire equipment and staff are housed with other emergency services equipment and organizations (e.g., law enforcement, search and rescue) on South and North Rims and Desert View. Fire equipment is also co-located with ranger stations in the Cross-Canyon Corridor and Tuweep.

In addition, aviation staff is responsible for maintaining park helibases and other safe helicopter landing sites that may support fire management activities, in addition to other management activities. The primary helibase is located on South Rim; a summer helibase exists on North Rim.

Most fire management water needs are met by water tanks maintained at South and North Rim helibases.

3.9.1.4 Park Operations Related to Fire Management Park Operations

Fires have occasionally disrupted routine park operations, particularly when developed areas and other values are threatened from unplanned, unwanted wildland fires. Planned fire management activities that meet objectives stated in an approved FMP come with a risk of routine operations disruption.

Strategies proposed include suppression, prescribed fire, wildland fire use, and thinning by manual or mechanical means to protect values at risk (see Chapter 2). Suppression operations are considered park emergencies, and thus disruptions in normal routines often cannot be mitigated during suppression incidents. Evacuation Plans are in place for all park developed areas.

Conversely, prescribed fires and thinning projects are planned events and thus subject to requirements that include pre-planning, coordination with other park functions to prevent disruptions in areas such as traffic, personnel schedules, air operations, interpretive programs, routine maintenance, patrols, and resident routines. Planned fire management activities often involve S&RM staff locating and mitigating effects to sensitive park resources or visitor experience in advance of (sometimes also during) fire management activities. Often OPAC and S&RM staff work with Fire and Aviation personnel to prepare environmental and/or cultural resource compliance documentation prior to fire management activities to minimize impacts on park resources and visitor experience, and ensure compliance with applicable laws, regulations, and policies. When treatment activities are scheduled, fire management staff works with the Public Affairs Office to provide appropriate notice and information to the public, other park staff, and nearby residents. Park rangers may need to provide traffic control or visitor management to maintain safety and keep visitors safe from fire management activities.

Wildland fire use operations also impact park functions. Although they are unplanned events, selected management strategies are based on pre-planned decision charts referenced in the FMP (NPS, 1992a as amended). Often there are arrangements and protocols in place between fire staff and other park functional areas regarding use of personnel for traffic control, public information, and other support tasks. Also, fire managers convene and lead an Interdisciplinary Team as appropriate to facilitate informed decision-making regarding WFU incidents management.

Most prescribed burns and wildland fires take place using limited closures or management restrictions. Emphasis is placed on providing information to visitors to reduce visit impacts and promote public safety. Visitors can use park and other information resources to receive information on fire management activities that might influence their visit. The park's public affairs office and incident fire information personnel distribute information through press releases, special notices, and other communications, as needed to inform other agencies, communities, and individuals of fire management activities. For some fire management activities, visitors are given information at park entrance stations, while signs are used to inform visitors along major thoroughfares, including roads and trails. Staff at park visitor facilities post information on cautions, closures, and restrictions, as needed, and are available to answer questions and provide interpretation regarding fire management activities and their purposes.

3.10 Issue Topics Dismissed from Detailed Analysis

Federal regulations (40 CFR 1500 et seq.) and NPS policy (DO-12) require that certain topics be addressed as part of NEPA analysis. The NPS reviewed the mandatory topics listed below and determined the proposed action has no potential to effect them for the reasons stated. These topics have been dismissed from detailed analysis in this document.

3.10.1 Possible Conflicts between the Proposal and Land Use Plans, Policies, or Controls for the Area Concerned

NEPA regulations at 40 CFR 1502.16 require potential land-use conflicts be addressed if they occur. For the most part, fire management strategies would be implemented in GRCA boundaries and jurisdiction managed according to the GRCA GMP (NPS 1995). The proposed actions are fully consistent with management objectives set forth in that plan. Managing boundary areas where wildland fires could burn out of the park may require consultation with neighboring agencies where existing agreements do not allow fire management across mutual boundaries. Consultation and coordination between agencies would preclude conflicts with other land use plans, policies, or controls.

Under each alternative, GRCA would continue to coordinate and collaborate with neighboring land management agencies and tribes to provide efficiencies for fire management activities across boundaries. These efforts will continue through use of the following programs and agreements.

- Interagency Fire Management Organization on North Rim and North Kaibab
- USFS and NPS Interagency Dispatch Center located in Williams, Arizona, staffed with both U.S. Forest Service and NPS employees
- GRCA support of an Interagency Aviation Program Manager to coordinate all fire-related aviation programs for GRCA and the Kaibab National Forest
- GRCA fire management program interagency prescribed fire burn plans that allow fire managers to implement cross-boundary prescribed fire projects
- Interagency Agreements with the U.S. Forest Service through the Kaibab National Forest for use of resources on GRCA prescribed fire projects
- Interagency Agreements with four local fire departments for use of firefighter resources on GRCA prescribed fire projects
- Membership in the Northern Arizona Area Interagency Board that includes the U.S. Forest Service, Bureau of Indian Affairs, NPS, and State of Arizona and which provides guidance and policy oversight for the GRCA and Flagstaff Zones (groups of northern Arizona fire programs)
- Fire staff membership in interagency, regional, and national incident management teams
- Fire staff representation on a variety of interagency faculties and committees
- Active communication between USFS and NPS during pre-season prescribed fire planning, prescribed fire implementation, pre-season preparedness planning, and resource allocation during peak fire season

Adjacent land issues would be similar for all alternatives with little or no differences. Coordination provides continued communication with adjacent land owners to foster enhanced relationships and partnerships. All tribal government-to-government consultations will be covered under appropriate regulations and policies. Further discussion on tribal interests is included in the cultural environment section of Chapter 4. Fire program effects on the community of Tusayan are covered in Chapter 4, Air Quality and Socioeconomic topics.

Because the FMP would be implemented within GRCA boundaries, proposed actions are fully consistent with approved management objectives, and consultation and coordination between neighboring agencies would preclude conflicts with other land use plans, policies, or controls, this impact topic is dismissed from further analysis.

3.10.2 Research Natural Areas

Research Natural Areas (RNAs) are administratively designated areas identified for their unique natural features that have essentially no past human influence. They are part of a national network of sites designed to facilitate research and preserve natural features, and are usually established as a typical example of an ecological community type, preferably one little disturbed in the past and where natural processes are not unduly impeded. The RNA is set aside permanently and is managed exclusively for approved non-manipulative research, i.e., research that measures but does not alter existing conditions.

NPS Management Policies 2006 (4.3.1; 2006) states

> *Research Natural Areas contain prime examples of natural resources and processes, including significant genetic resources, that have value for long-term observational studies or as control areas for manipulative research taking place outside the parks. Superintendents recommend areas of parks to their regional director, who is authorized to designate them as Research Natural Areas. Superintendents cooperate with other federal land managers in identifying park sites for designation, and in planning research and educational activities for this interagency program. Activities in Research Natural Areas generally will be restricted to non- manipulative research, education, and other activities that will not detract from an area's research values.*

The NPS Organic Act of 1916 and the NPS Omnibus Management Act of 1998 provides authority to establish RNAs. Grand Canyon's RNA are listed in Table 1-5.

The 1995 GMP states that six research natural areas totaling 8,845 acres were officially designated in GRCA in the 1970s, this program has not been active in recent years, and no special management of these areas is occurring. RNAs will be treated as proposed wilderness; possible impacts are analyzed under Vegetation, Soils and Watersheds, and Wilderness Character. Thus RNAs are dismissed as an impact topic. RNAs will be studied and their use analyzed in the planning process for a new Backcountry Management Plan.

3.10.3 Energy Requirements and Conservation Potential

NPS Guiding Principles of Sustainable Design (available online at http://www.nps.gov/dsc/dsgncnstr/gpsd/toc.html) provide a basis for achieving sustainability in facility planning and design, emphasizes biodiversity importance, and encourages responsible decisions. The guidebook articulates guiding principles such as resource conservation and recycling. None of the proposed alternatives would minimize or add to GRCA resource conservation or pollution prevention.

NPS Management Policies 2006 address energy management in section 9.1.7 GRCA Fire Management Program will adhere to all Federal Policies governing energy and water efficiency, renewable resources, use of alternative rules, and Federal fleet goals as established in the Energy Policy Act of 1992.

GRCA will comply with guidelines and policy, including EO's and NPS Director's Orders. The park's Fire Management Program will have less that minor, adverse or beneficial impacts which would effect energy requirements and conservation potential; therefore, this impact topic is dismissed from further analysis.

3.10.4 Urban Quality and Design of the Built Environment

NEPA regulations at 40 CFR 1502.16 require urban quality and design of the built environment be considered if potentially affected. Park developed areas that exhibit municipal design values would be managed under all alternatives as part of the Wildland-Urban Interface Fire Management Unit, and be protected from wildland fire's adverse effects; therefore, this impact topic is dismissed from further analysis.

3.10.5 Environmental Justice

Executive Order 12898 requires Federal agencies to avoid disproportionately high adverse effects on minorities and low-income populations. While such populations do reside in areas that could receive smoke from park fires, it is not anticipated that these populations would be affected disproportionately by proposed fire management strategies; therefore, this impact topic is dismissed from further analysis. Potential public health effects are addressed under Air Quality.

3.10.6 Wetlands

Executive Order 11990 directs the NPS to 1) provide leadership and take action to minimize wetlands destruction, loss, or degradation 2) preserve and enhance natural and beneficial values of wetlands and 3) to avoid direct or indirect support of new construction in wetlands unless there are no practicable alternatives to such construction and the proposed action includes all practicable measures to minimize harm to wetlands.

NPS Director's Order 77-1, Wetland Protection (issued October 22, 1998), and the accompanying Procedural Manual 77-1 directs NPS proposed actions that may adversely impact wetlands be addressed in an Environmental Assessment (EA) or an EIS. If the preferred alternative in an EA or EIS will result in adverse impacts, a Statement of Findings documenting compliance with the Director's Order and Procedural Manual will be completed. Actions that may be exempted from the Statement of Findings requirement are identified in the Procedural Manual. Given that wetland protection, as defined in these documents, deals primarily with proposed construction and dredging in wetlands, there is currently minimal cause to formally consider a separate wetlands analysis based on landscape-level activities such as wildland fire management.

Although small springs, seeps, and intermittent riparian areas occur in GRCA, primarily on North Rim, there are no jurisdictional wetlands in proposed treatment areas. Mitigation measures have been developed to minimize direct and indirect effects from fire activities on water resources and riparian areas (see Soils and Watersheds, Chapter 4). With these mitigation measures, potential impacts on resources such as small springs, seeps, and intermittent riparian areas are expected to be negligible; therefore, this impact topic is dismissed from further analysis.

3.10.7 Floodplains

Executive Order 11988 requires all Federal agencies to avoid construction in the 100-year floodplain unless no other practical alternative exists. Certain construction in a 100-year floodplain requires a Statement of Findings. All park base-flood elevations are well away from any locations subject to proposed prescribed fire or fuels treatment projects and would not be affected; therefore, this impact topic is dismissed from further analysis.

3.10.8 Prime and Unique Farmland

In August 1980, the Council on Environmental Quality (CEQ) directed Federal agencies to assess their action's impacts on farmland soils classified by the U.S. Natural Resources Conservation Service (NRCS) as prime or unique. Prime or unique farmland is defined as soil that particularly produces general crops such as common foods, forage, fiber, and oil seed; unique farmland produces specialty crops such as fruits, vegetables, and nuts. According to the NRCS, no GRCA soils are classified as prime or unique; therefore, this impact topic is dismissed from further analysis.

3.10.9 Wild and Scenic Rivers, World Heritage Site Designation

NEPA regulations (40 CFR 1508.27) require intensity of potential impacts be evaluated on unique natural resources including Wild and Scenic Rivers. No GRCA waterways are designated Wild and Scenic Rivers.

GRCA was designated a World Heritage Site in 1979 for its evolutionary history, ongoing geological processes, exceptional natural beauty, and rare and endangered species. The GRCA GMP (NPS 1995) reiterates the importance of preserving those values as part of the heritage of all people. The intent of proposed fire management plan is to enhance the park's natural resource values. Because the proposed FMP will not adversely affect the World Heritage Site status, this topic is dismissed from further analysis.

3.10.10 Indian Trust Resources

Under Department of the Interior Secretarial Order 3175 and Environmental Compliance Memorandum 95-2, department agencies are required to consider effects of their actions on Indian trust assets, defined as legal interests in property held in trust by the Federal government for the benefit of Indian tribes or individuals. Examples of such assets include lands and mineral, hunting, fishing, and water rights. No such assets occur in GRCA or would likely be affected by fire management strategies; therefore, this impact topic is dismissed from further analysis.

3.10.11 Depletable Resource Requirements and Conservation Potential

None of the alternatives involves the use of depletable (consumptive) resources. Therefore this topic has been dismissed from further analysis.