Chapter IV: Environmental Consequences

This chapter evaluates the environmental effects of the three fire management alternatives retained in Chapter II on the eight impact topics.

Methodology

This EA analyzes the effects of differing amounts of prescribed fire, wildland fire use, suppression, non-fire treatments under the three alternatives. Alternative A allows the least use of fire and poses the greatest risk of future wildland fires. Alternative B was developed with the understanding that fire shaped park vegetation. It is envisioned to reduce fuels over more of the park fastest, but possibly with some negative effects over the short-term. Alternative C curbs the possible negative impacts of Alternative B in sensitive habitats with the use of the Special Treatment Zone in the Chisos, and use of research burns in a variety of habitats and species where fire effects are not well understood. The Special Treatment Zone is a 'red light' to managers to pay special attention to natural and prescribed fire in the Chisos. Lightning ignitions may be allowed to burn in selected areas at low and moderate intensity. Prescribed burns will be guided in area, intensity, and habitat by research questions and protocols.

The three alternatives were the IDT's best attempt to satisfy NPS policy and the goals and objectives of Big Bend's fire program. In developing Alternative C, they found a balance between reducing immediate threats from high fuels and providing long-term information from research burns to improve future management decisions. Given the uncertain nature of fire, weather, and regional priorities and resources, the IDT cannot guarantee that the alternatives will have the predicted effects, and may even result in similar outcomes.

Environmental Consequences

Under NEPA, effects of alternatives are defined in terms of :

- *context* (are effects site specific, local or regional?) A site specific effect might be a decrease in population, a local effect might be erosion across a watershed, a regional effect might be at the level of entire ecosystems or landscapes across a mountain range.
- *intensity* (are the effects negligible, minor, moderate, or major, or would they lead to impairment of Big Bend's resources and values?) Definitions vary by impact topic
- *duration (*are effects short-term or long-term?) Short-term effects result in return to predisturbance condition or appearance within hours to the duration of the FMP. Long-term effects may exceed the duration of the FMP.
- *timing* (do the effects vary with the timing of alternative actions?*)* Prescribed fires are scheduled outside normal fire season and may impact some fire dependent species.
- *direct impacts (*are resources adversely or beneficially affected?) Adverse effects take a resource away from a desired condition or appearance. Beneficial impacts have the opposite effects.
- *indirect impacts (*do other adverse or beneficial outcomes occur from the action?)
- *cumulative impacts* are discussed in the next section, and
- *mitigative effects* are actions that reduce environmental effects of alternatives.

Cumulative Effects

Cumulative impacts are defined by the Council of Environmental Quality as "the impact on the environment that results from the incremental effect of action (s) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) undertakes such

action" (40 CFR 1508.7). Actions with a potential to add to the effects of the FMP were contributed by the IDT. They include:

- Development of walking trails (1) to connect Kibbe Springs along the south side of Casa Grande with the Lost Mine Trail, and (2) to provide a link from the Castolon historic area to the river.
- Construction of new buildings including several new houses or duplexes to replace old trailers, construction of a fire managment office, and enlargement of the visitor center –all at Panther Junction.
- Continued but slow growth in the western gateway communities of Study Butte and Terlingua, and the resort town of Lajitas.
- Fires on state and private lands adjacent to the park.
- Fire events at Big Bend preceding and following the term of the new FMP.
- Continued fuel accumulations in the Chisos.
- Expansion of nonnative plant species.
- Pilot revegetation of natives along riparian corridor.
- Past and future flood and erosion events.
- Defoliation of trees by caterpillers in the Chisos during periods of stress.
- Expanded interpretive and education programs.

Impairment Analysis
NPS is required by law (Organic Act, General Authorities Act) to guarantee that natural and cultural resources will be passed onto future generations unimpaired. Managers must seek ways to avoid, or minimize to the extent possible, actions that would adversely affect resources and values that are essential to the identity or purpose or part of the enabling legislation of the park. Each natural and cutural impact topic has NPS specific language. Impairment determinations were made with the judgement of professional staff and relevent studies.

Appendices
There are three appendices that provide supporting information for this chapter. They are Fire Effects on Dominant Plant Species (Appendix B), the Cultural Resources Component (Appendix C) which was prepared for evaluation by the Texas Historical Preservation Office, and a list of plant and animal species discussed thougout the text (Appendix D).

Impact Topic (1). Life and Property
Fire is an effective tool for reducing hazard fuels, but it is also a threat to the public, firefighters, park staff, developed areas, and neighboring properties.

The first and foremost objectives for fire management are the protection of life, property, and resources from the unacceptable effects of wildland or prescribed fire. Life and property encompasses park staff, firefighters, visitors as well as park developments and personal property of everyone concerned. Life and property on neighboring lands are also of concern. The paradox facing resource managers is that while fire is a threat, it is also an effective tool for reducing fire hazards.

Assessment Methodology
Assessment of environmental consequences on life and property is based on historically observed wildland fire intensity (the amount of energy released) and severity (impact on soils and amount of canopy burned) at Big Bend National Park or in similar vegetation communities elsewhere, and on the expertise of resource managers at the park. Staff also considered the number of wildland fires and escapes of several prescribed fires in determining fire safety.

Intensity of effects for life and property are defined as:

Negligible: The impact is at the lowest levels of detection with no injuries or property damage.

Minor: The impact is small, localized, and detectable. Mitigation would be a standard procedure and highly effective in minimizing risky activities such as thinning and prescribed burns to reduce fuels.

Moderate: The impact is readily apparent. Mitigation is moderately complex and effective activities such as rebuilding structures.

Major: The impact is severely adverse or exceptionally beneficial. Effects may be permanent. Mitigation may result in permanent positive change in human values or procedures, or mitigation to offset negative effects such as loss of historic register buildings may not be possible.

Short-term: Within the duration of a specific fire program activity such as a prescribed burn or suppression action.

Long-term: Beyond the duration of a specific fire program activity; perhaps longer than the tenure of the FMP.

Alternative A

Impact Analysis
Fire threats are greatest in late spring coinciding with peak visitation. Fire intensity is greatest where fuels have increased in the Chisos forests, along the riparian corridor and where exotic bunching grasses form dense understory mats. Alternative A (No Action) continues the direction of the 1995 RMP and 1994 FMP focusing on protection through suppression. Long-term direct beneficial effects accrue as developments continue to be protected by prescribed burns and manual thinning, mowing or herbicide applications. Strict decision criteria on natural ignitions mean that few natural fires are allowed to burn elsewhere in the park. Direct minor to moderate adverse effects accrue with the continual build up of fuels, particularly in the Chisos, that could threaten developments in the Chisos basin, hikers in wilderness, and some historic sites. A puzzle to staff is that despite buildup of fuels, few lightning fires have required suppression in the Chisos. This observation suggests that fire may not have burned as frequently as supposed or that fire is naturally contained by topography.

Under Alternative A the probability of high-severity fire in the Chisos increases when fuels are dry and wind speeds are high. Buildup of pine needles and leaf litter, ladder fuels, woody dead and down material, and closure of tree canopies will increasingly predispose the area to extreme fire conditions during summer fire season. Evacuating visitors from the Chisos basin and hikers from wilderness would be difficult during extreme fire events. Even with additional regional resources, the likelihood exists that the fire would burn large areas before containment. Creation of a one-mile suppression zone to buffer neighbors from fire has been successful where vegetation is sparse along west, north and eastern borders. It is more difficult along the riparian Rio Grande corridor where dense, flammable saltcedar and giantreed may hinder suppression efforts and endanger firefighters.

Mitigation actions are: Continuing to reduce fuels through prescribed burns and minimizing adminstrator’s reluctance to allow wildland fires; public education and notification of fire activities;

maintenance of cooperative agreements with neighboring landowner's and agencies; manual and mechanical fuel reduction; fuel breaks around developments; evacuation plans.

Cumulative Effects
Cumulative effects on life and property are expected to be minor to moderate with other activities having little impact on threats to life and property. Additional trails, built areas and growth of nearby communities reduce fuels and threat of fire. The relative isolation of the park minimizes the influence of the fire program on humans other than staff and visitors.

Conclusions
Alternative A may result in long-term minor to moderate adverse impacts to life and property by allowing fuels to increase. Burning of slash, mowing, herbicides and manual thinning and small prescribed burns pose minor short-term risks to life and property. Fuels continue to buildup in the Chisos, which raises the probability of more intense fires initiated by lightning strikes during the summer monsoon. Suppression of fire under extreme conditions in rugged terrain—a requirement under the current FMP—poses direct, moderate to major adverse risks to firefighters, hikers and visitors in the Chisos Basin. Fire occurrence and history of effects is limited but no impairment has occurred to date from fire.

Alternative B

Impact Analysis
Under Alternative B there will be more fire in the park. Initially this poses risks to life and property because of fuel accumulations in the Chisos, areas of flammable exotics, and increased need for fire fighting. Over the longer-term, increased experience by firefighters, familiarity with fire in different vegetation types within the park, and reduced fuels are expected to lower risks to life and property across the park. Allowing more fire is expected to reduce the risk of high-severity fire in the Chisos and the difficulties of evacuating people. Long-term beneficial effects to life and property are expected as neighbors learn and contribute to a more cohesive fire program.

Mitigation actions are: fuels assessment to allow natural fires to burn at low and moderate intensities; focus negotiations with neighbors on allowing fires to burn to natural boundaries; have adequately trained staff within the park or regionally available to handle the increase in fire activities.

Cumulative Effects
Increased wildland fire use may draw resources from other projects in the park over the short-term. Minor, long-term beneficial effects to life and property are expected as fuels are reduced across the park.

Conclusions
This alternative may expose firefighters to more fire and risk than other alternatives. While firefighters and the public may initially be exposed to greater risks; adverse impacts ranging from minor to moderate intensity over the short-term; these risks decline as fuels are reduced providing minor to moderate long-term benefits. Alternately, more exposure to fighting fire increases staff expertise leading to long-term moderate beneficial effects on life and property.

Alternative C

Impact Analysis
Impacts to life and property would be similar to those under Alternative B. More restrictive wildland fire use could necessitate more suppression activities that expose firefighters to dangers. Research burns would guide application of prescribed fire and wildland fire use over the tenure of the fire management plan, and program adjustment based on new knowledge should decrease risks to life and property.

Mitigation actions are similar to Alternative B. Research burns decrease potential adverse effects by providing a better understanding of fire effects.

Cumulative Effects
Cumulative effects are the same as Alternative B.

Conclusions
Effects are similar to B with increased risk to firefighters and the public in the short-term with increased burning. More frequent fires wildland fires and prescribed/research fires would reduce fuels, build firefighter skills, and a database that has the potential to provide long-term moderate to major beneficial effects on life and property. Conducting research burns would involve short-term minor to moderate direct adverse risks. Activities associated with research burns improve the skill base in the park and provide a platform for adaptive management, a long-term moderate to major beneficial effect in reducing risk to life and property.

Impact Topic (2): Preservation of Visitor Experience

Fire program activities may result in road closures and deter visitors; conversely some visitors are interested in fire and the post-fire activities offer interpretative opportunities.

Increased fires in the park would affect the approximately 300,000 annual visitors. Depending on the fire size, wind speed and direction, and fire duration visitors may be barred from roads, river, and mountains– the key recreational features of the park. Campgrounds may be closed and evacuations may be necessary from the Chisos wilderness and Basin. Smoke may veil the panoramic views of mountains and desert that draw many visitors. Interpretation of fire events is expected to lower aversion to the effects of fire on the landscape.

Communication by park staff via visitor centers, press releases, radio, signs and web site to visitors, local community and agencies of planned and unplanned fire activities is aimed first and foremost, at protecting life and property. Visitor Center staff are updated frequently to provide guidance on trail and road closures, safety and alternate destinations if needed. Backpackers are apprised of fire danger and responsibilities of using campfires and stoves before entering the Chisos when obtaining their camping permit. During periods of high fire danger, staff are posted at major trailheads to give further instructions. Evacuation plans are in place for the high country and Chisos Basin.

All alternatives have similar prescriptions governing prescribed fire and wildland fire use. Staff have perceived likely fire effects under these prescriptions and can plan, monitor and make cautious predictions based on these ranges. The planned reduction of fuels under the action alternatives will reduce threats to visitors from high-severity fire.

Assessment Methodology
Visitor surveys provide the background for understanding the park attributes most valued by visitors. Staff considered past experience with visitors during fire events and general knowledge of visitor patterns and expectations to determine impacts.

Intensity of effects for visitor experience is defined as:

Negligible: An action that could cause a change in visitor activities and/or aesthetic resource values, but the change would be so small that it would not be of any measurable or perceptible effect. Few visitors would be affected.

Minor: An action that would affect some visitors and cause a change in visitor's activities or aesthetic resources, but the change would be small and localized. Mitigation would not be necessary.

Moderate: An action that would cause a substantial measurable change in activities available to many park visitors. Mitigation to offset adverse effects would be necessary such as providing alternative routes and itineraries. Aesthetic resources would be degraded.

Major: An action would cause a severe change or exceptional benefit to the activities of most park visitors. The change would have substantial and possibly permanent effects on visitor use such as the loss of views and unique sites. Aesthetic resources would be substantially degraded. Mitigation to offset adverse effects would be needed.

Short-term: Duration of the fire event.

Long-term: Duration of the fire management program, or longer.

Alternative A

Impact Analysis
Prescribed burning to reduce fuels around developments generally occurs in fall and early spring outside peak visitation times. The intensity and duration would vary with fuel load and fire conditions within the prescription ranges. Visitors may experience short-term, minor direct effects when their plans are changed, views obscured, vegetation charred and wildlife disrupted from a prescribed burn. Disruption to visitors is minimized however, with a full suppression policy of lightning ignitions in areas most used by visitors. Views, wildlife, and access remains unimpeded to the river and the Chisos. These are direct, moderate to major benefits to visitors.

An indirect minor to major adverse impact of a suppression policy across much of the park is that visitors have become habituated to expect a fire-free and well-vegetated park. Tight decision criteria on ignitions and few fires in the park make it a challenge to familiarize visitors to the beneficial effects of fire for ecosystems. Under extreme conditions, high-severity fire may occur in the Chisos with long-term adverse effects on visitor experiences.

Mitigation actions are: inform visitors through multiple media, the visitor's center and entrance station; provide alternate destinations; link fire program activities to interpretation and education; time prescribed burns outside peak visitation periods; coordinate burns with adjacent and nearby land managers to minimize cumulative impacts to the region.

Cumulative Effects
Cumulative effects to visitors are most likely from continued increase in fuels. In the Chisos stresses from high stocking rates of trees are postulated as a reason for defoliation during drought. Increased dead material and continuing buildup of fuels makes high-severity fire more probable with long-term impacts on aesthetics in the park. Increased exotic species impacts wildlife patterns and exotic bunching grasses can lead to higher fire temperatures around rare and endangered cactus.

Conclusions
Current management strategies under Alternative A preserve visitor resources, amenities and aesthetic values, and have provided direct beneficial impacts for 60 years. Prescribed burns occur outside peak visitation times minimizing disruption to visitors and posing minor, indirect adverse impacts. Such fires also offer interpretive opportunities. Over the long-term continuance of Alternative A increases the probability of increasing fuels and risk of fire in woodlands and forest, and a widespread, high-severity

fire in the Chisos. Suppression of such a fire would create direct and indirect long-term adverse impacts to visitor resources and park aesthetics.

Alternative B

Impact Analysis
Greater wildland fire use and more prescribed burns would result in more periods of inconvenience. The duration and frequency of visitor use restrictions would decrease over time as fuel loads are reduced. Minor adverse effects can be expected from smoke and short-term localized trail and road closures. A possible effect of increased fire is reduced visitation from altered landscapes and limited access, or alternately, increased visitation as rubbernecks seek to witness landscape fires. Reduced visitation is an adverse impact to visitor's experience. Increase visitation draws park resources to providing greater interpretive experiences and providing more direction to visitors during actual fire events.

The long-term effect of more fire in the park is reducing the risk of high-severity fire in the Chisos and so preserving, aesthetics, plant communities and wildlife - direct beneficial long-term effects.

Mitigation actions are similar to Alternative A with increased emphasis of the benefits of fire in communications with the public.

Cumulative Effects
Cumulative effects are similar to Alternative A but more inconveniences are likely from increased wildland fire use.

Conclusions
More wildland fire would result in greater direct short-term minor to moderate adverse impacts to visitors as they experience road closures, smoke and limited access to the park. Reduction of fuels particularly in the Chisos minimizes the threat of high-severity fire maintaining a resource valued by visitors and limiting the need for disruptive suppression tactics that could include overflights. Greater interpretive efforts by park staff would provide long-term indirect beneficial effects as visitors support policies that encourage natural fire regimes in park ecosystems.

Alternative C

Impact Analysis
Under Alternative C prescribed burns and natural ignitions follow a similar pattern to Alternative B. Visitors will suffer short-term, direct, adverse impacts from smoke and closure of roads and trails denying access to views, wildlife and amenities. Research burns may also cause short-term adverse effects to visitors. Scientific assessment of these burns is also expected to yield indirect beneficial effects over the long-term from improved management of cherished resources and habitats. Under Alternative C the potential for high-intensity widespread wildfires in the Chisos continues and will not abate until staff understand how to safely reintroduce fire into areas of high fuels.

Mitigation actions are the same as Alternative B.

Cumulative effects
Cumulative effects are similar to Alternative B with benefits from fire taking longer to accrue.

Conclusions
Effects of Alternative C are beneficial and minor over the short-term. Scientific evaluation of research burns applied to fire policy and interpreted for the public, provide a touchstone enabling visitors to weigh

immediate direct adverse effects with potential long-term beneficial effects on ecosystems. Benefits to visitors are expected to be greatest under this alternative.

Impact Topic (3). Local Economy

Fire events provide business for local merchants and firefighters but may deter visitors. More routine fire events provide extended benefits to the local economy than a single large high-severity fire.

The park lies in a sparsely populated region in connection with other large protected landscapes. Big Bend is a major employer of this region and supplies high-quality permanent employment, seasonal jobs and volunteer opportunities in a number of departments. Local gateway communities provide motel and supplies to park visitors and employees, furnish seasonal firefighters such as Los Diablos for the fire program, and provide support services for the luxurious Lajitas resort. Benefits to the local economy depend upon the size, intensity and duration of fires. A large, high-intensity fire may provide a one-time windfall for local merchants while more routine fire events are likely to provide more lasting impacts to suppliers and seasonal employees.

Assessment Methodology

Long-time park staff provided information on the types of expenditures associated with fires and their relative benefit to the local economy. For example, revenues for merchants increase when firefighters cash their paychecks to buy food, water and other supplies during fire events.

Intensity of effects for the local economy is defined as:

Negligible: Economic and socioeconomic effects would not be affected or the effects would not be measurable.

Minor: The effects on economic and socioeconomic conditions would be small but measurable, affecting a small portion of the local population.

Moderate: The effects on economic and socioeconomic conditions would be apparent in the vicinity of the park.

Major: The effects on economic and socioeconomic conditions would be readily apparent and would substantially change the economic or social services within the area.

Short-term: For a specific fire program activity.

Long-term: Beyond the duration of a specific fire program activity such as a fire season or the duration of the FMP.

Alternative A

Impact Analysis

Under Alternative A, a policy of prescribed burns around developments and suppression elsewhere in the park has resulted in a few fires of short duration with little impacts on visitors or the local economy. Continual buildup of fuels in the Chisos increases the problem of widespread, high-intensity fire under extreme conditions. A large fire would create short-term direct moderate benefits for retail merchants. Visiting and local seasonal firefighters may also cash paychecks and purchase items in the areas returning revenues to local businesses. Overall effects on the economy are sporadic under this alternative.

Mitigative actions are: continue to employ local firefighters including Los Diablos on a seasonal basis whenever possible; provide options for local merchants to supply goods and services for the fire program

when practical; keep local communities and neighbors notified of park activities to minimize adverse effects.

Cumulative Effects
Cumulative effects outlined at the beginning of the chapter are likely to increase revenues to the local economy independent of fire activities. These effects include the impacts of building trails, constructing housing, a fire office and visitor center at Panther Junction, and increasing visitation as gateway communities grow. Trails provide greater accessibility to more of the park and together with improved visitor amenities are likely to draw more visitors resulting in direct short to long-term beneficial effects on the local economy. Visitors spend money on meals and souvenirs while staying at the park and nearby motels.

Conclusion
Alternative A would result in short-term moderately beneficial impacts from seasonal firefighter employment and high visitor use- the results of a primarily suppression fire policy. Should a high-severity fire occur during extreme weather conditions local merchants and visiting firefighter would receive a one-time windfall. Post-fire economic effects following such a fire are unknown. Visitors may choose to investigate post-fire effects thereby boosting local revenues, or choose another, greener destination. There is sufficient staff within the park to manage the fire program with minimal outside additional support.

Alternative B

Impact Analysis
Alternative B represents a shift from primarily suppression activities under Alternative A to much more fire from lightning ignitions. Additional fires may tax existing staff to meet safety requirements necessitating reallocation of staff duties and/or hiring additional seasonal firefighters to meet high demand periods. Under this scenario, Alternative B would result in direct, short-to long-term beneficial effects to seasonal workers and local merchants. More fire may dissuade visitation (with negative effects on the economy) or encourage visitation (with positive effects on the economy) depending on visitors' perceptions.

Mitigation actions are: similar to Alternative A with greater emphasis on education and interpretation to counter any falling visitor attendance such as Visitor Center information on alternate destinations, closures or cautions; hire additional staff locally if possible.

Cumulative Effects
More fire is allowed in the park under Alternative B potentially straining existing resources during fire season. Other fires on nearby state lands, private holdings and the Mexican preserves may further strain park resources. Regionally more routine fire events would benefit local suppliers of goods and services and provide a pool of expertise, which could serve a number of agencies. These effects would cumulatively result in minor to moderate direct beneficial impacts to local seasonal employees and merchants, with benefits diminishing as fuels are reduced over time.

Conclusion
Alternative B would result in short to long-term beneficial effects by providing income to seasonal firefighters and sales to local merchants as fire frequency increases in the park. Benefits are expected outside fire season for prescribed burns and during fire season for natural ignitions, extending the period of benefits to firefighters and merchants.

Alternative C

Impact Analysis
Alternative C is similar to Alternative B but with more planned prescriptive/research fire events. Conceivably this alternative could provide the most reliable economic benefits to seasonal employees and merchants. The additional tasks and seasonal employment to undertake monitoring and control of more fire events would be expected to provide short- to long-term direct beneficial effects to firefighters and suppliers.

Mitigation actions are the same as for Alternative B.

Cumulative Effects
Cumulative effects would taxed already burdened permanent staff. The economic effects of stress are unknown in this scenario. The benefits to seasonal employees, and merchants are likely to be direct, beneficial and minor to moderate over the life of the FMP.

Conclusion
Under Alternative C beneficial impacts to the economy would range from minor to moderate depending on fire frequency, duration, intensity and size, and whether permanent park staff can meet staffing and additional seasonal firefighter needs.

Impact Topic (4): Vegetation

While trained observers pointed to the need for reintroducing fire into Big Bend since the 1940s (McDougal) and 1960s (Leopold), park staff followed the national policy of suppression. Historical vegetation structure has changed from heavy grazing prior to park formation. Extended drought slowed recovery of grasses on limestone allowing woody species to increase (Muldavin et al. 2001). High elevation grasslands appear to have recovered however, but woodland canopy is far greater than that recorded by biological surveyor Vernon Bailey in 1901 (Schmidley 2002). The park began a modest prescribed burn program in 1980s to protect developments. Fuels have continued to increase across the park and in preparing this EA, staff recalibrated vegetation types to reflect fire program concerns. Staff added measures to protect unique habitats, took account of the effects of spreading nonnative plants, and developed a research agenda to better understand ecological processes.

<u>Floodplain and Upland Riparian</u>
Fire effects on species: Table A-1 in Appendix B
Until the formation of the park and frequent visitors, fire was uncommon along the river. Spring floods removed understory, which could act as ladder fuels, from the scattered gallery forests of cottonwood and mesquite. Relative humidity and fuel moisture were high keeping fires small. Frequent human visitation, together with lower river flows and dense stands of saltcedar and giantreed has led to an increase in fires along the river. Saltcedars ability to reestablish rapidly from seed, roots and stem means it will continue to outcompete native species. Bermuda grass and buffelgrass, both exotics are also established along the riparian corridor and form mats of fuel under moist summer growing conditions. Both respond rapidly after fire and can outcompete local natives. Fire is an impediment in this category unless followed up with control measures for saltcedar and the exotic grasses.

Upland springs have had saltcedar removed. The IDT proposes to protect native canopy species from fire if possible, and remove exotics as they appear.

Scrub Desert

Fire effects on species: Table A-2 in Appendix B

Desert scrub is dominated by shrubs (creosote, mariola and ocotillo), and succulents (prickly pear, lechuguilla, and Texas hetchia or falseagave). These shrubs will carry fire under high winds. Grasses are subdominent and provide insufficient fuels to carry fire. Muldavin et al. (2001) in a survey of 77 transects from 1950 to 1996 in the northwest of the park identified soil type, elevation and moisture conditions as determining shrub cover. Greater runoff and erosion and high evaporation during the growing period leads to establishment of deeper-rooted and probably widely-spaced shrubs on drier limestone soils. Recovery of grasses is not expected except during cycles of above average rainfall. Wonzell et al. (1996) show a similar correlation between shrub and grass cover and predominant landforms. Almost half the park is scrub desert, which does burn when canopies are dense, winds high, and plants close enough for fire to carry. Depending on biomass production, fire may occur every 30-250 years (infrequent) (USFS – FEIS site). Staff are establishing research plots to understand if fire can increase tobosagrass and chino grama.

High Desert Grasslands

Fire effects on species: Table A-3 in Appendix B

The largest fires in the park have occurred in this vegetation type (>1,000 acres). The studies above would have predicted post-grazing recovery on igneous, depositional ecotone with low runoff and evaporation during the growing season. Shrubs are still present in these grasslands and fire would shift them towards occupying shallow rocky soils on ridge tops and along drainage bottoms. The IDT know that lightning caused fire is likely to spread uphill into woodlands along drainage bottoms. Control will be extremely difficult because of the high fuel loads under some woodlands and forest. Fire return intervals for desert grasslands may be as frequent as 7-10 years (McPherson 1995). Sexton and Kaufmann estimated up to 20 years for this association (Burns will favor an increase in grasses and containment of shrubs and seedling trees.

Shrub Woodlands

Fire effects on species: Table A-4 in Appendix B

Oaks, acacia, mimosa and sumac all resprout after fire and the small shiny-leaved shrubs reflect fire. The grazing era removed grassy understory, and dense clumps of aloysia persist in former stock corrals. Fire would have thinned shrub densities and killed sapling juniper and pinyon. Because of grazing and suppression there is perhaps more shrub cover than before Europeans, skewing types of habitat (black-capped vireo) and foods available (berries eaten by black bear). Alligator juniper sprouts vigerously from the underground base and the bark protects mature trees from damage. Redberry juniper may reach maturity within 10 years. Prescribed fires at low to moderate intensity are unlikely to be useful in removing current mature junipers but high-intensity fire may remove junipers for up to 50 years. Mexican pinyon is relatively resistant to fire. Moir (1982) counted four fires in a tree ring sample in an 80-year-old tree. Fire return intervals for maintaining open stands of pinyon-juniper are commonly 10-30 years (FEIS web site). Baker and Shinneman (2004) point to the difficulty of lowering P-J densities using low-intensity fire (usually becomes high-intensity) and recommends experimental work on site to determine correct prescriptions.

Grassy Woodlands

Fire effects on species: Table A-5 in Appendix B

This predominately pinyon-juniper-oak vegetation is a fire maintained assemblage. Trees are mature and unlikely to be seriously impacted by low-intensity fire. However, fuel levels are moderate to high and canopies are closing or closed which together could lead to crown fire. More fire will open canopies and increase grasses but a cycle of burn will probably be necessary to achieve the greater grass cover recorded by Vernon Bailey in 1901.

Forest

Fire effects on species: Table A-6 in Appendix B

Moir (1982) found 10 fires between 1770 and 1940 at a range of 9-60 years and estimated fire frequency in this assemblage at 70 years (Moir 1982). Baisan and Swetnam (1995) in averaging results across 63 sites suggested 25 years. The numerous species with differing responses to fire suggest that topography has shaped fire behavior. Redberry juniper can tolerate fires 10-20 years, Pinchot juniper every 30-50 years, and Alligator Juniper 20-30 years. Aspen typically regrows as a clone after a severe fire event. Arizona Cypress is quite intolerant of fire and probably survived due to patchy fire. Oaks typically resprout after fire from the base. Mature ponderosa pine is expected to survive fire. The talus slopes, sheer cliffs and rocky terrain would direct fire so that mosaics of burned and unburned vegetation occur.

The IDT want to retain most mature trees and burn understory fuels and saplings at low intensities.

Assessment Methodology

Impacts of the fire program on vegetation were developed from the experience of park staff, the US Forest Service maintained fire effects web site, and from the literature.

Intensity of effects are defined for vegetation as:

Negligible: An action that could affect individuals with no measurable effect on populations or vegetative communities. Impacts would be barely perceptible to landscape features

Minor: An action that could cause a change to populations, but the change would be small, and if measurable, would have a small and localized effect and not cause decrease or increase of species diversity in the park. Impacts would remain localized and confined to a single element of significant characteristic of a landscape such as a particular plant community over a small area. Restoration would be relatively easy.

Moderate: An action that could cause a change to populations and communities that increase or decreases species diversity in the park. The change would be localized and not considered a threat to the long-term survivability of the species in question. Impacts would be sufficient to cause a noticeable but not substantial change in landscape features such as alteration of a particular plant community in several localized areas. Restoration may be time-consuming, costly, or relatively complex.

Major: An action that could decrease the species diversity of the park, be considered a threat to the long-term survivability of populations in question and/or eliminate the population of a species that is locally endemic or considered key to the natural integrity of the park. Impacts would result in substantial and highly noticeable changes in landscape features, such as complete loss of vegetation over a widespread area. Restoration may not be feasible.

Impairment: A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purpose identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Short-term: A return to the pre-event range of variability in distribution and abundance of species or arrangement of vegetation on the landscape within the natural fire interval of the affected habitat.

Long-term: Unlikely to return to pre-event range of variability in distribution and abundance of species or arrangement of vegetation on the landscape within the natural fire interval of the affected habitat.

Alternative A

Impact Analysis
Alternative A would continue suppression of most natural ignitions across the park. This would protect unique habitats such as upland springs and dunes, and the floodplain where exotic plant establishment and seed dispersal may be enhanced by fire, favoring more fire tolerant vegetation over time. Excluding fire from mountain meadows, woodlands, and grasslands allows further shrub encroachment and canopy closure, which impacts vegetation structure and species diversity— long-term adverse impacts. The dynamics of fire in these altered environments may be difficult to predict. Fuel buildup in the woodlands and high fuel loads in Chisos forests increase the risk of high-severity, widespread fire to relic and rare systems under extreme conditions during the summer fire season. Wilderness suppression requirements increase the difficulty of controlling fire and create hazards for firefighters and the public. Landscapes and ecological processes may be changed for many decades. Under this alternative effects are likely to be moderate to major, direct, indirect, adverse and long-term.

Prescribed fire with mechanical and manual fuel reduction around developments would result in mortality to a small number of plants. Localized, direct minor effects to plant communities would result from the activities of work crews, such as: laying firelines, burning slash piles, and removing individual trees and shrubs. Burning would release some nutrients to the soil and allow seedling establishment.

Mitigation actions include: locating potential firebreaks, staging camps and spike camps ahead of fire; restore site immediately after fire if needed; restrict prescribed fire to low and moderate intensity; use Minimum Impact Suppression Techniques whenever possible; manage wilderness in accordance with the Wilderness Act including: hand tools rather than mechanized tools and aircraft; no spike camps, crews or other personnel overnight; biodegradable retardant if it must be use; avoid spills, foam or erosion near water.

Cumulative Effects
Cumulative actions which add to proposed actions under the fire program include:

- Large fires on lands adjacent to the park at the same time as fires within the park may create problems for obtaining sufficient resources to manage fire and probably result in continued suppression – an direct, minor to moderate adverse impact.
- Fire events at Big Bend preceding and following the term of the new FMP. High-severity fire may occur leading to loss of mature trees and views.
- Continued fuel accumulations in the Chisos predispose the forests and woodlands to high-severity fire – a moderate adverse direct impact.
- Expansion of nonnative plant species increases the flammability of these sites jeopardizing endangered species and changing fire regimes.
- Pilot revegetation of natives along the riparian corridor will remove saltcedar, a minor to moderate beneficial effect.
- Past and future flood and erosion events would reduce seedling in low desert areas (erosion) but high rainfall may increase recruitment of seedlings elsewhere – minor long-term beneficial effects.
- Defoliation of trees by caterpillers in the Chisos during periods of stress is an adverse effect creating more fuels. Prescribed burns that remove fuels provides minor to moderate beneficial effects to mature trees.

- Expanded interpretive and education programs may lead to minor beneficial effects as the public develop understanding of fire's role in the landscape.

Conclusion
Actions under Alternative A limiting the spread of exotic species and preventing the loss of valued habitats through suppression provides beneficial direct short-term impacts. Restrictive initial decision criteria that determine whether fires are allowed to burn have curtailed the use of natural ignitions allowing fuels to build up and preventing fire in fire-adapted systems. High severity fire in the Chisos leads to moderate to major adverse impacts over the short-term. Long-term the effects are unknown.

Under Alternative A, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
The goal of Alternative B is to atempt to quickly reduce fuels across the park and avert a high severity event. Decision criteria on ignitions are flexible and prescriptions maintain safety by only allowing fires to burn at low to moderate intensities. Under this alternative, there is confidence that burning even if the fire frequency and effects of fire are unknown will benefit park ecosystems in the long-term. Fuels would be reduced, plant communities regenerated, and a natural fire regime returned to the park. More frequent disturbance, however, could predispose sites to invasion by exotic species changing flammability and species composition over time. More fire tolerant saltcedar is displacing cottonwood and willow along the riparian corridor. Buffelgrass, Bermuda grass and giantreed predispose the floodplain to more and hotter fires. Without control of exotic species following fire there would be long-term direct minor to moderate adverse effects as vegetation composition shifts to more fire tolerant species. More frequent fire could maintain high desert grasslands by increasing species diversity, reverse shrub encroachment in meadows, remove saplings and water competition among oak, pinyon-juniper woodlands, remove ladder fuels and duff in forests, and through creation of low fuel buffer areas provide greater protection for legally protected species and cultural resources. These impacts are expected to be direct moderately beneficial and long-term.

Prescribed fire with mechanical and manual fuel reduction around developments would result in mortality to a small number of plants. Localized, direct minor effects to plant communities would result from the activities of work crews, such as: laying firelines, burning slash piles, and removing individual trees and shrubs. Burning would release some nutrients to the soil and allow seedling establishment.

Mitigation actions in addition to those under Alternative A include: flexible boundary agreements with neighbors would allow fire to be controlled at natural barriers reducing the effects of control and suppression activities on vegetation.

Cumulative Effects
Similar to Alternative A; agreements with neighbors may lead to minor short-term, direct beneficial effects for vegetation.

Conclusion
Minor adverse short-term impacts from fire with moderately long-term beneficial effects to vegetation communities and fuel levels as natural fire regimes are restored. Applying mitigation measures to burned areas of exotics provides short-term beneficial effects.

Under Alternative B, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Under Alternative C prescribed fires and mechanical and manual fuel reduction around developments would result in mortality to a small number of plants as for the other alternatives. Like Alternative B, more natural and prescribed fire would be allowed in the rest of the park with similar effects to fire-tolerant habitats and areas of exotics. Alternative C adds research burns to identify fire-effects to Chisos forests and woodlands, to better understand restoration of grasslands, enhance habitat of threatened species where possible, assist in the protection of cultural resources, and aid restoration of riparian areas. Observing fire dynamics under low and moderate intensity burns coupled with careful pre-fire and post-fire monitoring would aid reintroduction of fire where the fire regime is not well documented. Using research burns is expected to lower any unknown but potentially adverse effects from allowing prescribed and natural ignitions where suppression has been the norm or where fire frequency is unknown. Fire would be gradually reintroduced with the effects leading to direct beneficial, long-term benefits to vegetation. An adverse indirect effect is the time required until effects are understood and applied. A high-severity, widespread fire could occur in the Chisos before research is completed and implemented into fire operations.

Mitigation actions are the same as Alternative B.

Cumulative Effects
Cumulative effects are the same as Alternative B.

Conclusion
Short-term adverse minor to moderate impacts are expected from vegetation loss with direct long-term beneficial effects to plant communities.

Under Alternative C, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (5): Threatened & Endangered Species

Protecting federally listed species require careful precautions to safeguard individuals, populations, and their habitats over the long-term.

Wildlife
The park supports many animal species, but staff considered only those that for reasons of population size, federal protection, or limited habitat, needed special consideration in this EA. Potential fire effects

were initially investigated for 11 federally protected animals listed in Table III-1 and sensitive species listed under this topic in Chapter III. The endangered Mexican long-nosed bat (*Leptonycteris nivalis*), and endangered black-capped vireo (*Vireo atricapilla)* were formally evaluated for potential effects under the three fire alternatives. The effects of the FMP on these two species is being evaluated under a Biological Assessment (BA).

Fire is known to cause direct injury and death to animals caught in its path (Howard, Fenner and Childs 1959). Effects depend on the size, intensity, and speed of fire, and the speed and mobility of the animal. Mountain lion, deer, and bear without young could be expected to flee an advancing fire front but small animals may be unable to escape. Snakes, lizards, rodents and amphibians living underground can survive intense fire insulated by earth (Lyons et al. 2000). The Texas horned lizard survives wind driven fire in desert scrub because carrier fuels are discontinuous providing avenues for escape. Birds and bats are highly mobile and unlikely to be adversely affected by fire directly if it occurs outside nesting or roosting seasons (Robbins and Myers 1992). While fire may kill some individuals, in general effects on populations are usually negligible (Patton 1992). The Chisos is likely to pose greatest direct effects to small populations of bear and mountain lion with young, and nesting birds during extreme fire conditions.

Indirect effects of fire on habitat have greater effect on populations then individuals (Singer et al. 1989) Effects include migration, predation, starvation or death due to loss of habitat. Fire may kill agaves needed by nectar feeding bats, destroy nesting and fledgling sites for birds, eliminate insect habitat, and expose adults and young to weather extremes. Under the preferred alternative patchy burns during cool seasons outside nesting periods ensures mosaics of unburned habitat remain, reducing browsing pressure and providing alternative cover and food for small mammals, retiles and birds. Limited food sources following fire may lead to starvation of female bears and migration of males. Raptors however, may be attracted to recently burned areas that expose rodents and other prey. Successional changes from woodland or forest to shrublands or from shrublands to more grasslands will influence wildlife distributions.

Increased sediment loads may occur from erosion following fire. Amphibians and the Texas hornshell could be adversely affected as silt fills seeps and drainages, but agricultural pesticides in low river flows may prove a bigger threat. Fish are affected by changes in physical and chemical qualities of water following fire. Sediment loads increase because of erosion and may kill eggs or fry (Patton 1992). Removal of vegetation along waterways by fire may increase water temperatures leading to changes in species composition and distribution. In general these indirect effects are more important because slow reestablishment delays or may jeopardize recovery of populations.

Plants

Staff evaluated 33 plants for potential effects under the FMP and one species the Chisos Mountain hedgehog cacus is being formally evaluated in a BA by the USFWS.

Plants survive fire by either surviving the direct effects of fire, or surviving post-fire conditions (Whelan 1995). Survival during fire is facilitated by thick bark, suppression of understory limiting ladder fuels, and non-flammable foliage. Root callus, deep underground roots, soil seed reserves, epicormic buds, regeneration of vegetative plant parts, post-fire weather, and triggering of seed capsules by fire or smoke, facilitate regeneration following fire. Staff are most interested in maintaining species diversity, expecting populations of any particular species to be dynamic over time. The fire program is an investigative tool to understand how this may be achieved.

Methodology

Information from the U.S. Fish and Wildlife Service (USFWS) species recovery plans, park monitoring reports, and the experience of researchers and park staff were consulted in understanding how the FMP may affect threatened and endangered species.

Intensity of effects for threatened and endangered species is defined as:

Negligible: No federally listed species would be affected or the alternative would affect an individual of a listed species or its critical habitat, but the change would be so small that it would not be of any measurable or perceptible consequence to the protected individual or its population.

Minor: An individual(s) of a listed species or its critical habitat may be affected, but the change would be small and would not adversely affect the continued existence of the species or cause the death of any individual of the species.

Moderate: An individual or population of a listed species, or its critical habitat would be noticeably affected. The effect would have some long-term consequence to the individual, population, or habitat and would be difficult to mitigate.

Major: An individual or population of a listed species, or its critical habitat, would be noticeably affected with long-term, vital consequences to the individual, population, or habitat.

Impairment: A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Short-term: Recovers in less than one to three years after the fire or other action (depending on the species).

Long-term: Takes more than one to three years to recover after the fire or other action (depending on the species).

The Biological Assessment prepared in support of the FMP revision applies USFWS criteria:

No Effect. When a proposed action would not affect a listed species or designated critical habitat.

May affect/not likely to adversely affect: Effects on special status species or designated critical habitat are discountable (i.e. extremely unlikely to occur and not able to be meaningfully measured, detected, or evaluated) or completely beneficial.

May affect/likely to adversely affect: When an adverse effect to a listed species or designated critical habitat may occur as a direct or indirect result of proposed actions and the effect is either not discountable or completely beneficial. Staff of the USFWS review the park's assessment of impacts on threatened and endangered species and in response issues a Biological Opinion identifying agreement or areas requiring modification.

Is likely to jeopardize proposed species/adversely modify proposed critical habitat: The appropriate conclusion when the National Park Service or the U.S. Fish and Wildlife Service identifies situations in which the fire program could jeopardize the continued existence of a proposed species or adversely modify critical habitat to a species within or outside park boundaries. Staff of the USFWS review the park's assessment of impacts on threatened and endangered species and in response issues a Biological Opinion identifying agreement or areas requiring modification.

Alternative A (No Action)

Impact Analysis

Mexican long-nosed bat (*Leptonycteris nivalis*)
Under Alternative A most fires are suppressed protecting the roost and foraging range of the bat but fuels are allowed to buildup across the park and ecosystem processes are interrupted.

Mitigation actions include: assessment of agave populations (the main food of the bat) to ensure 80% of foraging area is present at any time including after fire, maintenance or suppression actions; suppression of all high-intensity fires in the vicinity of foraging areas; careful fuel reduction near the roost entrance; retaining a buffer zone of low fuels around the roost site; no retardant drops where the roost could be impacted; identification of potential fireline and spike camps prior to fires; construction of firelines using minimal impact techniques; and rehabilitation of areas near the roosting site by replanting; handbrushing lines; and, removing trash and preventing erosion. Post-fire monitoring would assess fire effects and plant recovery.

Black-capped vireo (*Vireo atricapillaus*)
Under Alternative A fires have been suppressed, protecting the birds' territories and nesting sites. Vireo habitat may be an artifact of suppression, the shrub understory growing in response to removal of grasses throiugh grazing. No fire in over 100 years makes these canyon drainages very vulnerable to fire from increased fuels.

Mitigation actions include: not burning any areas currently occupied by vireos; assessing current habitat by vireo experts to understand likely responses from fire; identifying where fuel reduction would be beneficial to habitat; identifying other areas in the park with similar vegetation structure that could be occupied; maintaining a ¼ mile buffer from fire; identifying potential firelines and staging camps ahead of fire; following fires with restoration actions such as replanting and brushing handlines and preventing erosion; and, seeking funding for a population dynamics study to understand why vireos are not occupying suitable habitat. Any research fires in nearby areas would be conducted in late fall and winter outside the vireo nesting season.

Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis* var. *chisoensis*)
This cactus is found primarily on gravelly limestone derived terraces and sloping pediments with sparse associated vegetation of lechuguilla, creosote and dog cholla. Strict decision criteria on ignitions together with few fuels in the cactus habitat have protected current populations from fire.

Mitigation actions include: establishing new populations from plants and seed, removing buffelgrass around populations and individuals, assigning a resource advisor preferably the park botanist to any fire in the area, identifying firelines and staging camps ahead of fires, avoiding retardant drops in the vicinity of the plants, and rehabilitating areas following fire suppression actions such as recontouring soils, repositioning rocks, or restoring drainage lines.

Guadalupe Fescue (*Festuca ligulata*)
Currently the only known populations of this grass are in the Chisos Mountains of Big Bend National Park and the Sierra del Carmen in Mexico. A small population of about 500 plants occurs on shaded moist slopes in Boot Canyon, and is managed under a Candidate Conservation Agreement with the Austin Texas Ecological Services of USFWS signed by the park on 9 April 1998. It is not known whether fire would potentially benefit this species. Park botanist Joe Sirotnak is currently evaluating the plants' lifecycle and requirements for reproduction. Seed set is prolific but establishment is extremely low perhaps due to high duff levels. Fire is one research approach being considered for very small areas to

test seedling establishment in mineral soils. A determination is not made for candidate species. The park will continue to coordinate with the USFWS before burns take place that may affect this species.

Under Alternative A, duff levels will continue to increase and possibly interfere with seedling establishment.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Southwestern willow flycatcher prefers thick streamside vegetation, and its rarity is a consequence of the loss of such habitat in the Southwest. In addition to habitat destruction by humans, cowbird parasitism, predation, and negative effects of recreation and research activities are all cited as threats (New Mexico Game and Fish Department 2000) leading to federal listing as endangered on September 1992 (57 FR 39664). Information on flycatcher use of the lower Rio Grande is anecdotal. The flycatcher has been recorded as nesting in the middle and lower stretches of the Rio Grande River in saltcedar (Mark Sogge, personal communication, March 2004). Since 1990, Kelly Bryant working on state lands throughout the southwest has observed the flycatchers during migration in the lower Rio Grande but has not found evidence of them nesting along the river (Personal communication, March 2004). Mark Flippo, park biologist at Big Bend confirmed Bryant's observations (March 2004). If the flycatcher nests in the riparian corridor it would be present from mid-May through September.

Fire may be a component of pilot programs in 2006 testing methods to restore sections of native riparian vegetation along the 118 miles of Rio Grande inside the park border (Joe Sirotnak, personal communication, January 2004). These small sections would be surveyed prior to any disturbance in the area. The susceptibility of the flycatcher to fire effects is slight given the bird's rarity in this region, and the extensive areas of riparian vegetation in the park, and the commitment to suppression along park borders. Because of the rarity of flycatcher sightings, a "may affect- not likely to adversely affect" determination is made for this species.

Alternative A ensures suppression of fires along the riparian border with Mexico but suppression efforts may damage vegetation.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
This medium-sized falcon was once found throughout southeast Arizona, southern New Mexico, West Texas and much of Mexico. Generally they inhabit open grasslands with scattered trees and relatively low ground cover, needing a supply of suitable nesting platforms and an abundance of small to medium-sized birds as prey. The park's grasslands have probably changed dramatically since the 1880s and what may have been ideal habitat has been greatly diminished. Aplomados have been reestablished at Marfa, 100 miles northwest of the park but none have been sighted in the park. The preferred alternative may improve habitat conditions for Aplomados and attract them to the park in the future. The determination for this species is "no effect."

Under Alternative A, suppression allows continued shrub encroachment into grasslands dissuading return of this species.

Big Bend Gambusia (*Gambusia gaigei*)
The greatest dangers to fish numbers come from competition with Western mosquitofish and the introduced Green Sunfish, which probably arrived through dumping of excess bait into the ponds. Fire program threats include petroleum from vehicles leaking into the ponds and changes in pH from fire ash. A prescribed burn close to the ponds in February 2003 dumped high levels of ash without ill-effect to the fish suggesting that the change in pH was either not large or not of sufficient duration to cause harm (Raymond Skiles, Personal communication, February, 2004). A nearby bridge made from recycled plastic may pose problems if it burns and smoldering residues drop into the water. The ponds have been protected from runoff and petroleum leaks by large earthen berms. Future prescribed burns would protect

mature cottonwoods and remove some vegetation reducing the intensity of the burn. Burns would create a mosaic to ensure some shading and protection from predators. Research burns that reduce fuels may improve spring flows increasing volume and improving water quality. A "may affect-is not likely to adversely affect" determination is made for this species under the proposed fire alternative.

Without fuel reduction measures there is the risk of fire around the ponds particularly as they are near a well-used camping area. Suppression under Alternative A would continue to increase fuels leading to higher risk prescribed burns.

Bunched Cory Cactus (*Coryphantha ramillosa*)
This cactus occurs on the limestone of the Boquillas and Santa Elena formations with creosote and lechuguilla. The plant is also found in Terrell County, Texas and the state of Choahuila in Mexico. Park staff are currently mapping all known locations of this species and will continue to update GIS databases of rare, endemic, and listed plants (Alex, 2003). Researchers Kathy Rice, Ted Anderson and Robert Schmalze at the Desert Botanical Gardens in Phoenix have been analyzing the reproductive characteristics, microhabitat, and associated vegetation of this cactus (1 April, 2004). The proposed alternative for the FMP is unlikely to cause adverse impacts on known populations in the absence of grasses and other vegetation to carry fire. The determination for this species under the preferred alternative is "may affect – not likely to adversely affect."

While suppression under Alternative A protects current populations, the suppression activities may inadvertently damage plants.

Lloyd's Mariposa Cactus (*Sclerocactus mariposensis*)
Named for the Mariposa Mine in Southern Brewster County where it was first discovered, this cactus occurs on rocky, gravelly soils primarily derived from limestone. It is an attractive, rounded plant to four inches with pale star-shaped spines and pink, green or tan flowers in February through March, with fruiting from April through May. This cactus was listed as threatened in 1979 because of over-collecting. A recovery plan was developed in 1992 by the U.S.FWS. Park staff estimate there are many hundreds of individuals on about 30 sites primarily in the Eastern side of the park and the Black Gap Wildlife Management Area at elevations of 2,600-4,600 feet. Associated vegetation includes sparse creosote, lechuguilla, candelilla, leather stem, and other cacti. It is unlikely that fire will have an adverse impact on the park populations as fuels are sparse and discontinuous. Therefore the park makes a determination of "may affect- not likely to adversely affect" for the proposed fire program.

While suppression under Alternative A protects current populations, the suppression activities may inadvertently damage plants.

Hinckley's Oak (*Quercus hinkleyii*)
This oak is unlikely to occur in the park as the extremely distinctive foliage is difficult to miss.

Mitigative actions are: following USFWS Recovery Plans for listed species; ensuring resource experts are consulted during fire operations; preemptive plans are in place before fires to minimize damage; non-fire fuel reduction or prescribed burns are used to protect habitat; post-fire monitoring is used to improve prescriptions.

Cumulative Effects
Cumulative effects include

- Development of walking trails in the Chisos and along the river may increase disruption to established wildlife use patterns – a minor adverse effect.
- Large fires on state and private lands adjacent to the park may jeopardize recolonization of animals (e.g. bear) and plants if the park has losses after fire.

- High-severity fire could occur before the outcomes of the preferred alternative take effect – a minor to moderate direct adverse effect.
- Continued fuel accumulations in the Chisos increase the likelihood of high-severity fire and the loss of rare plants and animal habitat – direct, adverse minor to moderate effects.
- Expansion of nonnative plant species increases the intensity of fire – a direct adverse minor effect.
- Pilot revegetation of natives along riparian corridor could be minor direct beneficial effect.
- The effect of past and future flood and erosion events are difficult to ascertain.
- Defoliation of trees by caterpillers in the Chisos during periods of stress increases woody fuels and fires burn hotter – a minor to moderate direct adverse effect.
- Expanded interpretive and education programs may increase public support for fire operations that reduce fuel loads and protect habitat - a minor to moderate direct beneficial effect.

Conclusion
In the short-term, effects to listed plant and animal species are minimized by suppression. The likelihood of adverse affects increases with time as fuels build and fires are likely to be more widespread and burn hotter. Removal of habitat is likely to cause greater loss than direct impacts of fire to animal species.

Under Alternative A, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
Mexican long-nosed bat (*Leptonycteris nivalis*)
More natural and prescribed fire is proposed under Alternative B outside the bats seasonal stays from mid May to late July in the park. Alternative B provides the option of prescribed burns to lower fuels if deemed necessary.

Mitigation actions are the same as the No Action Alternative.

Black-capped vireo (*Vireo atricapillaus*)
Under Alternative B, more low and medium intensity natural and prescribed fire will be allowed in the park to reduce fuels and quickly allow fire to resume its role in the landscape. Vireo experts met in the park in June-July 2004 to identify the best strategies for the bird's protection. A mix of non-fire treatments, prescribed burns, monitoring and research was proposed.

Mitigation actions are the same as the No Action Alternative.

Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis* var. *chisoensis*)
Under Alternative B, more natural ignitions will be allowed to burn across the park under flexible criteria governing decisions on fire. Prescriptions are broad to allow natural fires to burn at low to moderate intensity. While fires are allowed under these Alternatives, fires in cactus habitat have been uncommon due to sparse, discontinuous fine understory fuels. However, movement of buffelgrass into nearby arroyos and around some populations increases fuels, flammability and the potential for injury from fire.

Mitigation actions are the same as the No Action Alternative.

Guadalupe Fescue (*Festuca ligulata*)

Under Alternative B fire may sweep through the entire population with unknown consequences.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Under Alternative B, the use of agreements with neighbors could lead to larger burn areas as fires are allowed to burn to natural barriers such as the river, roads or canyon walls. The trade off is maintaining potential habitat versus safety and firefighting effectiveness.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
Alternatives B both allow more fire across the park with potentially beneficial effects on grasses and prey for this species.

Big Bend Gambusia (*Gambusia gaigei*)
Decades of suppression and abundant vegetative growth fed by springs have led to accumulations of fuels in some area around the ponds. Prescribed burns around the ponds in 2003 to reduce fuels were difficult to control. Other non-fire thinning and mechanical reduction followed by burning of slash piles may be one way to reduce risks associated with burning. Some fuel reduction is planned to lower hazards in nearby campgrounds.

Bunched Cory Cactus (*Coryphantha ramillosa*)
Alternatives B allow more fire across the park. Low discontinuous fuels on limestone reduce the likelihood of intense or widespread fire under either alternative.

Lloyd's Mariposa Cactus (*Sclerocactus mariposensis*)
Alternative B would allow natural fires to burn. However, fires are uncommon because fine fuels that facilitate the spread of fire are low and discontinuous.

Hinckley's Oak (*Quercus hinkleyii*)
Same as Alternative A.

Cumulative Effects
Cumulative effects are the same as the No Action Alternative.

Conclusion
Allowing more low and moderate intensity wildland fire and additional prescribed burns lessens fuels and the likelihood of adverse effects to plant and animal species and habitat from high-severity fire. These are indirect long-term minor to moderate and beneficial.

Under Alternative B, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Mexican long-nosed bat (*Leptonycteris nivalis*)
Alternative C allows for prescribed burns to reduce fuels and provides the option of research burns to improve foraging habitat if deemed necessary. This Alternative is the preferred scenario as fuels and plant populations are assessed before any decision to conduct prescribed or research burns, fires would be reintroduced carefully to minimize agave mortality, and a natural fire dynamic gradually restored.

Mitigation actions are the same as the No Action Alternative.

Black-capped vireo (*Vireo atricapillaus*)
Under Alternative C, the preferred Alternative, more natural fire and prescribed fire will be allowed in the park as for Alternative B. However, fire will be allowed into areas based on the results of research burns that identify fire effects and dynamics and answer management questions.

Mitigation actions are the same as the No Action Alternative.

Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis var. chisoensis*)
Under Alternatives B and C more natural ignitions will be allowed to burn across the park under flexible criteria governing decisions on fire. Prescriptions are broad to allow natural fires to burn at low to moderate intensities. While fires are allowed under these alternatives, fires in cactus habitat have been uncommon due to sparse, discontinuous fine understory fuels. Movement of buffelgrass into nearby arroyos and around some cactus populations however, increases fuels, flammability and the potential for injury from fire.

Mitigation actions are the same as the No Action Alternative.

Guadalupe Fescue (*Festuca ligulata*)
Under Alternative A, duff levels will continue to increase and possibly interfere with seedling establishment. Under Alternative B fire may sweep through the population with unknown consequences. Under the preferred alternative, Alternative C, a small research burn may be considered to identify germination and establishment rates as most grasses evolved in association with fire.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Under Alternative C the use of agreements with neighbors could lead to larger burn areas as fires are allowed to burn to natural barriers such as the river, roads or canyon walls. The tradeoff is loss of potential habitat versus safety and firefighting effectiveness.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
Both Alternatives B and C allow more fire across the park with potentially beneficial effects on grasses and prey for this species.

Big Bend Gambusia (*Gambusia gaigei*)
Decades of suppression and abundant vegetative growth fed by springs have led to accumulations of fuels in some areas around the ponds. Prescribed burns under Alternative A in 2003 around the ponds reduced fuels but proved difficult to control. The ponds proximity to a high-use camping area maintains the risk of fire from carelessness. Alternatives B and C allow more fire across the park reducing fuel levels including the nearby campsite.

Bunched Cory Cactus (*Coryphantha ramillosa*)
Alternative C is the same as Alternative B.

Lloyd's Mariposa Cactus (*Sclerocactus mariposensis*)
Alternative C is the same as Alternative B.

Hinckley's Oak (*Quercus hinkleyii*)
It is unlikely that the oak is present in the park as it has extremely distinctive foliage but has not been found.

Cumulative Effects
Cumulative effects are the same as the No Action Alternative.

Conclusion
Reduction of fuels across the park reduces fire intensity – a direct minor beneficial effect. Applying research results to manage habitats of protected species is a long-term direct beneficial effect.

Under Alternative C, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (6): Cultural Resources

Fire may help reduce hazard fuels, maintain historic views and ethnographic resources, but can also remove plant populations that are important as ethnographic resources, damage and destroy structures and artifacts, and cause adverse changes to significant vegetative components of cultural landscapes.

The rich cultural history of Big Bend National Park is contained in the archeological record and in numerous historic buildings, sites, and settlements. The park as a whole is itself a complex cultural landscape characterized by visible effect of human influence on the natural environment as reflected in communities, small farming settlements, ranch sites, over 450 individual buildings and ruins, extensive farmlands with vernacular irrigation features, and a widespread network of roads and trails. The four main resource types include historic structures, cultural landscapes, archeological resources and ethnographic resources. Fire and fire management activities affects these types of cultural resources very differently.

Greatest damage can occur to historic buildings containing combustible materials. Under extreme fire temperatures, metals and glass melt, ceramics crack and vitrify. Structural integrity of these artifacts is impaired at 232 C and at higher temperatures pollens and other woody materials (which enable dating) are consumed or transformed (Jones, 2002). At temperatures greater than 135 C solder joints in metal cans melt and mortar joints in masonry walls begins to spall. These sites are also damaged by smoke, suppression activities and post-fire erosion, and damage to buildings jeopardizes National Register standing. The fire program sought specific guidelines from the staff cultural resource specialist (CRS) to reduce risk to this group of cultural resources.

The most important consideration in planning fire activities is that of protecting archeological context. The significance of sites, site features, and artifacts is in the degree of integrity of archeological context. Any activity that dislodges features or artifacts from their original location and context changes the scientific interpretation of the site. Any activity that alters the original condition of the site or the cultural materials within it potentially reduces the scientific values which qualify the site for the National Register. Prehistoric archeological sites are presumed to have burned occasionally. Studies in New Mexico show that damage can occur as deep as 20cm into the soil and substantial damage at all fire intensities (Lentz et al. 1996). Fire that burns woody stems of plants growing in prehistoric hearths introduces new carbon into the feature as the plant base decays and debris falls into the depths of the feature, which potentially contaminates radiocarbon dating of the feature. Reducing flammable brush can contain risks from fire, but the removal of the vegetative cover from a site exposes site features and the increasesd visibility increases the potential of damage from vandalism and theft. Managers must weigh these advantages and disadvantages during fire planning. Archeological identification surveying prior to prescribed burns will slowly identify additional sites within the park.

Vegetation that covers sites and cultural landscapes can screen these sites from view and protect them from the erosive force of rain and sun. An important character defining component of cultural landscapes are the historic plantings placed there by the site occupants. It is important to exclude these vegetative components from damage or loss from either wildland fire or prescribed burning activities. Plants can also

undermine building foundations, and alter historically used springs. Water erosion and fire suppression activities place cultural landscapes at risk.

Ethnographic resources include plants, animals, landscapes or sites that held significance for American Indians. Whether the maintenance of these resources depended upon the deliberate use of fire is unclear but Cabeza de Vaca noted in 1528, that Indians use fire sticks to ignite plains and timber to drive out game (in Kozlwoski and Ahlgren 1974:392). Indscriminant removal of or alteration of plants from a traditional gathering site must be avoided during prescribed fire planning.

Assessment Methodology

Information in this section was developed primarily from the detailed analysis of cultural resources listed as Appendix 11, from the draft GMP (2003), technical literature, and staff at the park. Cultural resources in the park occur in all of the FMUs. The treatment of the cultural resource is determined by the nature of the resource and not by the FMU. Consequently, suggested treatments in Appendix 11 are grouped primarily according to resource type.

Intensity of effects for cultural resources is defined as:

Negligible: Effects are at their lowest level. There are no perceptible consequences to archeological sites, historic structures or cultural landscapes.

Minor: Adverse effects would be confined to a small area with little loss of important archeological information; non-measurable loss of defining characteristics of historic buildings or cultural landscapes. Beneficial impacts include stabilization of sites.

Moderate: Adverse effects would be disturbance to a site without loss of important archeological information or character defining features of historic structures or landscapes. These would still be eligible for the National Register. Beneficial impacts include stabilization of a site or rehabilitation of a landscape while preserving its character-defining features.

Major: Adverse effects include disturbance of a site so that much of the important information is lost, the integrity of buildings or cultural landscapes are damaged and the site no longer fulfills requirements for National Register status. Major beneficial actions include the intention to preserve a site and restoration of a building following Secretary of the Interior's Guidelines for Treatment of Historic Properties.

Impairment: A major, adverse effect to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Duration Definitions:

Duration of impacts to cultural resources is not usually considered under the National Historical Preservation Act. Direct impacts are usually adverse and permanent. Landscapes may recover and even benefit from fire and fuel reduction.

Alternative A

Impact Analysis

Under Alternative A, a prescribed burning and fuels reduction program has been developed over the past 20 years to protect developments. Cultural resources have yet to be included under this regime because of limited resources and lack of understanding about how to use the program for best results. The park is currently assessing fuels around particular types of resources, historic buildings, cultural landscapes, ethnographic resources, and archeological sites. There are no blanket prescriptions because all types of resources are found throughout the park in differing types of vegetation and subject to differing risks from fire. Therefore, fire treatment is site-specific and must be tailored to the nature of each individual site. Wherever possible general prescriptions are developed to treat the different resource types and those resources on the Register of National Historic Historic Places. Overall, strict criteria governing fire in the park has likely protected many structures but fuels continue to build up (particularly in the Chisos), which increases flammability and fire temperatures.

Estimates of possible cultural resource sites in the park exceed 26,000, which make accurate estimates of impacts difficult without surveys. The most important consideration in planning fire activities is that of protecting archeological context. The significance of sites, site features, and artifacts is in the degree of integrity of archeological context. Any activity that dislodges features or artifacts from their original location and context changes the scientific interpretation of the site. Any activity that alters the original condition of the site or the cultural materials within it potentially reduces the scientific values which qualify the site for the National Register. Firelines and spike camps placed under emergency conditions may result in direct, adverse long-term impacts such as displacing artifacts from their original archeological context, and damage from crushing, spalling, cracking or consumption of materials.

Mitigation actions are: locate and identify sites vulnerable to fire effect; manually or mechanically reduce fuels; construct fire breaks around registered sites; use minimum impact techniques; ensure an archelologist or similarly qualified resources person is consulted during fires.

Cumulative Effects

Cumulative effects include:

- Construction of building and trails could have minor adverse effects minimized by surveys.
- Past and future prescribed burns, wildland fire use and non-fire fuel treatments may have adverse minor impacts, minimized by surveys and use of resource experts.
- Continued fuel accumulations in the Chisos, and expansion of exotic plants may lead to hotter burns and cause minor adverse effects.
- Revegetation of natives may reduce fuels leading to minor beneficial effects.
- Past and future flood and erosion events may have moderate to major adverse impacts.
- Expanded interpretive and education programs may lead to minor beneficial effects.
- Ground disturbance during suppression and hotter fires would result in minor direct and indirect adverse effects. Under Alternative A (No Action), cumulative impacts could be more intense because of the increased potential for high-severity fires.

Conclusion
Under Alternative A, minor to moderate beneficial impacts are likely to known sites. Impacts are likely to be localized and long-term. Under Alternative A, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
Allowing more prescribed and natural fire across the park increases the opportunity for fire to damage known sites and for undocumented sites to be damaged by fire control activities. Reducing fuels throughout the park is likely to result in minor to moderate direct beneficial effects for cultural resources over the short-term. The length of benefits depends on frequency of burns, their intensity, and control methods. Unknown archeological sites are at moderate adverse risks from suppression activities.

Mitigation actions are the same as Alternative A with the addition of allowing fire to burn to natural barriers along the park border. Allowing fire to extinguish naturally would reduce damage from suppression.

Cumulative Effects
Culumlative effects would initially be the same as Alternative A until fuels are reduced in the Chisos.

Conclusion
Alternative B is likely to result in long-term beneficial effects as fuels are reduced across the park and treatments of specific sites are implemented. Effects on unknown sites cannot be easily ascertained but prehistoric sites that have burned previously likely will not be damaged further. Greatest risks are from suppression activities.

Under Alternative B, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Under Alternative C, developed areas remain protected through prescribed burning and no-fire treatments, and an expanded monitoring program builds knowledge of fire effects. More fires will be allowed to burn elsewhere in the park under prescriptions and may cause minor direct adverse effects over the short-term as archeological sites are blackened and exposed. Like Alternative B, suppression and control activities could inadvertently cause adverse effect to unknown prehistoric archeological sites. Increased burns using low intensity fire treatment will reduce fuel levels leading to lower levels of risk to cultural resources from high-intensity fires.

Mitigation actions are the same as Alternative A with the inclusion of more sites found through surveys associated with increased prescribed burns and monitoring.

Cumulative Effects
Cumulative effects are similar to Alternative A. Adverse impacts from increased prescribed burning could be greater unless accompanied by surveys and minimum impact suppression techniques.

Conclusion
Implementing mitigative measures in conjunction with increased fire use in the park would keep minor adverse long-term impacts to a minimum.

Under Alternative C, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (7): Watershed Effects

Fire can remove vegetation and organic matter, and followed by intense thunderstorms lead to loss of rare plant and animal species through erosion, debris flows, and siltation, the demise of relict forests, invasion by weed species, loss of wildlife habitat, and substantial long-term changes in the vegetation.

The Chisos Mountains are a premier destination for visitors to Big Bend. Camping in the mountains is the most popular recreational activity (GMP 2003), and one the park wants to maintain. The sparsely vegetated lowland desert grasslands are a sharp contrast to the mountains and a reminder of the predominant climate throughout this region. Staff believe the region is significantly altered since grazing but some areas may have the potential to be restored, which would represent a significant scientific contribution to desert grassland restoration.

Post-fire impacts on watersheds are influenced by many factors. Fire intensity, rainfall intensity and amount, slope, soil texture, water depth and holding capacity, rock fractures and outcrops, and amount of vegetation and charred material will affect infiltration, runoff, and potential erosion. Vegetation removed by fire is no longer available to break the erosive impact of rain, nor utilize water that infiltrates soils. Severe fires burn the tree canopy and soil seedbeds, and invasive plants better adapted to drier soils may colonize exposed sites. During fire, soil surface temperatures are high and dry out, which makes them initially hydrophobic and prone to runoff. Other effects are the release of nitrogen upon burning and stimulation of microbial activity upon exposure of soils to higher temperatures and oxygen. Post-fire temperatures of soil are elevated and may aid seedling germination with sufficient moisture (Scifres and Hamilton 1993). Erosion becomes a threat immediately following fire as intense thunderstorms may dislodge soil particles on bare steep slopes, which carries them into drainage lines and silting areas below. These flows could be short-lived but overwhelm seasonal drainages where mesic plant and amphibians live. Recovery may also be jeopardized by the changes in nutrient levels and ph within shallow ponds that become silted. The amount of erosion is influenced by rainfall intensity, permeability of the soil, and amount of vegetation, cobbles or rock on the surface. The intense summer rainfall is absorbed more readily by sandy, gravelly, and loamy soils than by fine-textured clays and silts, found in flatter areas and in depressions.

Assessment Methodology
Staff estimated likely impacts of erosion and debris flows on 11 watersheds with 6 major soil map units in the Chisos Mountains. The estimate of effects was based on soil type, slope, and rainfall conditions following a (1) high severity, widespread fire that could occur without fuels reduction, and (2) a moderate intensity fire, which is the upper limit of allowed fire conditions under the preferred alternative. Park hydrologist Jeffrey Bennett and soil scientist Lynn Loomis (USDA/NRCD Marfa, January-May 2004), provided guidance for this watershed evaluations.

Intensity of effects for watersheds is defined as:

Negligible: No runoff, debris flows, or perceptible effects on soils.

Minor: Perceptible but hardly measurable effects on soils or debris flow. Effects easily restored.

Moderate: Measurable and noticeable effects. Runoff causes erosion. Debris flows silt drainages and ponds. Restoration work required to prevent downcutting and siltation of drainages.

Major: Erosion is apparent and cannot be remedied easily. Debris flows have silted low lying areas. Soils and organic matter layer are removed. Restoration is extensive.

Impairment: A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Short-term: For the duration of the fire season.

Long-term: For the duration of the fire program or longer.

Alternative A

Impact analysis
Under Alternative A, restrictive go/no-go decision criteria mean most lightning ignitions are suppressed. The probability of widespread, high-intensity fire in woodlands and forests of the Chisos Mountains increases with the buildup of leaf and needle litter, downfall, ladder fuels and the closure of tree canopies. A high-severity, high-intensity fire would result in long-term, moderate to major adverse impacts on watersheds. The intensity and duration of rainfall, coupled with soil texture and depth, slope, rock fractures and outcrops would determine erosion and debris flows following fire. Intense thunderstorms may silt drainages containing rare species. Sparse vegetation in the lowland deserts means most fire is driven by high winds and results in a mosaic of burned and unburned areas.

Mitigation actions are: prescribed low-intensity burns in the Chisos; identifying firebreaks, staging camps and spike camps ahead of fires to minimize ground disturbance from suppression activities; uppressing fire in Upper Pine Canyon, a Research Natural Area, where fire would interrupt long-term ecological studies. There are few options for reintroducing fire due to restrictive decision criteria on natural ignitions and treatment of the Chisos as a suppression zone. Staff have been reluctant to explore grassland restoration in lowland deserts without a clear research agenda.

Cumulative Effects
Cumulative effects that would increase adverse effects in the Chisos are the construction of additional hiking trails, and continuing buildup of fuels. No action in the lowland deserts may result in continual erosion, the rate dependent on precipitation, climatic cycles, and periodic thunderstorm events. Under Alternative A, cumulative impacts could be more intense in the Chisos because of the increased potential for high-severity fires.

Conclusion
Fire management suppression impacts to watersheds in the Chisos are likely to be adverse, minor to moderate and long-term while suppression continues, fuels build, and the potential for high-severity fire increases. The potential continues for moderate, adverse impacts to soil stability and debris flows following high-severity fire and summer monsoons. While suppression remains successful impairment is unlikely. Minor, adverse impacts are expected to watersheds in lowland deserts without restoration efforts.

Under Alternative A, because there would be no major adverse impacts to watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Alternative B

Impact Analysis
Under Alternative B, natural and prescribed fires are allowed to burn under prescription across the entire park up to buffered areas around developments. This alternative proposes rapid reintroduction of fire to park ecosystems to reduce high fuel loads in the Chisos woodlands and forests. This would also regenerate plant communities where fire occurred naturally. The prescriptions ensure that initially burns are low- to moderate-intensity until fire effects are understood. Staff would review of fire effects annually and adjust intensity and season to allow more lightning ignitions just prior and during summer monsoon when most fire historically occurred.

Impacts are expected to be short- to long-term and minor to moderately beneficial in reducing fuels and regenerating plant communities. There may also be short- to long-term minor to moderate adverse effects to views and soils in the Chisos as vegetation reestablishes.

Mitigation actions are similar to Alternative A with the addition of post-fire monitoring of prescribed and natural ignitions, and annual review of prescribed burns and fine-tuning of prescriptions.

Cumulative Effects
Alternative B would have fewer adverse long-term effects than Alternative A. Allowing fire in the Chisos at low and moderate intensities should lessen cumulative effects of fuels on the likelihood of high-severity fire.

Conclusion
Under Alternative B adverse impacts to the Chisos Mountain watersheds would be minor to moderate and short-term. Minor adverse impacts from fire are likely in lowland desert areas. Beneficial impacts are expected over the long-term for watersheds in the Chisos. Extreme fire events outside prescription before fuels can be reduced would create moderate to major direct adverse impacts over the short and long-term.

Under Alternative B, because there would be no major adverse impacts to watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Alternative C

Impact Analysis
The Zone of Special Treatment under Alternative C calls for research fires and careful management of lightning ignitions within prescriptions. Research results potentially allow fires to be managed in

sensitive habitats and watersheds with less damage than high-severity fire. Natural fire reduces fuels and potential moderate adverse impacts to watersheds. Application of research burn knowledge is expected to yield short to long-term direct and indirect beneficial impacts to watersheds.

Mitigation actions are similar to Alternative B with the additions of: erecting brush or other structures to limit erosion and avoid silting rock pools and drainages; reestablishing native plants where needed; preventing the spread of exotics particularly into sites where native species are establishing; allowing natural ignitions in desert scrub and grasslands to slow the shrub encroachment; establish small research burns in areas where soils appear stable, seed sources of desired species are present, and knowledge of 'fix-it' techniques are known if the burn results are unsuccessful; use brush and other appropriate techniques to slow overland flows, increase infiltration, cool soil temperatures and generally improve conditions for germination and establishment of plants; control exotics that may have invaded scrub or grasslands.

Cumulative Effects
Cumulative effects may be similar to Alternative B but take longer to accrue. Research results in the Chisos from prescribed burns would then be reapplied under suitable climatic and management conditions. Any recovery in lowland deserts will be shaped by wet climate cycles more than fire events. These effects would cumulatively result in minor to moderate direct and indirect beneficial short-term effects to watershed integrity and long-term benefits to nutrient cycling.

Conclusion
The preferred alternative would result in long-term moderate direct and indirect beneficial effects. Low to moderate intensity research burns, assessment of fire effects and gradual reintroduction of natural ignitions based on this knowledge is expected to safely reduce fuels and preserve resources valued by the public. Fire management guided by research into restoration of lowland deserts may have direct and indirect benefits to watersheds over the long-term.

Under Alternative C, because there would be no major adverse impacts watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Impact Topic (8): Resources for the Fire Program

Big Bend is a large park with a relatively small fire program. The emphasis on the proposed action alternatives is to (1) reduce fuels to safe levels through a mix of wildland fire use, prescribed burns, and no-fire thinning, and to (2) better understand fire effects in a number of sensitive habitats. Staffing levels currently dictate that some routine tasks in most divisions are deferred. An increase in routine fire operations would drain the already taxed staff and suggests additional human resources are needed to support the increased level of fire program activities. Attempting to "make-do" with existing staff can lead to inadequate reporting, insufficient supervision of staff new to tasks, stress and burnout, and failure to adequately monitor pre-fire and post-fire burn sites for cultural resources and natural resource data. In addition, lack of time and resources may result in new data not being translated into management decisions. Currently, the park can cope with wildland fires to a limited degree with initial attack and confinement operations, and some extended attack efforts depending on the circumstances (for example: personnel availability, visitation numbers, risks, regional readiness, and logistical support).

Assessment Methodology
Evaluation of existing resources and proposed needs under action alternatives was obtained primarily from the Fire Management Officer based on experience catering to prescribed and wildland fires under the No Action Alternative (Alternative A).

Intensity of effects for resources for the fire program is defined as:

Negligible: Impacts are at the lowest levels of detection with no additional staff or funding required.

Minor: Detectable effect but additional staff and funding can be found from within existing park resources.

Moderate: Effect is such that additional outside resources are needed for fire activities and outside funding is required to support such activities on a seasonal basis.

Major: Additional permanent staff and resources are required to carry out fire management activities.

Short-term: Duration of the planning and execution of fire program activities.

Long-term: Long-term effects of insufficient resources extend beyond the FMP and cumulate in patchy research results, sporadic fulfillment of fuels assessment and fuels reduction, inability to provide monitoring timely or accurate monitoring data, all factors that limit knowledge for future decision making around fire effects.

Alternative A

Impact Analysis
The major thrust of the fire program under Alternative A is protection of developments through prescribed burns and mechanical and manual thinning. The park has maintained a 'safety by suppression' approach to lightning ignitions. Fuels continue to buildup in the Chisos and the park lacks the resources to confine or control large fires or a fire that spreads rapidly with multiple resource type requirements—engines, crews, and aircraft. Several years of above average rainfall (2002, 2003) combined with fuel buildup in the Chisos and unfilled key personnel positions, creates the potential for a high-intensity fire that would strain existing resources. The current alternative has contributed to direct and indirect moderate adverse impacts in the short-term and the long-term. How this situation is resolved adverse beneficial, depends on the level of training, availability of funding and personnel for seasonal firefighting, ability to undertake higher risk operations, and whether current key positions are filled, such as Engine Boss and Crew Boss.

Mitigation actions are: recruitment and training of seasonal Los Diablos firefighters from Mexico; training of existing staff; and sharing of trained staff from other departments, agencies and the region. Staff sharing occurs on a regional basis during extreme fire events.

Cumulative Effects
Cumulative effects under Alternative A include the diversion of fire staff assigned to other duties such as trail maintenance or interpretive activities due to rising visitation. The impact of this Alternative will vary depending on the year, number of fires, weather conditions in addition to regional conditions. Severe fire conditions in combination with increased visitation would create moderate adverse seasonally short- and long-term effects.

Conclusion
Under the current management direction there would be long-term minor to major adverse impacts to park values and resources as existing staff are called to meet increasing numbers of emergency fire situations.

Alternative B

Impact Analysis
More natural fire is expected in the park under Alternative B requiring intermittent non-predictable staffing needs. The fire program can create scenarios identifying needed staff and other resources but cannot predict which scenario will actually occur. Additional protection activities are planned for developments, selected cultural resource sites, and sensitive species habitats. Communications with neighbors about changing boundary agreements to create safer conditions for fire fighters and reduce damage to soils and vegetation – will take time. Effects depend on size, intensity and location of fire, the number of fires within a particular period and available support from other agencies and the region. Short-term minor to moderate direct adverse impacts are expected to resources if fires are large or occur before sufficient trained personnel and resources can be utilized.

Mitigation actions are: increasing preplanning such as fuels assessment prior to burning; allowing only low to moderate intensity burns; developing buffer areas and defensible space; identification of potential firelines and spike camps; use of a resource advisors; fine-tuning prescriptions; and recruitment and training of seasonal firefighters and permanent staff.

Cumulative Effects
Cumulative effects are similar to Alternative A but could be more adverse unless additional resources are available to meet higher demands for fuels reduction and more natural fire. Moderate direct adverse short to long-term impacts would be expected in high fuel areas of the park as staff are redeployed to cope with more fire related demands.

Conclusion
Under Alternative B, more frequent and larger natural fires, and more fuels reduction treatments are expected to tax existing staff, seasonal firefighters, engines, and equipment. Shifting from suppression under Alternative A to more routine fire events will require reassignment of staff priorities and/or hiring of additional staff with sufficient engines, equipment and safety training. Depending on how resource needs are met, these changes could be minor to moderate adverse (if met within the park) or beneficial (additional hires from outside the park) with direct and indirect long-term effects to park resources.

Alternative C

Impact Analysis
Under Alternative C, more natural and prescribed burns are allowed across the park after fuels assessment. Protection of developments will continue with a program of prescribed burns, thinning, mowing, and herbicide application. A unique aspect of this alternative is the use of research burns to better understand fire effects in sensitive habitats, particularly the woodlands and forests of the Chisos. Scientific design, pre-fire and post-fire monitoring, and evaluation of results will enable outcomes to be incorporated into management practices for these sensitive resource areas. Expanding, developing and maintaining this three-pronged approach to fire management will require a considerable change in direction for fire staff and managers. Not only will additional resources be required but also time for the planning, evaluation, and interpreting results into adaptive management.

Short to long-term minor to moderate direct and indirect adverse effects are expected if staff are reassigned from existing positions to share additional tasks. A benefit is that additional trained personnel available to assist with fire activities. The level of skill and experience for some tasks, such as scientific design of research burns, will required specialized backgrounds. Burns conducted in rugged terrain or around rare or threatened habitat may require that ignitors and/or firefighters receive additional training from specialized crews such as the “Hot Shots.”

Mitigation actions are: the recruitment of additional Los Diablos to handle prescribed and natural ignitions on a more routine basis in the park; filling key positions within the fire program including Engine Boss, Crew Boss and fuels specialist; determining priorities and methods for reducing fuels around cultural resource sites; and determining specific questions to be answered by research burns.

Cumulative Effects

Cumulative effects of Alternative C on park resources for the fire program will depend on the frequency, timing, and severity of fires. Prescribed burns will mostly occur outside the fire season when pressures on park fire crews are lowest. Allowing for more ignitions during fire season will increase pressures on permanent and seasonal resources within the park and regionally. In an emergency staff would be deployed from existing duties to provide logistical support as needed. If support is needed frequently, other planned projects such as construction of buildings and trails would be delayed and may incur additional costs – a short-term direct minor to moderate adverse impact.

Conclusion

Under Alternative C, impacts to resources for the current fire program and staffing levels are likely to result in moderate direct and indirect adverse effects. The expected increase in actions cannot be met without additional input from scientists for research burns, cultural resource specialists for protection of specific sites, knowledge of fire effects across the park (requiring pre-monitoring and post-monitoring (whenever possible)), and additional permanent or seasonal staff. These requirements are likely to instigate long-term changes in the park fire policy to enable adaptive management of resources and values.

Chapter V: Consultations and Preparers

Preparers

Alex, Betty, *GIS Specialist, Big Bend National Park.* BS in Wildlife Biology Corpus Christi State University. Five years sedimentation scientist with USGS, 24 years with NPS, 11 as activities clerk, 13 as GIS specialist. Performs spatial analyses, creates maps and coordinates mapping of all park resources; special interest in rare plants. Compiled all maps for this project and shaped rare plants information.

Alex, , *Cultural Resource Specialist, Big Bend National Park* - BA in Cultural Anthropology from Stephen F. Austin University in Nacogdoches, Texas. 36 years experience in the field; contract archeologist for municipalities and mines in Texas and Louisiana; research assistant, supervisor for excavations and field supervisor; 20 yrs with NPS at Big Bend NP. Lead on cultural resource issues.

Bennett, Jeffery, *Hydrologist, Big Bend National Park.* BS from Sul Ross University, Alpine, TX in Earth Sciences, MS in Geology from Northern Arizona University, Flagstaff, AZ. 4 years soils/beach erosion and 5 years water quality in Grand Canyon NP, 3 years groundwater hydrogeologist, 1½ years at Big Bend NP. Lead on watershed effects.

Davila, Vidal, *Chief of Science and Natural Resources, Big Bend National Park.* BS in Recreation and Parks Administration from Texas A & M University. Management of cultural and natural resources at Armistad Recreation area 3yrs, Santa Fe Regional Office 1 year, Guadalupe NP 6 years, Great Basin NP 5 years and Big Bend NP a total of 15 years. Lead on compliance issues and correspondence with agencies.

Gatewood, **Richard,** *Fire Ecologist, National Park Service, Chihuahuan Desert Units*. Ph.D Disturbance and Restoration Ecology, Colorado State University. 4 years Ecologist, State of Texas; Research Associate, USDA Forest Service Rocky Mountain Experiment Station; 4 years Ecologist Bandelier National Monument. Lead on fire ecology and fire effects research and monitoring for the park. Technical representative between Big Bend NP and University of Arizona.

Moodie, Susan, *Research Associate, University of Arizona School of Renewable Natural Resources*. Ph.D. Candidate Arid Lands, University of Arizona. 5 years technical advisor, policy development community-based ecological restoration, Australia; 2 years organic market gardener New Mexico, 3 years entomology research, 2 years farming systems research Malawi, Africa, 4 years teaching and curriculum development. Lead coordinator for this EIS and associated compliance documents.

Morlock, John, *Fire Management Officer, Big Bend National Park*. BS in Conservation of Natural Resources from Texas A & M University; 7 years as River Ranger at Big Bend NP; 16 years as FMO at Bryce Canyon, Utah, El Malpais, New Mexico and Big Bend NP. Lead on fire management issues.

Skiles, Raymond, *Senior Wildlife Management Officer, Big Bend National Park.* B.S in Wildlife Ecology from Texas A & M University. Seasonal worker on interpretations, law enforcement and natural resources at Big Bend NP, Death Valley NP, Colorado NM, and Shenandoah NP; 1 year Washington D.C. public affairs; 17 years Big Bend as Wildlife Biologist. Lead on wildlife, federally listed species and fire effects.

Sirotnak, Joe, Botanist, Big Bend National Park. Ph.D in Ecology, Idaho State University. 4 years Botanist at Big Bend NP; 1 year Ecologist at Great Basin NP; 6 years Research Assistant in Ecological Research Idaho State University; I year Biological Technician; 1 year Research Biologist, Lead on vegetation categorization, federally listed plant species and fire effects; co-developed research approaches.

Reviewers:

Internal Review
Gebow, Brooke, *Senior Research Specialist, University of Arizona School of Renewable Natural Resources*. MS in Ecology and Evolutionary Biology from University of Arizona, 6 years energy consulting, 12 years free-lance science writer, 4 years Tucson Botanical Gardens, 5 years project support for UA USGS Sonoran Desert Research Station. Cooperator with the NPS to coordinate production of a number of NPS Fire Management Plans and associated compliance documents.

Peer Review
Lujan, John, *Superintendent Guadalupe Mountains NP*. BA in History from Sul Ross State University in Alpine, Texas: 27 years with the NPS at eight park units representing cultural, natural and recreational areas. Fire Management background includes fire fighting experiences across the west and southeast. Oversight of the development of the Interagency FMP between the NPS and the BLM.

Chronology

The preparation of this draft Environmental Assessment involved consultation between the NPS and UA partners, government agencies, and outside experts and researchers from December 2002 to December 2004. The chronology below identifies important scoping periods, meetings, and outside consultation.

12-11-02 12-12-02	Internal Scoping Meeting at Big Bend National Park; 18 staff present; goals and objectives of the fire program identified; issues and impact topics clarified using NEPA guidelines.
4-14-03	Notice of Intent to produce an Environmental Impact Statement for FMP published in Federal Register.
6-10-03 to 7-30-03	Newletter mailed to park mailing list and also posted on the Big Bend National Park website. Public scoping comment period; period extended as newsletter sent mid May to public, agencies, researchers.
5-28-03	Meeting of IDT at El Paso. Identify vegetation categories (start) and fuel models
6-26-03	Public Scoping Meeting, Sul Ross State University, Alpine, Texas 5-7 pm.
6-27-03	Public Scoping Meeting, Community Center, Study Butte, Texas 5-7 pm.
11-20-03	Intiate consultation with USFWS to conduct Biological Assessment (BA) under Section 7 consultation requirements.
1-1-04 1-2-04	Meeting at Big Bend NP. Identified prescriptions for alternatives and finalized vegetation categories under FMP; conservatin measures for BA.
1-04	List of tribal governments associated with park updated to seven.
1-27-04	First informal review of Biologial Assessment by USFWS.
5-18-04	Informal review of draft BA by Texas Parks and Wildlife Service
6-1-04 6-2-04	Meeting at Big Bend NP with vireo experts to determine conservation measures under the FMP: John Maresh, John Cornelius, Bill Armstrong.
5-04	Initiate consultation with TX SHPO for National Histoic Preservation Act Section 106 complainace
6-29-04 6-30-04	Meeting at Big Bend NP to develop fuels treatment program; identify watersheds at risk; develop research protocols; intiate maps
7-10-04	Second informal assessment of BA by US FWS
10-04	Internal review of BA by park
10-04	Internal review of Cultural Resource Component by park
12-04	Notice of Intent to change Environmental Impact Statement to Environmental Assessment appeared in the Federal Register.

6-05	Peer review by Superintendent of Guadalupe Mountains National Park
6 05	Biological Assessment submitted to USFWS for formal evaluation
6 05	Cultural Resource Component submitted to TX SHPO for formal evaluation
6-1-05	Environmental Assessment released for review.

The Draft EA will be sent to agencies, tribes, and organizations. It will be accessible to the public through the Big Bend National Park website and a paper copy will be kept in the park visitor center. Landowners adjacent to the park (for whom the park has an address) and other interested individuals wil be sent notification of the availability of the document, with information on how to obtain a copy. Public comments will be received for at least 60 days.

Following the public review period for the draft EA, a final EA will be developed that considers, addresses and seeks to resolve all substantive issues and comments raised by the public or agencies.

List of Recipients

The following will receive hard copies of the draft Environmental Assessment. A letter will be sent to the park's mailing list to inform interested parties of alternative methods of aquiring the DEA.

Carlsbad Caverns National Park\
Guadalupe Mountains National Park?
Big Bend Ranch State Park
Black Gap Wildlife Management Area
Sul Ross State Univeristy Library
Texas State Historic Preservation Office, Debra Beene
Texas Parks and Wildlife , Jackie Poole
U.S. Fish and Wildlife Service, Jana Milliken

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Appropriate Management Response (ARM)	Strategic and flexible response to fighting fire based on best information and experience available at the time; may include control (direct action to install firebreaks and stop a fire from spreading), containment (action on one or more sides of fire) or confinement (allowing a fire to burn to a barrier)
Biological Assessment (BA)	An assessment presented to U.S. Fish and Wildlife Service of effects on federally listed species, proposed listed species, or critical habitats of proposed federal actions that are not major construction projects (in this particular case, implementing a new FMP is the proposed action)
Biological Opinion (BO)	The opinion of the U.S. Fish and Wildlife Service on whether or not a proposed federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat
Context	The geographical or temporal environment of a proposed action, such that a change in the action relative to space or time might alter impacts
Control, contain, confine	A sequence of progressively less aggressive actions applied to wildland fire. *Control* consists of actions to suppress fire including installing firelines and suppressing hot spots, *contain* keeps fire within established boundaries and *confine* typically allows fire to burn itself out within a natural or constructed fireline.
Cultural Landscape	Landscapes as affected by people through time— the definition of such captures overlapping occupancy by different groups of people
Cultural Resources	Valued aspects of a cultural system that might be tangible (districts, sites, structures, objects)
Cultural Resources Component (CRC)	Document analyzing effects of the proposed action on cultural resources for review by the State Historic Preservation Office
Cumulative Effect	Effects of actions (those in the past, present, or reasonably foreseeable future) that have an additive impact on the resources affected by the proposed action
Debris Flow	“Rivers” of earth, rock, and debris saturated with water; one cause is intense summer thunderstorms following removal of organic matter from soils by fire
Direct Effect	An impact that occurs as a result of the proposed action or alternative in the same place and at the same time as the action
Duration	The length of time of effects of an action
Duff	Decomposing organic matter lying beneath the litter layer and above mineral soil
Ecoregion	A large-scale area with a common geological and biological history
Exotic Species (also non-native)	Species not native to a particular ecosystem
Fire break	A natural or manmade barrier to fire, such as a river, road, or excavated line, that is devoid of flammable vegetation
Fuel continuity	Describes how connected fuels are horizontally across the ground and vertically

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	into canopies; continuous fuels support fire spread
Fire frequency/return interval/ fire cycle	The recurrence of fire in a given area/habitat over time
Fire intensity	The amount of energy released by the fire usually measured as per unit length of fire front; reported as low, moderate or high
Fuel moisture	Most important determinant of flammability; varies daily within plants but over a lifetime plants become drier and more flammable as they mature
Fire severity	Qualitative measure of mortality and survival on above ground plants and animals and below ground effects on loss of organic matter; determined by heat released; little organic matter is removed or tree canopy scorched under low severity, while high severity signals very hot burns removing soil organic matter and burning forest canopy
Fire Management Plan (FMP)	The plan that guides all fire-related activities at a park that is consistent with land and resource management plans and follows NPS guidelines
Fire Management Unit (FMU)	A delineated area of the park that permits particular fire management strategies
Fuel	Vegetation, both living and dead, capable of burning
Fuel management	The use of methods such as prescribed fire and manual and mechanical means to reduce flammable vegetation that accumulates over time
Impairment	Impacts on resources that negatively, significantly, and possibly irreversibly alter their character from the state that made them important to protect in a park
Ground fire	Burns down through the litter into the duff and organic matter; can kill roots and destroy soil seedbanks
Indirect effect	An impact that occurs as a result of the proposed action, but removed in time and space from the action
Intensity	Magnitude of effect, from low to high
Inter-disciplinary team (IDT)	Group of interdisciplinary specialists that identifies important issues, relationships, and alternatives for public scrutiny
Manual fuel reduction	Removal of vegetation or creation of fire breaks using hand tools and chainsaws
Mechanical fuel reduction	Removal of vegetation or creation of fire breaks by bulldozer or road grader
Minimum requirement	The lowest impact means of accomplishing a task, frequently considered with respect to wilderness
Mitigation	Modification of an action that lessens intensity of its impacts on a particular resource
Monitoring program	Collecting information in a systematic way on species, species distribution, growth, fuel loading and health, archeological remains, before and after prescribed burning and after natural ignitions
National Environmental Policy Act (NEPA)	The 1969 law that dictates the objective analysis and public scrutiny of the environmental as well as social and economic impacts of proposed federal

	actions and their alternatives prior to implementation
Natural resources	A feature of the natural (physical and biological) environment that has value to humans
No Action	Under NEPA, No Action continues the current planning and operational direction and provides a baseline against which other alternatives can be measured
Non-fire treatments	Removal of vegetation without using fire, most commonly through mechanical/manual means including mowing, slashing, chainsaws or herbicidal treatments
Non-native species	Species not native to a particular ecosystem (used like “exotic”)
Prescribed fire	Fire ignited by management to meet specific objectives
Prescription	Measurable environmental criteria, particularly temperature, relative humidity, wind speed and direction, and fuel moisture, that define the conditions under which a fire would be ignited by management, guide selection of appropriate management responses, and indicate other required actions
Research burn	Prescribed burns with greater investment in examining, recording, analyzing, evaluating and applying monitoring results of fire effects and fire dynamics to management decisions
Resource advisor	An expert in a particular resource area (such as an archeologist or botanist) who is brought on site to advise fire crews relative to protecting sensitive resources
Rhizome	Creeping stem growing beneath the soil surface sending up new leaf shoots from nodes; characteristic of lechuguilla, saltcedar and Bermuda grass
Root crown	Mass of woody tissues from which stems and roots originate; usually applied to shrubs and herbaceous plants; often indicates drought tolerance and ability to resprout after fire
Scoping	Compilation of knowledge and opinions in order to properly develop and decide on alternative courses of action, both internally to the park and externally with the public
Sensitive species	Species sensitive to perturbation from the proposed action, frequently rare species that are federal or state-listed, proposed for listing, occurring in very few places, or particularly sensitive to the action’s impacts
Species diversity	A measure of the number of species in an area (species richness) that also accounts for species abundance
State Historic Preservation Office	The state office overseeing protection of cultural resources
Succession	The natural evolution of biotic communities over time following disturbance
Suppression	All the work of extinguishing a fire beginning with its discovery, using confine, contain, and control actions
Thinning	Reduction of density of vegetation, frequently using non-fire means

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Timing	How effects vary depending on when the action takes place
U. S. Fish and Wildlife Service	U.S. Department of Interior agency charged with overseeing protection of threatened and endangered species
Unique Sites	Sites sufficiently uncommon such that their presence is a special feature of the park with intrinsic value and of interest to visitors
Unique Stands	Patches of vegetation that are uncommon in an area that may be relicts from an earlier age
Watershed	Land above a given point in a drainage that potentially contributes water to the streamflow at that point
Wilderness	Designated area managed to perpetuate natural processes and minimize human impacts
Wildland fire	Any fire except prescribed fire or fire in developments, that occurs in the wildland or backcountry
Wildland Fire Use (WFU)	Naturally (lightning) ignited fire managed to meet resource benefits

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Appendix A: Full list of issues related to fire management planning at Big Bend National Park.

Identified from the Intermountain Regional Office Environmental Screening Form (IMRO ESF). Meeting held at Big Bend NP December 11-12, 2002.

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
Human Experience & Interaction	**Visitor Experience**	
	safety	• Fire can put visitors, staff and firefighters at risk • The use of fire can reduce hazard fuels • Evacuations could adversely affect visitor experience and be costly • Hikers and campers in wilderness are at risk • A single road into and out of the Chisos Basin could cause evacuation problems
	air quality	• This class I airshed allows broad day time views • Smoke obscures views
	night skies	• Crystal clear views are obscured but smoke creates great sunsets
	mechanical sounds	• Equipment used during suppression is noisy (chainsaws, helicopters, vehicles and generators)
	views	• Cherished views may become charred • Fire may enhance and reveal new vistas
	visitation interpretation	• Some visitors may seek alternate destinations • Fire operations and sites provide interpretative opportunities
	recreational opportunities	• Trails, vistas, campgrounds, and roads may be temporarily closed
	Land Use	
	property damage	• Structures, signage and landscaping are at risk
	neighbors	• Fire may cross boundaries- private, state and international • Ranch inholdings may lose grazing, fences, and livestock • Loss of telephone and utility poles may lead to litigation against the park • Hunters camping on inholdings may start illegal campfires
	local economy	• Tourism may decline after a well-publicized fire resulting in loss of income to local merchants and the park
Natural Resources	**Vegetation**	
	composition	• Fire intolerant species suffer • Fire-tolerant species benefit from decreased competition such as mid-elevation grasses • Diversity can increase after fire • Diversity can decrease with fires in fire-adapted exotics
	structure	• Intense fires can eliminate entire stands of vegetation
	unique stands	• Fire may damage or eliminate unique stands of vegetation where there are no colonizing seed sources
	non-indigenous species	• Fire facilitates invasion by exotic fire-tolerant buffelgrass, Bermuda grass, Johnson grass, saltcedar, Russian thistle, Lehmann's lovegrass and giantreed.
	Species of Special Concern	
	plants	• Rare, protected, or listed plants may suffer injury, death, or destruction of habitat by fire • Fire adapted species benefit from reduced competition • Nutrient ash may be beneficial to seedlings
	animals	• Rare, protected, or listed animals may suffer injury, death, or destruction of habitat by fire

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
		• The effects of fire on the habitat of many species is unknown • Fire creates edge habitat preferred by some species • Fire can increase browse and forage for deer • Fish and mussels could be affected by petroleum leaking into creeks from trucks and igniters used in fire management activities • Reducing brush around springs can increase subsurface flows benefiting amphibians and fish • Reducing brush can also increase trampling around springs and raise water temperatures
	Important Wildlife Considerations	
	key species	• Fire may kill, injure, or displace species that visitors want to see such as black bear, mountain lion and Colima warblers
	fire timing	• Fires during breeding seasons can disrupt nesting and maturation of species • Species adapted to cyclical fire will recover provided that there are sufficient populations for recolonizing and enough remaining habitat
	Unique Sites	
	ecoregions	• The Chisos Mountains and Pine Canyon are unique in the US and perhaps the US-Mexico region containing relic populations of aspen and Arizona Cypress, and many endemic species
	education	• Opportunities exist to use these special areas to illustrate the importance of the Biosphere designation
	natural sites	• Meadows, grasslands, savannahs, dunes, springs, limestone habitat, woodlands and forest
	Wilderness	
	ecology	• Allowing fire maintains natural succession processes
	visitor experience	• Presence and effects of fire help maintain the integrity of wilderness
	fire operations	• Evacuations from wilderness can be challenging • Fire operations may attract people to closed areas hampering operations • Restrictions on suppression techniques in wilderness can determine the course of fire
	Geological Resources	
	soils	• Fire can negatively impact soils by reducing infiltration, initiating erosion, silting waterways and roads, and transporting weed seed
	education	• Exposed vistas and features offer opportunities for interpretation and education
	visual quality	• Exfoliation and blackening (spalling) creates stark visual impacts
	Geohazards/mudflows	• Potential for increased runoff and erosion when rain hits bare soils • Potential for flooding increases with storms following fires • Creek drainages and other aquatic habitats vulnerable from silt and debris

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
	Water	
	quantity	• Less vegetation after fire results in greater runoff
	quality	• Runoff from slopes will contain increased particulate load; may change pH of streams affecting aquatic life
	Floodplains/wetlands	
	hydrology	• Excessive sediment loads in Rio Grande may affect relationships with downstream users • Waters may become polluted with petroleum from suppression activities • Water taken for suppression may decrease availability in already low areas
	vegetation	• Knocking back thickets near streams can increase flows benefiting wildlife • Removal of tamarisk can lead to a rise in the watertable • Sites may become drier following fire • Vegetation may be trampled during suppression
	wildlife	• Some springs may be more heavily used when fire removes the surrounding vegetation
Cultural Resources	**Cultural Resources**	
	archeological sites	• Suppression activities can directly damage site features and contribute to loss of significant archeological context • Fires can expose sites to vandalism • Fires cause loss of vegetative cover which open sites to erosion • Only 3% of the park is surveyed and damage could occur inadvertently
	structures	• Timbers, glass, metals and ceramics can be destroyed by fire in historic structures • Historic artifacts on the surface and in trash dumps are important for interpreting use of the site and can be adversely damaged by fire and suppression activities
	cultural landscapes	• Cultural sites are not well documented; losses could be permanent or recoverable only after long periods • The vegetative component of a landscape may be a significant character defining resource to preserve instead of burn
Federal and State Policies	**Agency Policies**	
	U.S. Fish & Wildlife Service	• The park works with the USFWS on protection of threatened and endangered species
	Texas SHPO	• The park works with the Texas State Historic Preservation Office on protection of cultural resources
	Mexico	• Existing agreements of cooperation exist; Los Diablos fight fires in the US. New agreements are being developed
	Texas Parks & Wildlife	• Agreements are being developed to work with several species of concern, and on fire along the border of the Blackgap Wildlife Management Area
	Tribal Affiliates	• Agreements will be developed as needed
	Neighbors	• Formal agreements are being developed on an on-going basis to accommodate more cost-effective and ecologically sound suppression policies along park boundaries

Appendix B. Fire Effects on Dominant Plant Species in Big Bend National Park

Table B-1. Floodplain and Upland Riparian
Table B-2. Scrub Desert
Table B-3. High Desert Grasslands
Table B-4. Shrub Woodlands
Table B-5. Grassy Woodlands
Table B-6. Forest

Table B-1.Floodplain and Upland Riparian: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Baccharus halimifolia	Shrubby groundseltree is killed by fire and recolonization probably requires windborn seed sources.	FEIS
Chilopsis linearis	Desert willow can be top-killed by fire but resprouts from the root crown becoming multi-stemmed.	FEIS
Muhlenbergia rigens	Deer muhly is not included in the fire literature. Other grass species show variable response depending on fire season, top growth and post-fire conditions. Dense basal cover may protect growing points on a low-intensity fire; high fuels and intensity may lead to plant death. Reestablishment is probably by seed.	FEIS
Populus fremontii	Cottonwoods are easily killed by fire and resprouting from root crown is diminished after 25 years. Can reestablish be seed in absence of competitive vegetation.	FEIS
Prosopis glandulosa	Honey mesquite resprouts readily following topkill from buds on extensive underground root systems.	FEIS
Prosopis pubescens	Screwbean is more easily top-killed or killed by fire than other mesquites. Resprouts weakly; easily outcompeted by saltcedar.	FEIS
Sporobolus airoides	No literature on Alkali sacaton but other species respond after fire depending on amount of root crown loss, season of burn and post-fire precipitation.	FEIS
Exotic species		
Arundo donax	Giantreed is highly flammable year round; top-killed by fire but resprouts vigorously from rhizomes and overtakes native vegetation.	FEIS
Cynodon dactylon	Above ground stems are consumed by fire but Bermuda grass responds vigorously from rhizomes if moisture is available.	FEIS
Pennisetum ciliare	Buffelgrass is a warm-season perennial that resprouts following fire and also reestablishes by seed stored in soil. It may increase cover following fire.	
Tamarix ramossisima	Saltcedar can resprout from root crowns and stem pieces; buildup of fuels within plant increases flammability; post-fire response can lead to dense thickets.	FEIS

Table B-2. Desert Scrub: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Agave lechuguilla	Lechuguilla occurs in dense stands that can readily carry hot fire; mortality tends to be high; some plants survive and produce offsets; plants can escape fire by living in rocky microhabitats.	FEIS
Bouteloua curtipendula	Sideoats grama response to fire depends on growth form, climatic conditions, season of burn, and severity of fire; reestablishment occurs through seed and/or rhizomes; recovery time is variable, but 2 to 3 years may be required.	FEIS
Flourensia cenua	Little is known about the effects of fire onTarbush. Fire is not expected to kill except if buildup of understory fuels.	FEIS
Fouquieria splendens	Ocotillo is easily damaged by fire; less in the dormant season; can resprout from root crown after low-intensity fire; occurs where fire is unlikely except after wet years and buildup of grasses.	FEIS
Hechtia texensis	Texas falseagave or Hetchia	
Larrea tridentata	Creosote's resinous leaves are very flammable but sparse grasses and patchy fires mean few creosote burn. They resprout weakly.	FEIS
Opuntia spp.	Prickly pear is consumed by hot fire. Surviving pads that connect with the ground may reestablish.	McPherson 1995
Parthenium incanum	Mariola – resprouting effects unknown	
Yucca spp.	Yucca increases in the absence of fire. Can resprout from buds under the stem depending on fire severity.	FEIS
Hilaria mutica	Tobosagrass response to fire depends on season of burn, soil moisture and post-fire precipitation regimes; recovery appears to take several years. Underground rhizomes send out new shoots. Slow burning hot fires can be very damaging.	FEIS Humphrey 1974
Exotics		
Pennisetum ciliare	Buffelgrass is top killed by fire and reestablishes from seed stored in soil.	FEIS
Eragrostis lehmanniana	Lehmanns lovegrass survives fires by sending new shoots from underground stems or from seed. Severe fire kills most plants but rains following fire can lead to rapid reestablishment.	

Table B-3. High Desert Grasslands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Acacia constricta	Catclaw acacia can resprout from the root crown following top-kill. Severe fires will destroy underground roots.	FEIS
Agave lechuguilla	Lechuguilla burns hotly and suffers high mortality. Surviving rosettes and blades reestablish after several years.	FEIS
Aristida spp.	Three-awns suffer damage from fire with growing points close to the soil surface. A 1975 fire in November in Big Bend led to 650% increase in forb and succulent cover over grasses.	FEIS
Bouteloua breviseta	There wa no literature for Chino grama	
Bouteloua eriopoda	Black grama has the reputation of being fire-sensitive, recovering slowly after fire through vegetative growth; healthy stands recover more readily, given decent moisture; carries fire if cover dense and conditions windy.	FEIS
Bouteloua gracilis	Blue grama is topkilled by fire, but fire generally increases occurrence, production, and cover; seed and seedstalk production may also be stimulated by fire; wet years post-fire increase yield.	FEIS
Bouteloua hirsuta	Hairy grama cover was positively correlated with fire frequency in Minnesota; most studies conclude it is undamaged by fire following a season or two of depressed production.	FEIS
Dalea spp.	Dalea spp.	
Dasylirion wheeleri	Young sotol are easily killed; mature sotol with trunks sheathed in dead leaves makes them especially susceptible to fire; stalks attract lightning; plant tops spread fire by falling off and rolling downhill; plants occasionally resprout if lightly or moderately burned.	FEIS
Digitaria californica	Recovery of California cottontop depends on post-fire moisture; wet summers can lead to full recovery; growing points are protected underground.	FEIS
Lepochloa dubia	Green sprangletop	
Leucophyllum minus	Ceniza	
Nolina microcarpa	Bear-grass or Sacahuista resprouts from the woody, underground caudex after fire; cool fires result in little or no mortality; hot fires kill many young plants and some mature plants.	FEIS
Opuntia spp.	Prickly pear is susceptible to fire but rarely are all plants or parts burned. Resprouting from the root crown or from layering of surviving pads. Increased	FEIS

	fire frequency is thought to increase mortality.	
Pleuraphis mutica	Tobosagrass	
Sporobolus airoides	No literature on Alkali sacaton but other species respond after fire depending on amount of root crown loss, season of burn and post-fire precipitation.	FEIS
Viguiera stenoloba	Skeletonleaf goldeneye is highly flamable.	
Yucca torreyi	Yucca flowerstalks act as lightning receivers ; mature dead skirts of leaves are consumed by fire and may spread fire as the plant rolls downhill.	FEIS

Table B-4. Shrub Woodlands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	**Fire Ecology/Adaptations**	**Source**
Aloysia gratissima	Bee bush is not known to be easy to ignite or burn	Staff observation Big Bend.
Acacia constricta	Catclaw acacia can resprout from root crowns provide the fire is not severe.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Quercus grisea	No information in the literature on Gray oak. Most oaks survive low-intensity, fast-moving fire. Fires in closed canopy oak forests probably lead to stand replacement.	FEIS
Quercus emoryi	Emory oak resprouts vigorously from root crown or stump following fire; fire probably occurred every 10-20 years where lower elevation grasslands led into Madrean oak-pine woodlands.	FEIS
Rhus virens	There was no information on fire effects in the literature for Evergreen sumac. Other sumacs are top-killed by fire but resprout from root crowns and reestablish by seed. Some species increase following fire.	FEIS
Vauquelinia corymbosa subsp. *angustifolia*	Slimleaf vauquilinia	

Table B-5. Grassy Woodlands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Achnatherum hymenoides	Pinyon rice grass is relatively open limiting damage to below ground parts; usually top-killed by fire and reestablishes by seed. Not intensively researched	FEIS.
Agave harvardiana	Mature Harvard agave may take several years to die following fire. Young rosettes under the skirt of an adult are usually consumed by fire.	Howard 1996; Johnson 2001
Garrya wrightii	Wright silktassel resprouts from the root crown following fire. Most information comes from chapparal in Arizona.	FEIS
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Juniperus flaccida	Specific information about fire effects is lacking; shedding bark and volatile leaf oils probably make it very flammable and easily killed. Patchy burns would allow it to survive in refugia.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Muhlenbergia emersleyi	Low fire intensity can be survived but intense fire usually kills; reestablishment is by seed	FEIS
Pinus cembroides	Fire effects on Mexican pinyon depend on stand density and understory species and fuel levels. Mature 80 year old trees with grassy understory are fire resistant, young trees in dense stands are easily killed.	FEIS
Quercus grisea	No information in the literature on Gray oak. Most oaks survive low-intensity, fast-moving fire. Fires in closed canopy oak forests probably lead to stand replacement.	FEIS
Quercus emoryi	Emory oak resprouts vigorously from root crown or stump following fire; fire probably occurred every 10-20 years where lower elevation grasslands led into Madrean oak-pine woodlands.	FEIS
Quercus gravesii	There is no literature on Graves oak but most oaks can resprout from the root crown following fire.	

Table B-6. Forest: Fire Ecology of Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Dominant		
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Juniperus flaccida	Specific information about fire effects is lacking; shedding bark and volatile leaf oils probably make it very flammable and easily killed. Patchy burns would allow it to survive in refugia.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire at 10-20 year intervals kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Pinus cembroides	Fire effects on Mexican pinyon depend on stand density and understory species and fuel levels. Mature 80 year old trees with grassy understory are fire resistant, young trees in dense stands are easily killed.	FEIS Moir (1982)
Quercus gravesii	Graves oak	
Subdominant to rare		
Acer grandidentatum	Bigtooth maple live in moist sites , produce shady crowns that suppress understory and tend to burn infrequently; following crown destruction by fire, some resprout from root crown, but not vigorously.	FEIS
Arbutus xalapensis[texana]	Observation of fire scars on Texas madrone suggest some survival after fire; moist habitats generally protect from fire; post-fire sprouting is not documented but not ruled out; bird-dispersed seed may establish on burns.	FEIS: Staff observation Guadalupe Mountains NP
Cupressus arizonica	Arizona cypress less than 4” in diameter is killed by fire; relict populations probably survived patchy fast-moving grass fires; fire stimulates seed release.	FEIS
Ostrya chisosensis	Information on Chisos hophornbeam not available . Other hophornbeam species believed to be killed by fire; occur in juniper-pinyon communities that burned every 10-30 years	FEIS
Pinus ponderosa	Interior ponderosa pine can survive considerable scorching. Fire adaptations include: open crowns; self-pruning branches; thick, insulative, relatively unflammable bark; thick bud scales; tight needle	FEIS

	bunches that open into a loose arrangement that does not favor combustion; high foliar moisture; and a deep rooting habit.	
Populus tremuloides	Much work on quaking aspen comes from the northern Rockies and eastern U.S.; the species is topkilled by fire, but sends up a “profusion” of stems for several years post-fire; new stands can develop within a decade; fire-scarred aspens in Utah showed 7- to 10-year fire frequency pre-1885; lack of young stands in the west may be due to absence of fire.	FEIS
Pseudotsuga menziesii	Mature Rocky Mountain Douglas-fir is generally more fire resistant than spruces and true firs and equally or slightly less fire resistant than ponderosa pine. Mature trees can survive moderately severe ground fires because thick, corky bark insulates the cambium from heat damage. Where fire is frequent young trees are killed.	FEIS
Quercus rubra	Mature red oak can survive fires with up to 66% bark burn but are more susceptible than other oak species; trees may resprout from the root crown. Mortality increases with fire severity.	FEIS
Quercus rugosa	Netleaf oak. No literature on this species; severity of fire and protection of root crown determine resprouting in many oak species.	

Appendix C. Cultural Resource Matrix

This matrix was completed by Tom Alex and reviewed as part of the Cultural Resource Component (the document that summarizes all cultural resource concerns under the FMP) by W. Andy Cloud at Sul Ross State University at Alpine. The Texas State Historical Preservation Office reviewed the CRC.

The 6-page matrix considers historical, archeological, architectural, engineering, and cultural values to identify resources sensitive to fire program activities. It also specifies the particular aspects of the resource at risk, reviews what fire program activities create the risk, defines protection objectives for these resources, and suggests methods to minimize or mitigate impacts in order to achieve these objectives. An initial itemized list of treatment by site has been developed to guide operations under the new FMP.

Definition of terms:

Historic contexts are the historic and prehistoric themes under which various resources were created and used. Individual resources are best understood and evaluated by understanding the roles they played within specific historical periods. For example the various eras of the Prehistoric American Indian Period are characterized by changes in specialized hunting tools. Military forts or presidios, mining, and ranches characterize the Mexicans and Anglos Historic Period. The park period features superb rock construction by the Civilian Conservation Corps.

Resource types represent general function or morphology such as historic districts or cultural landscapes. They include stone hunting tools from prehistoric times, the remains of mines, farming systems and military establishments, and some resources more difficult to date such as lithic scatters.

Elements are the specific physical characteristics of resource types. Identifying the elements allows us to define specific elements or values at risk from various fire management activities. Historical buildings may contain burnable wooden timbers, glass that may melt, or ceramics that may crack under high temperatures. Retardant or water may crack or shatter rocks heated by fire within an archeological site.

Risk conditions or activities are the specific environmental conditions and/or fire management activities that place particular resources at risk. Growth of brush around historic sites increases the temperature of fire; the presence of burnable timbers, glass, metals and ceramics creates risks best mitigated by removal of nearby flammable materials.

Fire management objectives guide actions in a way that protects the elements or values at risk. The CRC recommends a variety of approaches for reducing risk from fire depending on the site and its components.

Treatments or prescriptions are methods of attaining the objectives for cultural resources. The park has prepared a preliminary list of sites and proposed treatments for consideration under the fire program. Treatments include:

- Reducing fuels in and around sites through manual or mechanical thinning, prescribed fire or natural ignitions depending on site.
- Manage nearby fire to ensure that sensitive resources are not affected by fire containment or suppression activities.
- Prior identification of vehicle access and fire breaks around sites with high public visitation.
- Undertaking cultural resource inventories designed by qualified cultural resource specialists in burn units prior to prescribed burn activities.

Seven tribes are affiliated with the park. Apache Tribes of Oklahoma, Blackfeet, Comanche Tribe of Oklahoma, Kickapoo Traditional Tribe of Texas, Kiowa Tribe of Oklahoma, Mescalero Apache Tribe,

and Ysleta Del Sur Pueblo. Also consulted are relevant state and federal agencies, local governments, local businesses, and private residents living along the boundary or nearby the park.

The park sent out public scoping newsletters in June 2003 and held open house meetings in Alpine and Study Butte, Texas. The comment period extended to the end of August 2003. Tribes were not informed within the original comment period because of confusion about which tribes were affiliated with the park. Research by staff in Santa Fe NPS and the park Tribal Liaison Officer, expanded the original list from 3 to 5 and then to 7 tribes. Each tribe will receive a copy of the draft EA when completed and invited to comment on the alternatives.

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
INDIGENOUS AMERICAN POPULATIONS: Prehistoric Archeology: Prehistoric Use of Natural Stone Sources and Regional Trade	Lithic source, quarried	Quarry Alcoves Quarry Pits Lithic concentrations	Extraction and lithic reduction techniques Chronological and functional data Dating/sourcing	Heat spalling of rock surfaces in alcoves from high intensity/ long residence fire; Ground disturbance; Retardant drops; Temperatures >500C	Avoid disturbance	Pretreatment: hand lines/ring firing; Use water where possible to suppress
	Lithic Source, Surface	Lithic concentrations	Chronological and functional data Lithic reduction techniques Dating/sourcing	High intensity/ long residence fire; Ground disturbance; Retardant drops; Temperatures >500 C	Avoid disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress
INDIGENOUS AMERICAN POPULATIONS: Prehistoric Resource Use, Landscape Use and Settlement Patterns 10,000 BC – AD 1550	Open Campsite	Stone-paved/lined hearths Lithic concentrations	Chronological and functional data Feature integrity Dateable contents of hearths Lithic reduction techniques Lithic sourcing	Moderate to high intensity/ long residence fire; Ground disturbance; Chemical retardant drops; Radiocarbon data contamination from vegetation growth contacting features; Temperatures 300-500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Sheltered Sites: Boulder Shelter	Petroglyphs Pictographs Midden Lithic concentrations	Morphological and stylistic data Pigment dating Chronological and functional data Lithic reduction technology Subsistence data	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Sheltered Sites: Rock Shelter	Middens Rock art Vegetal artifacts Stone artifacts Storage cysts Lithic caches Burials	Feature integrity Interpretive value Chronological and functional data Morphological and stylistic data Pigment dating	Heat spalling of rock surfaces; Radiocarbon data contamination from vegetation growth contacting features; Smoke blackening Heat alteration of biotic/mineralogic surface coatings Temperatures >50 C	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Food processing sites	Cooking pits Bedrock mortars & metates Molcajetes & metates Plant/animal processing tools	Chronological and functional data Subsistence data Lithic reduction techniques Hunting/Gathering methodology	Heat alteration of biotic & mineralogic surface coatings; Radiocarbon data contamination from vegetation growth contacting features; Temperatures >50 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Vision quest/ceremonial observation	Mountaintop stone enclosures Hearths Molcajetes and metates	Ceremonialism and spirituality Chronological data Stone alignments and cairns integrity	Moderate to high intensity/residence fire; Radiocarbon data contamination from vegetation growth contacting features; Heat alteration of biotic/mineralogic surface coatings Temperatures >50 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Medicine Wheel	Stone lines & circles, horizon alignments, stone mounds and cairns Human burials and associated artifacts Artifact caches	Ceremonialism and spirituality Human remains Mortuary practices Commemorative practices Stone alignments and cairns integrity	Foot traffic Fireline construction	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Burial Sites	Crevice burials: rock mounds and walls Subsurface burials: rock mounds or paved surfaces Pictographs and petroglyphs Associated artifact/burial goods caches	Human remains Mortuary practices Cultural affiliation Morphological and stylistic data Pigment dating Radiocarbon dating	Heat spalling of rock surface Vegetation growth contacting features Heavy ground disturbance Smoke blackening	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
INDIGENOUS AMERICAN POPULATIONS: Post-Archaic and Pre-Contact Developments: Intercultural Relations Between Southern Plains and Northern Mexico	Campsites containing constructed shelter: Stone enclosures; wickiups	Stacked stone walls Boulder metates Interior and exterior cooking hearths Lithic concentrations Artifact caches	Chronological and functional data Feature/structure integrity Cultural affiliation Radiocarbon data contamination	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
INDIGENOUS AMERICAN POPULATIONS: Contact Period - Post AD 1550	Campsites containing constructed shelter: Stone enclosures, wickiups	Stacked stone walls Boulder metates Interior and exterior cooking hearths Lithic concentrations Artifact caches	Chronological and functional data Feature/structure integrity Cultural affiliation Radiocarbon data contamination	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Rock Art	Red linear pictographs Depictions of horseback riders	Chronological and functional data Morphological and stylistic data Cultural affiliation Interpretive value Pigment dating	Heat spalling of rock surface Vegetation growth contacting features Smoke blackening Heat alteration of biotic/mineralogic surface coatings	Suppression	Manual fuel reduction

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Open Campsites	Stone-lined hearths Burned earth surfaces Metal artifacts Ceramic artifacts	Chronological and functional data Feature integrity Diagnostic artifacts	Foot traffic Fireline construction Moderate to high intensity/residence fire? Ground disturbance Chemical retardant drops Vegetation growth contacting features Radiocarbon data contamination Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
EUROPEAN/ AMERICAN EXPLORATION AND SETTLEMENT, 1848-1890: The Camel Expeditions by the Topographic Corps of Engineers	Landmarks along the routes of the 1859-1860 expeditions	Comanche Trail Campsites at springs and waterholes Glass and metal artifacts	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
POLITICAL AND MILITARY AFFAIRS, 1865-1939	Neville Spring Black/Seminole Indian Scout Outpost	Officers Quarters ruin Enlisted Barracks ruin Blacksmith area with metal artifacts Outlier observation posts	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Heat spalling of rock Heat spalling of mortar Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Military outlier lookout posts	Stone enclosures Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	La Noria Cavalry Camp	Stone alignments Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia Stone alignments defining parade ground Artifacts in trash dumps and on ground surface	Fireline construction Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Glenn Springs Cavalry Camp	Stone alignments/ and foundations Metal artifacts Rifle pits/machine gun emplacements Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia Stone alignments defining parade ground and Gary Owen insignia Artifacts in trash dumps and on ground surface	Foot traffic Fireline construction Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Johnson Ranch Airfield	Runway Building ruins and foundations Trash dumps Cemetery	Chronological and functional data Metal, glass, & ceramic artifacts Wooden grave markers and delineators	Melting of non-ferrous metal, glass, ceramic Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Camp Santa Helena (Castolon)	Buildings Historic artifact scatters	Chronological and functional data Interpretive value Commercial value (store) Govt. property value (storage) Structural integrity	Temperatures > 232 C	Avoid ground disturbance Suppression	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
WESTWARD EXPANSION OF THE UNITED STATES, 1763-1898: The Cattleman's Empire: Ranches	G-4 Ranch / Gano Ranch Site	Building foundations Trash piles Household objects Fence lines, corrals	Wooden structural elements Glass and ceramic artifacts	Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RANCHING: 1880-1944	Ranching sites: Homer Wilson Blue Creek Line Camp, Sam Nail Ranch, K-Bar Ranch, Buttrill Ranch, Rice Ranch, Other ranches	Stone, adobe, wood frame buildings Building foundations Stone ruins Adobe ruins Wooden framing elements Trash Piles Vegetative plantings Fence lines, corrals Masonry dams Earthen dams and stock ponds Waterlines and windmills Water storage structures Family cemeteries	Interpretive value Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression Avoid loss of physical patterning of corrals, fencelines, etc.	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
AGRICULTURE: Flood Plain Farming: Adaptations of the Spanish Acequia Farming System and Indigenous Farming Methodology	Terlingua Abajo community site	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Brick Kiln Cemetery Church Threshing floor	Interpretive value Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Luna Jacal	Rock structure Ocotillo / earth roofing Unmarked family graves Earthen berms and diversion structures	Structural integrity Wooden structural elements	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	La Coyota Community	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Cemetery	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression Community map needed	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	San Vicente Community	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Cemetery	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Community map needed	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
BUSINESS: The Candelilla Wax Industry	Wax camps and wax factories	Fireboxes Firebox pits Wax vats Wax strainers Sleeping shelters	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
COMMUNICATION	Telegraph and telephone lines	Wooden poles Glass insulators Wire	Wooden fixtures Patination surface on insulators	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features
ARCHITECTURE: Vernacular Architecture:	Indigenous construction in remote frontier locations	Jacal structures, Dugouts, Adobe and rock masonry residential structures, Outbuildings, Masonry dams	Structural integrity Unique wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
ARCHITECTURE: Rustic Architecture:	Civilian Conservation Corps	Stone cottages Rock masonry headwalls, retaining walls, and buttress walls on roads and trails	Commercial value (lodging) Interpretive value Wooden structural elements	Heat spalling of plasters Blistering of painted surfaces Electrical utility lines Temperatures > 135 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TECHNOLOGY:	Mining and mineral	Shafts and adits	Interpretive value	Temperatures > 135 C	Avoid ground	Manual fuel reduction around

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
Extraction of Raw Materials	extraction and processing	Rail transfer system Equipment mounting platforms Loading chutes Retorts Condensers Management infrastructure buildings Community structures Cemetery Trash piles	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects		disturbance Suppression on structures with combustible elements Prevent fire from falling into mine shafts	burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: American Indian travel routes	Comanche Trail, river crossings, routes through major terrain features	Entrenched trail at stream crossings Vegetation pattern defines trail	Loss of defining vegetation pattern	Moderate intensity fire	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: Mining	Puerto Rico Ore Tramway, Ore Road, Mariscal Mine haul road	Tramway towers Terminal ruin Cable Ore buckets	Interpretive value Wooden structural elements	Temperatures > 50 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: 19th and 20th Century Travel Routes	Pre-Park road system, NPS open roads	Roadbed Roadside debris Bridge ruins Highway camps	Non-ferrous metal, glass, ceramic artifacts	Temperatures > 135 C	Avoid ground disturbance	Avoid highway camps and trash piles; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: C.C.C. Road Construction	Road alignment Bridges & culverts	Original vertical and horizontal alignment Stone masonry	Scenic entry into park Interpretive value Structural integrity	Heat spalling of mortar joints on road culverts/trail structures	Avoid ground disturbance	Manual fuel reduction around masonry structures; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RELIGION: American Indian Ceremonial Practices	Vision Quest Sites, Calendric Sites, Medicine Wheels	Stone enclosures Stone alignments Commemorative cairns Burial cairns	Integrity of stone alignments, cairns, and enclosure walls		Avoid ground disturbance	Manual fuel reduction Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RELIGION: Euro-American Religious Practices	Churches, Private Chapels, Matachine Sites, Cemeteries	Foundations and walls Wooden framing elements Wooden crosses Glass and ceramic offering objects	Interpretive value Non-ferrous metal, glass, ceramic artifacts	Temperatures > 135 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
EDUCATION: Special Populations: Frontier Schools	School buildings and sites	Foundations Walls Trash piles	Interpretive value Non-ferrous metal, glass, ceramic artifacts	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Appendix D. Plant and Animal Species referred to in this EA

Acorn woodpecker (*Melanerpes formicivorus*)
Alkali sacaton (*Sporobolus airoides*)
Alligator juniper *(Juniperus deppeana)*
Arizona cypress (*Cupressus arizonica)*
Beaver (*Castor canadensis*)
Bear grass or Sacahuista (*Nolina microcarpa*)
Beebrush (*Aloysia gratissima*)
Bermuda grass (*Cynodon dactylon)*
Big Bend gambusia (*Gambusia gaigei*)
Bighorn desert sheep (*Ovis canadensis* spp.)
Bigpod bonamia (*Bonamia ovalifolia*)
Bigtooth maple *(Acer grandidentatum)*
Black bear (*Ursus americanus mexicanus*)
Black-capped vireo (*Vireo atricapilla)*
Black grama *(Bouteloua eriopoda)*
Black phoebe (*Sayornis nigricans*)
Black-tailed jackrabbit (*Lepus californicus*)
Black-tailed rattlesnake (*Crotalus molossus)*
Blue grama *(Bouteloua gracilis)*
Bobcat (*Lynx rufus*)
Broadtail hummingbirds (*Selasphorus platycercus*)
Buffelgrass (*Pennisetum cilare)*
Bull muhly (*Muhlenbergia emersleyi*)
Bunched cory cactus (*Coryphantha ramillosa)*
Bushtits (*Psaltriparus minimus*)
Cactus wren (*Campylorhynchus brunneicapillus*)
California cottontop (*Digitaria californica*)
Candelilla (*Euphorbia antisyphilitica)*
Catclaw Acacia *(Acacia constricta)*
Catclaw Mimosa (*Mimosa aculeaticarpa var. biuncifera*)
Ceniza (*Leucophyllum minus*)
Chino grama *(Bouteloua breviseta*)
Chisos agave (*Agave glomeruliflora*)
Chisos coral root (*Hexalectris revolute*)
Chisos hophornbeam (*Ostrya chisosensis*)
Chisos metalmark (*Apodemia chisosensis*)
Chisos Mountain or Lateleaf oak (*Quercus tardifolia)*
Chisos Mountain hedgehog cactus (*Echinocereus chisoensis* var. *chisoensis*)
Chisos pinweed (*Lechea mensalis)*
Chaffey's cory cactus (*Escobaria* var. *chaffeyi)*
Coachwhip snake (*Masticophis flagellum***)**
Coahuila oak (*Quercus polymorpha*)
Colima warbler (*Streptanthus cutleri)*
Common black hawk (*Buteogallus anthracinus***)**
Common reed (*Phragmites australis***)**
Cottonwood (*Populus deltoides* var. *fremontii)*
Coyote (*Canis latrans*)
Creosote (*Larrya tridentata)*
Curve-billed thrasher (*Toxostoma curvirostre*)
Cutler's Twistflower (*Streptanthus cutleri)*

Dalea spp. (approximately 12 species)
Deer muhly (*Muhlenbergia rigens)*
Dense cory cactus (*Escobaria dasyacantha* var. *dasyacantha)*
Desert willow (*Chiloensis linearis*)
Dog cholla (*Opuntia schottii*)
Douglas fir *(Pseudotsuga menziesii)*
Duncan's cory cactus (*Coryphantha duncanii)*
Elf owls (*Micrathene whitneyi*)
Emory oak (*Quercus emoryi)*
Evergreen sumac ((*Rhus virens* var. *choriophylla*)
Fragrant ash (*Fraxinus cuspidata*)
Giantreed (*Arundo donax)*
Glass Mountain coral root (*Hexalectrus nitida)*
Gnatcatchers (*Polioptila caerulea*)
Golden eagle (*Aquila chrysaetos)*
Golden-spined prickly pear (*Opuntia aureispina)*
Graves oak (*Quercus gravesii)*
Gray breasted jay (*Aphelocoma ultramarina*)
Gray fox (*Urocyon cinereoargenteus*)
Gray hawk (*Asturina plagiata*)
Gray oak (*Quercus grisea)*
Greater western mastiff bat (*Eumops perotis californicus)*
Green sprangletop (*Lepochloa dubia*)
Guayacan *(Guaiacum angustifolium)*
Guadalupe fescue (*Festuca ligulata*)
Hairy grama *(Bouteloua hirsuta)*
Harvard agave (*Agave harvardiana*)
Harvard's stonecrop (*Sedum harvardii)*
Harvard plum (*Prunus harvardii*)
Hetchia or falseagave (*Hechtia texensis)*
Hinckley's oak (*Quercus hinckleyi*)
Javalina (*Pecari tajacu)*
Johnson grass (*Sorghum halepense)*
Leatherstem (*Jatropha dioica*)
Lechuguilla (*Agave lechuguilla)*
Lehmanns lovegrass (*Eragrostis lehmanniana)*
Little-leaf brogniartia (*Brogniartia minutifolia)*
Lloyd's Mariposa cactus (*Sclerocactus mariposensis*)
Loggerhead shrike (*Lanius ludovicianus*)
Long-spur colombine (*Aquilegia longissima)*
Lovegrass (*Eragrostis* spp.)
Mariola *(Parthenium incanum)*
Mesquite *(Prosopis glandulosa)*
Mexican buckeye (*Ungnadia speciosa*)
Mexican gray wolf (*Canis lupus baileyi)*
Mexican long-nosed bat (*Leptonycteris nivalis*)
Mexican pinyon (*Pinus cembroides*)
Mexican spadefoot toad (*Spea multiplicata*)
Mockingbird (*Mimus polyglottos)*
Mountain lion (*Puma concolor)*
Mountain mahogany (*Cercocarpus montanus*)
Mule deer (*Odocoileus hemionus*)

Netleaf oak (*Quercus rugosa*)
Northern Aplomado falcon (*Falco femoralis septentrionalis)*
Northern flicker (*Colaptes auratus*)
Ocotillo *(Fouqueria splendens)*
Peregrine falcon (*Falco peregrinus)*
Pinyon ricegrass (*Pipochaetum fimbriatum*)
Ponderosa pine *(Pinus ponderosa)*
Prickly pear (*Opuntia* spp.)
Puckering nightshade (*Nectouxia formosa)*
Purple gay mallow (*Batesimalva violacea)*
Redberry juniper (*Juniperus pinchottii)*
Red oak (*Quercus rubra)*
Resurrection fern (*Selaginella lepidophylla*)
Rio Grande leopard frog (*Rana berlandieri*)
Roadrunner (*Geococcyx californianus*)
Robert's stonecrop (*Sedum robertsianum)*
Rock Squirrel (*Spermophilus variegates)*
Rufous towhe (*Pipilo erythrophthalmus)*
Russian thistle (*Salsola kali)*
Saltcedar (*Tamarix ramossissima)*
Scotts oriele (*Icterus parisorum*)
Screech owls (*Otus asio)*
Screwbean *(Prosopis pubescens)*
Scrub Oak (*Quercus turbinella*)
Sea urchin cactus (*Echinocactus asterias*)
Shorthorn jefea (*Jefea brevifolia)*
Shrubby groundsel (*Baccharis halimifolia)*
Sideoats grama *(Bouteloua curtipendula)*
Sierra del Carmen oak (*Quercus carmenensis)*
Sierra del Carmen whitetail deer (*Odocoileus virginianus)*
Silver-spined cholla (*Opuntia imbricata* var. *argentea)*
Skeletonleaf goldeneye (*Viguiera stenoloba*)
Slender Oak or Chisos oak (*Quercus graciliformis)*
Slimleaf vauquilinia (*Vauquelinia corymbosa* subsp. *angustifolia*)
Southwestern willow flycatcher (*Empidonax traillii extimus*)
Sotol *(Dasylirion wheeleri)*
Swallow spurge (*Chamaesyce golondrina)*
Tall-stemmed paintbrush or Squawflower (*Castilleja elongata* or *C. integra* var. *integra*, taxonomy questionable*)*
Tarbush *(Flourensia cernua)*
Texas antelope (*Antilocapra americana* and *A. mexicana)*
Texas hornshell (*Popenaias popei*)
Texas horned lizard (*Phrynosoma cornutum)*
Texas largeseed bittercress (*Cardamine macrocarpa* var. *texana)*
Texas madrone *(Arbutus xalapensis [texana])*
Texas persimmon (*Diospyros texana*)
Texas purple spike (*Hexalectris warnockii)*
Three-awns (*Aristida* spp.)
Three-tongued spurge (*Chamaesyce chaetocalyx* var. *triligulata)*
Tobosagrass *(Hilaria mutica)*
Trans-Pecos maidenbush (*Andrachne arida)*
Trans-Pecos rat snake (*Bogertophis subocularis*)

Striped Skunk (*Mephitis mephiis*)
Turkey vulture ***(****Cathartes aura)*
Two-Bristle rock daisy (*Perityle bisetosa* var. *bisetosa)*
Variable oakleaf caterpillar (*Lochmaeus manteo*)
Slimleaf rosewood (*Vauquelinia corymbosa* var. *heterodon)*
Weeping juniper (*Juniperus flaccidus)*
Western diamondback rattlesnake (*Crotalus atrox*)
Western pipistrelle (*Pipistrellus Hesperus*)
White column cactus (*Escobaria albicolumnaria*)
Willow, Goodding (*Salix gooddingii*), Black *(S. nigra)*, Coyote *(S. exigua)*
Wright silktassel (*Garrya wrightii)*
Yellow bells (*Tacoma stans*)
Yellow-billed cuckoo (*Coccyzus americanus*)
Yellow-breasted chat (*Icteria virens auricollis*)
Yellow-nosed cotton rat (*Sigmodon ochrognathus*)
Yucca (6 *Yucca* spp.)

Appendix E: Watershed areas and potential impacts following high-severity fire

Soils Mapping Unit	Watersheds	Area (Approx)	Soil Characteristics	Slope % (mostly)	*Vegetation*	Susceptibility to erosion & debris flows following high-intensity, widespread fire
BRG Brewster Rock Outcrop Complex Very Steep	Around the west and north sides of the Basin.		Shallow to very shallow well-drained soils formed on rolling to very steep igneous mountains with rock outcrops. About 1/3 of the soil is clay, with cobbles and gravel making up 35-70% of the soil volume.	20-45 some vertical walls.	Vegetation in rock fissures and lower slopes. Includes Mexican pinyon pine, juniper, oaks, with shrubby Texas Madrone, mountain mahogany, evergreen sumac, littleleaf sumac, skeletonleaf goldeneye, and grasses sideoats grama, cane bluestem and threeawns.	Water erosion and debris flows are a hazard with steep slopes, shallow depth to bedrock (4-20 inches) and a clay layer slowing infiltration. Cobbles and gravel together with grass cover reduce surface erosion on some areas.
LMF –Liv Mainstay Rock Outcrop Complex Steep	South of trail to Laguna Meadows to ….. Chisos Basin		Liv soils are deep (60-80 inches), well drained, moderately slowly permeable soils formed in clayey cobbly and gravelly materials over igneous bedrock. Mainstay soils are shallow (10 20 inches), well-drained on uplands Gravelly or cobbly with 35-80% coarse fragments by volume.	2-45	On Liv soils vegetation is grass with some areas having an overstory of oaks, junipers and pinion pines. Grasses are mainly grama, bluestem, muhly, and threeawn. Mainstay soils support Pinyon pine, oaks, junipers, Texas Madrone, bigtooth maple, sumacs, semi-succulents and grasses.	About 40 inches to bedrock and 35-60% by volume of cobbles and gravel. Surface runoff is rapid and permeability moderately slow. With steep slopes water erosion is a severe hazard. Debris flows likely. Surface runoff is rapid and permeability moderately slow. Rooting depth is shallow to less than 20 inches to bedrock. Water erosion is a severe hazard because of steep slopes. Debris flows likely.
PRF Puerta Madrone Complex Steep			Shallow and moderately deep, steep, very gravelly soils over 6000 ft.	20-45	Pinyon pine, oaks, Arizona Cypress with Ponderosa pine and Douglas fir on north slopes and canyon bottoms.	Puerta soils are ~50% of the unit and have rapid runoff and gravelly, silty loam to bedrock at 20 inches. Madrone soils are ~35% more permeable in the upper layers with clayey soils at bedrock ~32 inches.
ERF Ector – Rock Complex Steep	SW of Laguna Meadow		Shallow or very shallow, well drained soils that are moderately permeable above a very slowly	Up to 60		Depth to underlying limestone bedrock is 6-20 inches. Very slowly permeable and well drained. Runoff

			permeable limestone bedrock. They formed in loamy residuum. Cobbles make up 0-20% of soil volume			very high on slopes over 5% Erosion Low Debris flows:Low
HRF-Hurds Very Cobbly Loam Steep	Green Gulch Pine Canyon ?		Deep, very gravelly and very cobbly well-drained soils on igneous hills and mountains at 5,000-6,000ft.	20-45	Mexican pinyon pine, redberry juniper, gambel oak, catclaw, catclaw and foothill basketgrass, Mexican sagewort, wolftail, deer muhly, bracken fern, little bluestem, hairy grama and cane bluestem.	Although these soils are deep ~60 inches and well drained, low water holding capacity and steep slopes make water erosion a severe hazard. Debris flowsLow
HRD - Hurds Very Gravelly Sandy Loam Rolling	Green Gulch Pine Canyon bottom of slopes		Deep, very gravelly soils in valleys and foot of slopes from 4,500-5,600 feet.	3-20	Mexican buckeye, foothills basetgrass, littleleaf leadtree, Apacheplume, juniper, sotol, catclaw, agave, hairy grama little bluestem and cane bluestem.	These soils are well drained deep and and moderately permeable. Water holding capacity is low and slopes are moderate making water erosion a moderate hazard. Debris flows: Low

Table compiled from Soil Survey of Big Bend National Park (1985), and USDA Official Soil Series Descriptions (on line, April 2004).
Soil Mapping Unit: An area of the landscape where soils have the same or similar characteristics (Buol et al, 1997).

Watersheds, Slopes and Acres: Supplied by Jeffrey Bennett park hydrologist, April, 2004

Watershed	Acres (approximate)	% slope-highest elevation in watershed	% slope-middle elevation in watershed	% slope-lowest elevation in watershed
Green Gulch	2367	100	68	6.7
Northwest Undifferentiated	424			
Oak Canyon	3804	223	51	6
Boot Canyon	845	100	35	20
Juniper Canyon	3136	100	50	5.7
Cattail Canyon	1487	42	51	80
Western Undifferentiated	866			
Pine Canyon	3189	165	51	7.5
Northeast Undifferentiated	2797			
Blue Creek Canyon	1143	200	40	20
South rim Undifferentiated	1202			

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