Botany

Introduction

This section is a review of all planned, funded, executed, or permitted programs and activities for possible effects on endangered, threatened, or sensitive species and is the means of documenting the findings. Objectives include the following (FSM 2672.41):

- To ensure that Forest Service actions do not contribute to loss of viability of any native or desired nonnative plant or contribute to animal species or trends toward Federal listing of any species,
- To comply with the requirements of the Endangered Species Act that actions of Federal agencies not jeopardize or adversely modify critical habitat of federally listed species, and
- To provide a process and standard by which to ensure that threatened, endangered, and proposed species receive full consideration in the decisionmaking process.

Affected Environment

Species Evaluated and Carried into Consideration

The USFWS provided a list of species occurring in the county on May 17, 2006, and verified on September 20, 2006 (from website, http://arizonaes.fws.gov/). A specific project area list was created by comparing the Coconino County list provided by the USFWS Web site to district information on species occurrences and surveys. The USDA Forest Service Region 3 "Regional Forester's Sensitive Species List" of 1999 was used to develop the list of sensitive species considered by this biological evaluation (BE). Species lists were acquired from the Web sites of AGFD HDMS for Coconino County June 8, 2007 (http://www.fws.gov/southwest/es/arizona/). The Paradine plains cactus, *Pediocactus paradinei* (sensitive species with a conservation agreement in place), has been noted in the Warm Fire area and is addressed in this document. The conservation strategy, long-term monitoring, and inventories for management of the *Pediocactus paradinei* have documented the known locations for this species. Although some reforestation and very little fuels treatment is proposed in the cactus management area, no activities are proposed near known occurrences.

Description and Habitat

Paradine plains cactus is a small single, green globose cactus usually no more than 1.5 inches tall above ground, with half of its stem underground. During periods of drought, individual plants retract into the soil and are covered with soil and pebbles (Phillips et al. 1996). Flowering generally occurs in late April (see the biological evaluation available in the project record for a more detailed description).

Habitat for *Pediocactus paradinei* is fairly open, mostly level sites on alluvial fans, valley bottoms and ridgetops. Paradine plains cactus are associated with juniper species due to the endomycorrhizae present in juniper-related soils. Plants are preferentially associated with grass (blue grama), often occurring within the grass clump. In valley bottoms with sagebrush, it occurs in the grassy openings within open sagebrush stands (not found in pure sagebrush). The species

prefers gravelly soils derived from Kaibab limestone; high in calcium carbonate (reduced clay content). It is usually found at elevations of 5,000 to 7,000 feet (1,404 to 1,966 m) (AZGFD 1994, NatureServe 2000). Exposure tends to be south-facing slopes, level to slopes of no more than 10 to 15 percent (AZGFD 1994).

This species grows in the pinyon-juniper woodland and shrub/grassland. Shrub/grassland sites are dominated almost exclusively by big sagebrush (*Artemisia tridentata*) and blue grama (*Bouteloua gracilis*). Flood plains, adjoining toe slopes, recently disturbed sites and well-drained sites generally support shrub/grassland. Woodland sites are dominated by Colorado pinyon (*Pinus edulis*) in association with Utah juniper (*Juniperus osteosperma*) and a mixture of understory shrubs and perennial grasses. The most common understory perennial species are big sagebrush, cliffrose (*Purshia stansburiana*), banana yucca (*Yucca baccata*), rabbitbrush (*Chrysothamnus nauseosus*), blue grama and muttongrass (*Poa fendleriana*). Pinyon-juniper sites occur primarily on slopes and ridgetops or in areas that have not been recently disturbed. Tree canopy cover is greatest on north-facing slopes, high elevations, and on sites with no recent disturbance (Phillips et al. 1996). It appears that habitat conditions are less favorable for Paradine plains cactus within the Kane allotment due to natural factors such as higher precipitation, shorter growing season and colder weather, resulting in the presence of pinyon and ponderosa pine, and denser pinyon pine woodlands with ponderosa pine stringers in the drainages (less openings for *Pediocacti* habitat) (Phillips 2001).

Distribution

Distribution of this species includes the east side of the Kaibab Plateau (East Kaibab Monocline) and west edge of House Rock Valley, Coconino County, Arizona. The entire distribution of this species is within an area of approximately 15 miles, north-to-south, and 2 to 3 miles, east-to-west (AZGFD 1994, NatureServe 2000, Frye 2007).

Environmental Consequences

Direct and Indirect Effects

Alternative 1 - No Action

Under the no action alternative, plants would continue to exist in the areas where they are present and would be unaffected by the Warm Fire. Under the no action alternative, no treatments would occur, therefore, there would be no removal of dead fuels or replanting to accelerate reforestation of the area.

Action Alternatives 2, 3, and 4

No project activities would occur near any known populations of *Pediocactus paradinei* (Phillips, B. 2008). *P. paradinei* is associated with pinyon-juniper woodlands and shrub/grassland communities (Phillips et al. 1996). The key to presence and maintenance of this cactus is the occurrence of vescicular-arbuscular endomycorrhizaee to inoculate seedlings, which are associated with pinyon-juniper woodlands (Phillips, B. 2008). The proposed project would occur within mixed conifer and ponderosa pine vegetations types. By definition, no project activities would occur in pediocactus habitat.

No salvage treatments are proposed near any known occurrences of the cactus. Two stands slated for hand planting have potential to be near the Paradine Plains Cactus Conservation Assessment Area, but no known plants occur in this region of the conservation area. (Phillips, B. 2008).

Based on the discussion above, the effects of these activities, singly or in combination, would have no effect on the occurrences of Paradine plains cactus.

Wildfires

Fires temporarily remove vegetation and expose soil, but shortly afterwards, promote growth of new grass and forb forage and cover. Because fires open up the canopy and remove down woody material, they may also eventually promote development of herbaceous vegetation.

The available habitat for the Paradine plains cactus in the pinyon-juniper woodlands may have decreased due to increased size of trees; however, a repeat photography and aerial photography comparison study was inconclusive regarding increased density and encroachment of the pinyon-juniper woodlands in the cactus habitat during the past 50 years (Shaw 1999). Wildfires on the western side of the district act similarly to prescribed fire during the spring and monsoon seasons; however, they may be more aggressive during the dry summer with cheatgrass to fuel their spread. Most wildfires are a result of lightning strikes, and vary in size and frequency by year. This variability is largely due to moisture, topography, time between detection and suppression action, and the vegetation structure. The Warm Fire was intense enough to kill the Paradine plains cactus as it is generally more vulnerable to fire than other vegetation (Frye 2006).

Long term, there may be more available habitat for Paradine plains cactus as a result of the Warm Fire. But the spread of cheatgrass into the ecosystem could change fire patterns and compete with native plants for moisture and other resources. The Warm Fire Recovery project is not expected to increase the spread of noxious weeds due to design criteria.

However, cheatgrass is in the ecosystem and is likely to continue to be present until it is shaded out or reduced in amount by areas that have been revegetated.

Domestic Livestock Grazing

Domestic livestock grazing has altered and continues to alter forage and grass cover, herbaceous vegetation heights (where not limited by other factors), and vegetation within and around stock tanks and ephemeral wetlands within the analysis area. Past, present, and reasonably foreseeable livestock management actions within the analysis area indicate an increasing trend in forage and grass cover, and a likely increasing trend in herbaceous vegetation heights, where not limited by other factors. Grazing will be deferred for 2 years while the Warm Fire area re-vegetates. The forage and grass cover will likely increase, and increasing herbaceous vegetation heights are occurring within the project boundary and aid in holding soil in place.

Other Projects

Other projects in or near the Warm Fire Recovery project and within the range of the Paradine plains cactus would have the same avoidance criteria during implementation. As a result, no direct effects would occur from those projects. Effects from other projects that alter habitat (beneficially or detrimentally) could occur, but are designed to limit negative effects.

Summary of Effects to *Pediocactus paradinei*

The Paradine plains cactus *(Pediocactus paradinei)* is present within the fire area. No known occurrences are located near units proposed for treatments. Some treatments are present within the known range of the species (primarily reforestation). Due to the limited distribution and specific habitat types for this species, design criteria to prevent direct and indirect effects to this species include a complete flag and avoidance during project implementation. In addition, design criteria to reduce the chance of the project introducing noxious or invasive weeds have been established. No treatment units occur within the project area that would be considered cumulative in effects to the Paradine plains cactus. The Warm Fire may have contributed to the spread of cheatgrass, which has been proven to increase fire frequency. A portion of the Warm Fire impacted the conservation area for this species. The suppression portion of the fire, 4,660 out of 5,735 acres (81 percent), is estimated to have complete vegetation mortality (USDA Forest Service 2007c). Surveys for the Paradine plains cactus were conducted during September 2006 (Frye 2006) and the summer of 2007 (Rebitzke 2007) to determine the extent of effects from the Warm Fire to the species within the known range and found extensive mortality and impacts from downstream flooding. Past management activities and current use from grazing and illegal plant collections contribute to the existing conditions, but cause no new changes to the habitat for this species.

Estimated Cumulative Effects

The above activities and projects suggest the following trends across the analysis area: (1) stable trends (or at least not being impacted by treatment activities) for the Paradine plains cactus; (2) no direct or indirect effects to the Paradine plains cactus or its habitat; and (3) additional surveys within the Warm Fire area (including beyond the Warm Fire Recovery project area) to help determine the effects from the fire to the Paradine plains cactus.

Determination of Effects and Rationale

Based on the analysis, the action alternatives would have no effect on any federally listed (proposed, endangered, threatened, candidate or conservation agreement) species or their critical habitat, and no impact on any regionally listed sensitive species.

Nonnative Invasive Species

Introduction

Nonnative invasive plant species (NNIS) out-compete and displace native plants, interfere with native plant germination and survival, change soil functions, and contribute to a host of other factors that can dramatically alter vegetation composition and structure. When any ground-disturbing activity is proposed, the Forest Service must determine the risk of introducing or spreading noxious weeds associated with the proposed action. Soils disturbed by skidding logs and road construction can provide ideal habitat for invasive plants. Many nonnative invasive plant species take advantage of disturbance situations to enter and invade plant communities. Seeds can be carried in soil clinging to machinery or vehicles and deposited in weed-free areas. Roads can also facilitate NNIS invasion and spread by altering habitat conditions, stressing or removing native species, and allowing easier movement of wild or human vectors.

The chief of the Forest Service identified invasive species as one of four threats to National Forest System lands. As a result, the Forest Service developed a policy for preventing the introduction and establishment of nonnative plant species. This policy and other supporting documentation direct the Forest Service to: (1) determine the factors that favor establishment and spread of invasive plants; (2) analyze NNIS risks in resource management projects; and (3) design management practices that reduce these risks. Forest Service policies emphasize the prevention of weed establishment and have developed prevention practices such as equipment cleaning provisions in timber sale contracts, avoidance of travel through known weed patches, minimizing soil disturbance, and using weed-free gravel sources. These measures reduce the probability of spreading weed seeds and plant parts.

This section analyzes how the proposed Warm Fire Recovery project could affect the spread of nonnative invasive species (NNIS) plants (including noxious weeds) and the ability to control that spread. Actual weed establishment is associated with the proximity of a weed seed source, soil disturbance, as well as movement of animals (birds, deer) and mechanical equipment. Biomass removal activities (yarding, decking, skidding, and landing), removal of fuels, and burning could result in spread or introduction of NNIS. According to the "Kaibab National Forest Land and Resource Management Plan" as amended for the management of noxious weeds (USDA Forest Service 2004a; USDA Forest Service 2005), all projects are to "incorporate measures to control invasive species into project planning, implementation, and monitoring" (see the biological evaluation available in the project record for specific definitions and regulations pertaining to NNIS and noxious weeds).

Methodology for Analysis

The direct and indirect effects analysis for the NNIS portion of the Warm Fire Recovery project is bound by the project boundary. This analysis area is intersected by State or county highways and Forest Service roads, which are the main access routes into the project area. The vegetated roadsides of the main roads are located well off of the asphalt where vehicles travel and, therefore, present a low risk of transporting seeds.

This analysis area for direct and indirect effects was chosen to examine where the measures of change to NNIS would take place, such as in areas of soil disturbances and canopy openings. There would be no project related activities taking place outside of the analysis area.

Acres of soil disturbance within burned areas were chosen as they represent a new risk of maintaining unvegetated soil that was initially opened up from the Warm Fire. Cumulative effects will be analyzed qualitatively using the effects of this project and other past, present, and reasonably foreseeable activities in the area that may have impacts on NNIS populations in the Warm Fire Recovery project area.

Prior to this NNIS report, no listed noxious weeds were known in the project treatment areas; however, cheatgrass is well documented in the Warm Fire area.

Since NNIS plants spread quickly along travel routes via motorized vehicles, the proposed treated stands in the project area are not the only areas at risk of weed invasion. Therefore, analysis outside of the proposed treatment areas, as well as within the proposed treatment areas, is necessary.

Affected Environment

No Arizona state (http://www.azda.gov/PSD/quarantine5.htm) noxious weeds are present in the Warm Fire Recovery project area. A full list of nonnative invasive plants and their location is listed in table 53. The majority of known NNIS is along road corridors or in the Jacob Lake area (USDA Forest Service 2005; USDA Forest Service 2005a). Some species are known to be along the highway from Fredonia, Arizona, leading to the Jacob Lake area, and are listed as likely to be in the project area. The main vectors for spread are vehicles (road maintenance equipment, OHV, and passenger cars and trucks), although the seeds of many species are also wind or animal dispersed.

The invasive plant cheatgrass is located in all elevations along roads in the Warm Fire Recovery project area. Spotted knapweed has been reported along Highway 67 south of Jacob Lake, also in the project area. Other species, including bull thistle, Scotch thistle, houndstongue, and musk thistle may be in the project area. They are not currently known to be in proposed treatment areas. Primarily cheatgrass is found along road edges but is well known to invade burned areas. Of all of the NNIS species, cheatgrass is the most likely to spread widely and invade weed-free areas in the long term. Spotted knapweed has been treated by the district; however, seed can persist in the soil so continued monitoring and treatment will be necessary.

Table 53. Nonnative invasive plant species (USDA Forest Service 2005) in the Warm Fire Recovery project area

Nonnative Plant Species	Location Within WFRP Treatment Area	Habitat
Ripgut brome (*Bromus diandrus*)	likely	Road edges
Cheatgrass (*Bromus tectorum*)	widespread	Road edges and adjacent disturbed areas
Field bindweed (*Convolvulus arvense*)	likely	Road edge, alluvium, with other forbs
Musk thistle (*Carduus nutans*)	likely	Jacob Lake area
Scotch thistle (*Onopordum acanthium*)	likely	Scattered around the North Kaibab Ranger District
Bull thistle (*Cirsuim vulgare*)	likely	Jacob Lake area
Houndstongue (*Cynoglossum officinale*)		Private property at Jacob Lake and around north rim of the Grand Canyon
Spotted knapweed (*Centaurea maculosa*)	present	Road edges and adjacent disturbed areas
Oxeye Daisy (*Chrysanthemum leucanthemum)*	likely	Road edges
Dalmatian toadflax (*Linaria dalmatica*)	potential	Immediately adjacent in Dry Park

Nonnative Invasive Species Analyzed

Ripgut brome is an annual grass native to Europe and northern Africa that can grow 1 to 3 feet tall. It is a common weed of waste areas, roadsides, and is invasive on rangelands. The long stiff awns at maturity can cause injury to the nose and eyes of grazing animals. It is unrecorded, but highly likely that it is within the project area.

Field bindweed is a nonnative vine that is on the Arizona State Regulated Noxious Weed List under the prohibited and regulated categories. It may occur along roadsides and can be a contaminant in mulch and seed stocks.

Musk thistle is a biennial member of the sunflower family. In one growing season a single plant can produce over a 100,000 seeds. Therefore, it can increase from a single plant to a rather large infestation within 2 or 3 years. The seeds can remain viable in the soil for roughly 15 years, which necessitates intensive monitoring of sites and repeat treatments. There are isolated populations of musk thistle found throughout the project area including the North Kaibab Ranger District at Little Mountain, Forest Road 427, and Jacob Lake Campground (USDA Forest Service 2005).

Scotch thistle is a large, biennial thistle native to Europe. Characteristics of this species include broad, spiny stems with vertical ribs, large, spiny leaves with dense hairs and violet to reddish flowers. The plants can create an impenetrable thicket. Seeds are viable for 6 years. This species grows in disturbed habitats along roadsides and in waste areas. There are a few infestations on the North Kaibab Ranger District, Kaibab National Forest (USDA Forest Service 2005).

Bull thistle is a stout, biennial thistle with purple flowers from Eurasia. It invades disturbed sites including slash piles, old log decks, and roadsides. Regeneration is solely from short-lived seed. There are isolated populations on the North Kaibab Ranger District in the Jacob Lake area (USDA Forest Service 2005).

Houndstongue is a biennial herb with bright, reddish-purple flowers. Houndstongue can cause injury or death in grazing animals because it contains a substance that can cause liver failure. Populations are known from the North Rim of the Grand Canyon and from private property at Jacob Lake (USDA Forest Service 2005).

Spotted knapweed is a biennial or short-lived perennial from central Europe, growing 1 to 3 feet tall. It forms a monoculture, producing chemical compounds that inhibit other species from growing around it. Plants have been observed along Highway 67 from 1 mile south of Jacob Lake to south of Telephone Hill in the project area (Fowler, J.; personal communication to B. G. Phillips 2007).

Oxeye daisy is a prolific producer of wind-borne seeds. Large colonies can out-compete native plants and reduce the plant species diversity. When oxeye daisy, with small taproots, replaces perennial grasses with fibrous root systems, soil erosion can increase. A population of the species was observed along Highway 67, in DeMotte Park, North Kaibab RD, south of the project area by B. G. Phillips in August 2007.

Dalmatian toadflax is an introduced ornamental, perennial weed from the Dalmatian region of eastern Europe. It can grow up to 3 feet tall and reproduces both from seed and from underground rootstalks. One plant can produce up to a half million seeds, as well as lateral roots up to 10 feet from the plant. Dalmatian toadflax can crowd out native plants and reduce forage on rangelands. Dalmatian toadflax has been observed in Dry Park, adjacent to the project area (Fowler, J.; personal communication to B. G. Phillips 2007).

Cheatgrass is an erect winter and spring annual grass from Europe that can grow to a height of 2 feet. The plant is a prolific seed producer, and the density of this species has more to do with available sites (bare soil) for germination than the number of seeds produced. The presence of

cheatgrass has increased the fire frequency, similar to wild oats infestations. This will cause a loss of native plants. Large infestations are commonly found throughout the planning area, especially at lower elevations where most treatments are not proposed. One major threatened area is the North Kaibab Ranger District within the key winter habitat of mule deer (USDA Forest Service 2005). This species is pervasive across the Western United States. Cheatgrass has been well documented as a contributing cause of decreases in fire return intervals and changes in vegetative communities—especially in the sagebrush ecosystems in the Great Basin. In the coniferous ecosystems, the effect of cheatgrass would be expected to not be as strong as in ecosystems where fire and subsequent spread of cheatgrass can permanently alter the ecosystem (such as is common in the Great Basin). It crowds out native forbs and shrubs and can contribute to erosion due to its poor root system. Its invasion can be followed by nonnative invasive forbs, which in turn inhibit native plants due to their allelopathic chemicals, altering ecosystems permanently.

This species is reported to achieve initial dispersal into new habitats along trails and roads and it is likely that this species would disperse along the proposed skid trails and burn piles. Federal agencies, including the Forest Service, have programs to watch for and eliminate initial weed infestations. While this vigilance may help to slow the occurrence of this species, it is unlikely that infestations can be entirely stopped or eliminated.

Prevention by limiting vector opportunities and the amount of bare ground is the best way to keep cheatgrass out of an ecosystem. Once established it is hard to eradicate without affecting desirable plants on the site, but it is easily susceptible to herbicides.

Dominant vegetation, soil moisture, nutrients, soil depth, disturbance, and topography all can affect an area's susceptibility to invasion. Disturbed plant communities with deep, fertile soils are most susceptible. This project would not create new roads and would, in some areas, obliterate existing non-system roads, trails, and landings after treatment. This limited site disturbance would help confine weed infestations to narrow corridors where infestations may be controlled more effectively.

Environmental Consequences

Direct and Indirect Effects

Alternative 1 — No Action

Nonnative invasive plants would continue to increase at current rates via animals, wind, and humans. However, the rate would not increase or decrease as a result of the no action alternative. The no action alternative would not directly or indirectly increase or decrease the spread of NNIS plants in the project area or the surrounding area.

Alternative 2 — Proposed Action

Nonnative invasive plants would continue to increase at current rates via animals, wind, and humans. In addition, this alternative proposes to treat the most acres and poses the strongest risk of the spread of NNIS of all of the action alternatives.

Alternative 3 — Winter Logging for Increased Soil Protection

Nonnative invasive plants would continue to increase at current rates via animals, wind, and humans. In addition, this alternative proposes to treat the second lowest number of acres of the

action alternatives, and to treat all areas with an elevated erosion hazard in frozen ground conditions. It is expected the frozen ground treatment would lower the risk of weed spread to make this the lowest risk of the action alternatives.

Alternative 4 — Maintenance of Snags in Spotted Owl Habitat

Nonnative invasive plants would continue to increase at current rates via animals, wind, and humans. In addition, this alternative proposes to treat the lowest number of acres of the action alternatives. However, treatments could occur in non-frozen ground conditions and, thus, would have the second highest risk of NNIS spread of all of the action alternatives.

Cumulative Effects

The no action alternative would not interact with past, present, or foreseeable future actions in the Warm Fire Recovery project area or the north rim area of the Grand Canyon.

Alternative 2 could interact with past, present, or foreseeable future actions in the Warm Fire Recovery project area and the north rim area of the Grand Canyon.

This alternative would have the greatest potential of maintaining NNIS occurrences over the long term. The continued presence of weeds in the area in the long term could act as a reservoir for vectors to introduce weeds to other areas.

Alternative 3 could interact with past, present, or foreseeable future actions in the Warm Fire Recovery project area and the north rim area of the Grand Canyon. This alternative would have the least potential of maintaining NNIS occurrences over the long term of all of the action alternatives, but still does increase the risk. The continued presence of weeds in the area in the long term could act as a reservoir for vectors to introduce weeds to other areas.

Alternative 4 could interact with past, present, or foreseeable future actions in the Warm Fire Recovery project area and the north rim area of the Grand Canyon. This alternative would have the second lowest potential of maintaining NNIS occurrences over the long term of all of the action alternatives, but still does increase the risk. The continued presence of weeds in the area in the long term could act as a reservoir for vectors to introduce weeds to other areas.

Roads in the Project Area

Cumulatively, there may be a slight short-term increase in the spread of nonnative invasive plants due to this and other past, present and reasonably foreseeable forest actions. Roads are one of the most significant vectors for spreading weeds. Temporary skid trails would be decommissioned, blocked/gated, and revegetated with native seed or desirable annual nonnative plants, so they would be less likely to become weed infested. With mitigations incorporated into this project, it is expected that weeds should not increase.

Other Projects

Other ongoing forest projects within the cumulative effects area have similar timber and road activities. These were considered for their contribution to the spread of nonnative invasive plants. Project specific mitigation measures (and/or project design features) in conjunction with the Kaibab National Forest should all contribute to controlling the spread of NNIS across the forest.

Determination of Effects

Table 54 displays risk assessment ratings that determine the actions for controlling NNIS (for the complete risk rating evaluation process description, see the NNIS report available in the project record).

Table 54. Risk rating for the WFR project area

Risk Rating	Action	WFRP Area Rating
None	Proceed as planned	
Low	Proceed as planned. Initiate control treatments on undesirable plant populations that get established in the area.	
Moderate	Develop preventative management measures for the proposed project to reduce the risk of introduction or spread of undesirable plants into the area. Monitor the area for at least 3 consecutive years and provide for control of new infestations.	The combined score of weed presence and elevated risk of weed invasion is 25 giving the Warm Fire Recovery project a moderate risk rating.
High	Modify project design and implement preventative management measures for the proposed project to reduce the risk of introduction or spread of undesirable plants into the area. Monitor the area for at least 5 consecutive years and provide for control of new infestations.	

The Warm Fire Recovery project area has one State listed noxious weed present (spotted knapweed). Cheatgrass is present along roads in many of the treatment areas and likely other State listed noxious and nonnative European/Eurasian invasive plant species are present as well. This gives the Warm Fire Recovery project area a moderate risk rating.

The determination of a moderate risk of NNIS spread and invasion in the Warm Fire Recovery project area is based on compliance with the land and resource management plan (LRMP) standards and guidelines, FSM 2081.03, as well as additional project management requirements and mitigations. These measures and direction are designed to uphold EO 13112 and to help meet the chief's threat of invasive species. These alternatives have been developed in accordance with the "Kaibab National Forest Land and Resource Management Plan" (and as amended 2005 and 2005b for the treatment of noxious weeds) and other regulations set forth by the Forest Service and other regulatory agencies. Since the project design includes preventative measures against the spread of NNIS plants, the project would meet forest standards and guidelines, as well as EO 13112 and FSM 2081.03.

Fire Risk and Fuels

Desired Condition

The desired conditions for fuels in the Warm Fire area include:

- Surface fuel levels are such that effects from future fires are acceptable and the benefits to soil productivity and wildlife habitat can be realized. The future forest can be sustained with fire functioning as a key ecological process. Reduced fuel levels would result in lower fire hazard, including resistance to control. Future fuel loading would be closer to historical levels for large fuels, and small woody fuels would be 5 tons per acre or less

(Brown et al. 2003). Achieving these levels over extensive areas is not realistic given the scale of the fire and economic limitations. However, in order to increase the effectiveness of future fire management, it is desirable to make substantial progress toward these levels in areas that are located along ridgetops and/or are readily accessible, and are projected to have high fuel loadings over time.

Long-term desired conditions are based on Kaibab forest plan direction and supported by literature describing reference conditions (Fulé, et al. 2003b; Gildar and Fulé, 2004; White and Vankat, 1993) include:

- Surface fuel levels are such that the historic fire regime (relatively frequent and low to mixed fire intensity) and the associated ecological processes can be maintained.

Management Area Direction EMA 13

Standards:

- Implement resource operations and improvements which contribute to achievement of desired conditions and fulfillment of the Forest Service mission.

Guidelines for Fire Protection Operations and Improvements:

- Do not allow wildfires to spread to lands of other ownership
- Protect human life and improvements
- Provide fire protection to restrict wildfire size to 20 acres
- Minimize acreage burned by high intensity fires (200+ BTU/FT/SEC)
- Long-term average annual burned area should not exceed 70 acres
- Fires from natural ignitions may exceed these size limits when burning within an approved area and declared a wildland fire use action

Guidelines for Fuels Management:

- Priority for fuels treatment investment is given to:
- Rural-urban interface
- Areas that exceed the burning conditions that yield the historical 50 percentile rate of fire spread in fuel model K
- Maintenance of existing fuelbreaks and fuels reduction corridors

Management Area Direction EMA 16

Management Direction for Fire Protection:

Provide fire protection to restrict wildfire size to 200 acres. Emphasize suppression responses and tactics which minimize firefighting costs. Long-term average annual burned area should not exceed 2,900 acres. Fires from natural ignitions may exceed these size limits when burning within an approved area and declared a wildland fire use action. Priority for fuel treatment investment is

low and should be limited to rural/urban interface and protection of adjacent, higher value management areas.

There is a need to reduce fuels in order to increase the likelihood of safe and successful fire suppression efforts in the future. These areas should have a strategic arrangement where treatment can increase the management effectiveness of future fires (both wildland and prescribed).

The objective in these areas is to promote, over the longer term, fuel conditions with low surface fire intensity and fire severity, and low resistance to fire line construction; collectively helping to reduce the size of future fires and protect reforestation efforts.

Analysis Factors and Models

The following topics were analyzed with this project:

- Fuel loading (coarse woody debris and small fuels)
- Resistance to control
- Fuel continuity across the project area.

Fuel Loading (Coarse Woody Debris (CWD) and Small Fuels), Resistance to Control, Flame Length, Potential Soil Heating

Future fuel loading (tons per acre) for the Warm Fire Recovery (WFR) project were predicted by modeling data obtained through stand exams (see the silviculture report available in the project record for a detailed explanation of how the vegetation database was compiled and the assumptions used). Estimates of surface fuels were made using FVS-FFE, Forest Vegetation Simulator with the Fire and Fuels Extension (Rheinhardt and Crookston 2003). The Fire and Fuels Extension to FVS simulates fuels dynamics over time and can be used to simulate and predict snag fall down rates, fuel loadings, parameters affecting fire behavior, and fuels accumulation and decay. The decay and fall rates of snags and fuels within the model vary depending on species, size class, and the current condition of snags and logs. The simulated breaking and falling snags are added to the surface fuels where further decay modeling occurs. The fall down rates and subsequent fuel loading are important to model and compare effects of removing fuels and not removing fuels in future stand management. Modeling predicted fuel loads both small woody fuels (those less than 3 inches in diameter) and large woody fuels (also referred to as coarse woody debris) from current levels out to 40 years from the modeling date. Modeling was based on individual stand characteristics and on whether the stand experienced high, moderate, or low intensity fire. Currently standing woody fuels were included in future timeframes when they are anticipated to be on the ground and part of the available fuel bed.

Analysis of Effects

For fire and fuels management, direct and indirect effects are those that occur from the proposed activity. These can be determined through fuel loading and the resulting effect of that fuel loading on fire suppression efforts. In this report, effects will be considered for each alternative at 5, 20 and 40 years after the fire event. Cumulative effects are those effects from other activities—past, present, and future—that add to or subtract from the effects of this project.

Methodology

In order to compare the effects of alternatives on forest development over time, the establishment and growth of naturally occurring seedlings and planted seedlings are tracked into the future. As seedlings are established under the various burn severities and cover types, and because they add to overall stand composition and structure when combined with remaining live trees, stand development over time will be modeled into the future to describe changes in cover type and fuels.

Burn Severity and Regeneration Assumptions

The acreage by mortality class was compiled for each stand within the WFR project area. A stand level overstory mortality rating was then assigned based on the percentage of each mortality class within the stand. For determination of mortality levels, see details specified under "Vegetation Mortality" in the fuels specialist report located in the project record. Mortality for each stand with stand exam data was then simulated in FVS based on these ratings and stand conditions were projected. For stands without data, forest conditions were extrapolated based on similar stands that did have data.

See the "Vegetation Resources" section for assumptions made pertaining to natural regeneration and planting used in the Forest Vegetation Simulator (FVS) modeling.

Projecting tree and stand growth into the future is modeled using the Forest Vegetation Simulator. FVS is a firmly established tree and stand growth model that is fully supported and maintained by the Forest Service. A specifically calibrated variant of FVS is available for the Southwestern Region. Stand development over time is modeled using existing stand conditions, as provided by stand exam data collected prior to the fire from 1985 through 2005, and with the natural regeneration and planting assumptions discussed above. Salvage functions are included as well, so that estimates of future fuels, snags, and structural stages are based on realistic conditions. Growth projections do not necessarily predict the actual growth that will occur, because the models cannot predict all factors that effect stand and tree growth. Model results are used to highlight relative differences, not absolute conditions. No future activities or fires are included in growth simulations, but periodic establishment of natural regeneration is modeled.

Surface Fuel Assumptions

Surface fuels in FVS_FFE are tracked through litter, duff, and woody surface fuels. The woody debris is classified into six different size classes and four different decay rate classes, based on the species and diameter of the wood at the time it was added to the forest floor. The movement of fuel components between these size classes is not simulated in the model. Each fuel pool, including litter and duff, decays at a potentially different rate. As the fuels decay, a portion becomes duff and a portion goes into the atmosphere. Input to the fuels comes from the crowns of live trees and management slash. Fuels are removed through decay, management, or fire. Users can control the decay rates, the amount of the decayed material that becomes duff, fuel management options, and, to some degree, the amount of slash that is created at the time of a stand entry. The model contains default fuel levels based on stand cover and age, which are used to initialize the various fuel pools. The fuels component produces a detailed output report at a user-specified interval that gives the amount of fuel in each size class, as well as in live and dead trees and canopies. For the purposes of this analysis, default values were used for entries where user-defined variables are allowed. Activity fuels from salvage operations in the action

alternatives were included along with fuels that are projected to accumulate due to the fall down and breakage of existing standing dead woody fuels. For fuel model selection criteria see appendix B of the fuels specialist report, located in the project record.

Analysis Area for Direct and Indirect Effects

The project area includes National Forest System (NFS) lands contained within the part of the Warm Fire perimeter that was managed under a wildfire suppression strategy. The project area includes approximately 39,112 acres of NFS lands. The acreage for displaying affects are the areas proposed for treatment under the proposed action, as these are the only areas that will have potential fuel loading and resistance to control modified.

For fuels, the affected environment was defined using two activities from the proposed action: salvage timber harvest and those areas that are not salvaged but will be reforested under this proposal. Direct and indirect effects discussions are limited to the areas proposed for treatment for resistance to control and future fire severity and soil effects. Fire behavior was modeled for the entire WFRP area and is displayed in flame length classes according to the hauling charts.

Affected Environment - Historic and Existing Conditions

Forest Vegetation and Fuels

See the “Forest Vegetation Conditions” section for a description of the forest vegetation within the WFR project area in terms of species composition (cover type). Cover types present within the WFR project area include: pinyon-juniper (PJ), ponderosa pine (PP), mixed conifer (MC), and aspen (QA).

Fire Regimes

Fire regimes for the project area were determined utilizing local fire history studies as noted in the “Warm Fire Assessment” of post-fire conditions (USDA Forest Service 2007c). The following discussion of fire regime by vegetation type is taken from that document.

A fire regime is a description of the role fire plays in an ecosystem, based on characteristics of the disturbance, the dominant or potential vegetation being described, or the fire severity as it effects dominant vegetation (Agee 1993). Fire regimes are based on fire occurrence and behavior prior to the influence of European settlers, and described with characteristics of frequency, seasonality, intensity, duration and size. The three major cover types within the Warm Wildland Fire area—pinyon-juniper, ponderosa pine and mixed conifer—historically supported varying fire regimes based on their geographic location, edaphic factors, and climatic factors such as lightning and precipitation amounts. Several studies concerning fire history and forest composition have been completed in the north rim area of Grand Canyon National Park within similar elevation limits as the Warm Fire. These studies have described historic fire regimes based on these general cover types. For the purposes of this analysis, fire regimes, fuel loading, and resistance to control will be based on these four major cover types contained within the fire perimeter.

Fire regimes in the fire area range from high frequency, low intensity in ponderosa pine to mixed severity in the mixed conifer and pinyon-juniper. Generally, in low severity fire regimes, most trees survive a disturbance, while in high severity fire regimes, most trees are killed. These fire regimes are found in adjacent stands in the Southwest on steep elevation gradients.

A wildland fire disturbance that produces both low and high severity effects on adjacent forest patches is called a mixed severity fire regime (Fulé et al. 2003b).

White and VanKat (1993) found five major forest types in the high elevation coniferous forests of the North Rim of Grand Canyon National Park. They divided the cover types into four mixed conifer types: PIPO/PSME, PIPO/ABCO, PIPU/PIPO, and ABCO/PIPO/PSME and one spruce type, PIEN/ABLA (PIPO=ponderosa pine, PSME=Douglas-fir, ABCO=white fir, PIPU-PIEN=Engleman Spruce, ABLA=subalpine fir). All four of the mixed conifer types recorded a high frequency, low severity fire regime, with the frequency decreasing as site moisture conditions increased. The spruce type demonstrated the longest fire return interval, meaning that fuel buildup between subsequent fires would have been enough to support a more intense, high severity fire when they did occur.

A study of fire regimes in high elevation forests of the Grand Canyon (Fulé et al. 2003b) found similar fire regimes based on elevation and cover type. The authors compared two study sites, an upper elevation (2,794 m) more mesic mixed conifer (ponderosa pine, white fir, aspen, Engelmann spruce) site to a lower elevation (2,350 m) drier ponderosa pine site. The more mesic, mixed conifer site had a longer mean fire return interval, while the drier ponderosa pine site experienced more frequent fires.

Prior to 1880, Grand Canyon forests were characterized by large fires and high fire frequencies, with fire sizes prior to European settlement reaching at least hundreds of hectares (Fulé et al. 2003a, 2003b).

An abrupt curtailment of the historic fire regime began with the arrival of Mormon settlers in the 1850s. Extensive livestock grazing commenced by the 1880s, and in 1887 there were 200,000 sheep and 20,000 cows documented on the Kaibab Plateau. Large deer herds were blamed for overgrazing in the 1920s, 1930s and 1950s. Fire suppression started in the early 20th century (White and VanKat 1993). Most of the rim country experienced fire exclusion after 1879 with modern fire-free intervals about five and one-half times longer than historical at two sites that Fulé et al. (2003b) studied.

Historic Fire Regime by Cover Type

Pinyon-Juniper

Fire regime information for the pinyon-juniper type is derived from the upper limit of its extent where it transitions with the ponderosa pine type. Species in the pinyon-juniper woodlands include Utah and Rocky Mountain juniper as well as true pinyon. Fire was the most important natural disturbance before introduction of livestock grazing. Large areas of woodland savannas would have burned—especially during dry years following wet years when herbaceous growth would have been plentiful. A study in Walnut Canyon, Arizona, found a 20- to 30-year return interval for surface fires. Pre-settlement fire behavior in dense stands was a mixture of surface and ground fire. Frequency and intensity depended on site productivity. Where grass cover was higher and more continuous during pre-settlement, fire frequency would have been higher, a 10-year return interval or less, and the frequency would have maintained these areas as savannas or grasslands (Brown et al. 2000).

Woodland cover and stand densities have increased throughout the West over the last century. The increasing range of this pinyon-juniper type has been attributed to a variety of factors, including

grazing, lack of fire, and favorable climatic conditions. Present day, dense pinyon-juniper stands are known to experience crown fires when high winds and low relative humidity occurs (Brown et al. 2000).

Ponderosa Pine

For 300 to 500 years prior to the 19th century, Southwest ponderosa pine forests experienced high frequency, low intensity fires with return intervals of 2 to 20 years, while low frequency, high intensity crown fires were rare or nonexistent (Savage and Mast 2005). Ponderosa pine developed adaptive traits to survive these frequent disturbances, including thick bark, rapid seedling growth, and flammable litter that burned off easily with little soil damage. These frequent, low intensity fires maintained relatively open forests dominated by large trees with a diverse, productive understory. Lang and Stewart's 1910 survey on the Kaibab Plateau found a mean stand density of 128 trees per ha for ponderosa pine trees with d.b.h greater than 15.2 cm (Savage and Mast 2005).

Several fire history studies have been completed in the drier ponderosa pine forests of the North Rim of the Grand Canyon adjacent to the Warm Fire area (Fulé et al. 2003a; 2003b; Gildar and Fulé 2004). While frequencies varied, all studies found frequent, low intensity fire occurrence in the ponderosa pine type. Assessing fire regimes for forested types on both the North Rim and South Rim, Fulé et al. (2003b) found a mean fire return interval (MFI) of 3.2 to 5.5 for all scars for the North Rim sites, while for fires that scarred greater than 25 percent of the trees sampled, the MFI was 6.4 to 9.5 years. At all sites, fires tended to occur in dry years following wet years. Gildar and Fulé (2004) found fire frequencies of 6.1 to 7.5 MFI for greater than 25 percent of all fire-scarred trees sampled, and 3.4 to 3.9 MFI for all fires recorded. An additional study in ponderosa pine found a mean fire interval for all scars of 4 years, while fires found on more than 25 percent of all fire-scarred trees sampled had a frequency of 6.8 years, with a range of 2 to 18 years (Fulé et al. 2003a).

Essential fire exclusion since European cultural influence began in the late 1800s has resulted in removing the key ecosystem disturbance process of fire from ponderosa pine forests. The rapid onset of fire suppression and domestic livestock grazing brought an abrupt cessation to this surface fire regime (Savage and Mast 2005).

The results may be seen in denser forests, reduced understory species composition and plant cover, and higher accumulation of litter and duff on the forest floor (Gildar and Fulé 2004). Gildar and Fulé (2004) found, when measuring burned and unburned sites in ponderosa pine forests in Grand Canyon National Park, that tree density, forest floor and coarse woody debris were significantly higher at the site not burned for at least 120 years.

Mixed Conifer

While more mesic than the ponderosa pine type adjacent to it, the mixed conifer type on the Kaibab Plateau is still considered a dry form of this vegetation type. The drier mixed conifer type on the Kaibab Plateau contains a variety of dominant overstory species, including ponderosa pine, Douglas-fir, white fir, aspen and blue spruce. The increase in moisture on these sites allows for a slightly longer fire frequency than the ponderosa pine type. White and VanKat (1993) found fire frequencies ranging from 6 to 27 years in an ABCO dominated type. The more mesic site conditions on the ABCO/PIPO/PSME forest type they delineated allowed for longer fire return

intervals, and more intense fires, sometimes creating openings in the canopy where the more shade intolerant species of ponderosa pine and aspen could regenerate.

A study of fire regimes in high elevation forests of the Grand Canyon (Fulé et al. 2003b) found similar fire regimes based on elevation and cover type. The more mesic, mixed conifer site had a mean fire return interval of 31 years for fires scarring more than 25 percent of sampled trees, and a mean fire interval of 2.6 years for all scars.

Mixed conifer communities with similar site characteristics in south-central Utah on the Paunsaugunt Plateau were found to have a fire frequency of 7.5 years from 1500-1900 (Jenkins et al. 1998). They state the altered stand composition in favor of white fir and Douglas-fir observed since European influence began could not have occurred with frequent, low intensity fire. The reduction in surface fire is noted as altering community type structure and reducing area occupied by aspen and ponderosa pine. They note the change in vegetation composition and structure has brought about a change in fuel loading and subsequently changed the fuel model 2 (timber-grass and understory) to a fuel model 8 (closed timber litter) or 10 (timber litter and understory).

Touchan and others (1996) found the pre-settlement fire regime of mixed conifer forests in the Jemez Mountains of New Mexico to be a mixture of infrequent, small patch size, high intensity crown fires interspersed with more frequent, widespread and low intensity surface fires. In general, forests had a more open structure, with a larger proportion of older, larger trees, and a smaller proportion of younger, smaller trees. Historically, these forests were less dense. There were fewer fire sensitive species such as white fir and mixture of age classes; although there were small patches of trees in several age classes in areas that experienced frequent fire. Areas that experienced less frequent and more severe fires probably had even-aged stands of trees, although patches were smaller than those areas that experienced more frequent fire (Touchan and others 1996, Muldavin and Tonne 2003).

The frequent nature of fire disturbances in the forest types of the North Rim pre-European settlement favored regeneration of ponderosa pine, aspen and Douglas-fir. These species have adapted ecologically to these frequent disturbances and have become fire tolerant in a variety of ways. The observed increase in young, fire intolerant trees such as spruce and fir (White and VanKat 1993, Fulé et al. 2003, Fulé et al. 2004) now means greater vertical and horizontal fuel continuity when combined with dead fuel loading. This change in the fuel profile to an increase in ladder and crown fuels suggests a change in the fire regime from high frequency/low severity to infrequent, high severity.

Aspen

Fire regimes for aspen are determined by the surrounding forest (Schussman and Smith 2006 - TNC). In the WFR project area this includes ponderosa pine and mixed conifer cover types.

Aspen exists in small to large patches in the Southwest, resulting from a combination of intense, stand-replacing fires, and smaller surface fires and other disturbance events (Schussman and Smith 2006). Historically, within the WFR project area, the larger patches of aspen would occur within the mixed conifer cover types where more intense fires created openings in the canopy and aspen could regenerate.

Coarse scale definitions for natural (historical) fire regimes have been developed by Hardy et al. (2001) and Schmidt et al. (2002) and interpreted for fire and fuels management by Hann and

Bunnell (2001). The natural (historical) regimes are classified based on average number of years between fire (fire frequency) combined with the severity (amount of replacement) of the fire on dominant overstory vegetation. These five natural fire regime groups are described in table 55.

Fire regimes were determined based upon the fire history studies noted above and through input from local fire management personnel. In general the following fire regimes make up the bulk of the Warm Fire project area:

- Fire Regime I – ponderosa pine, mixed conifer, pinyon-juniper/grass
- Fire Regime II – aspen
- Fire Regime III – aspen, spruce-fir, pinyon-juniper woodlands

Table 55. Description of five fire regime groups

Fire Regime Group	Fire Return Frequency	Fire Intensity/Severity
I	0-35 years	Low to mixed severity (surface fires most common with less than 75 percent of the overstory vegetation replaced)
II	0-35 years	High Severity (stand replacement with greater than 75 percent of the dominant overstory replaced)
III	35-100+ years	Mixed (less than 75 percent of the overstory replaced)
IV	35-100+ years	High Severity (stand replacement with greater than 75 percent of the dominant overstory replaced)
V	>200 years	High Severity (stand replacement with greater than 75 percent of the dominant

The WFR project area had been represented by Fire Regimes I, II and III. Table 56 lists the historical fire regime groups for the WFR project area

Table 56. Acres and percentages of fire regimes present in the WFR project area

Fire Regime	Acres	Percent
I	34,897	89%
II	1,311	3%
III	1,502	4%
Non-Vegetated	1,414	<41%

Fire Risk and Occurrence

Fire Risk

Fire risk refers to the probability of an ignition occurring as determined from historical fire record data. The project area experiences fires caused by both people and lightning, with the majority of the fires starting from lightning. Fire risk due to lightning cannot be changed over a landscape. Although fuels must be receptible to ignition, the risk of an ignition occurring are for the most

part independent of fuels management. Fire risk from person-caused fires through prevention efforts already exists in the area.

Fire Occurrence

The tendency for a short fire return interval is reflected in the fire occurrence for the North Kaibab Ranger District. Over 2,000 fires occurred from 1970 to 2005 on the district. The vast majority of the fires were started by lightning. Regardless of management action, ignitions for lightning strikes will continue to occur throughout the project area and the North Kaibab Ranger District.

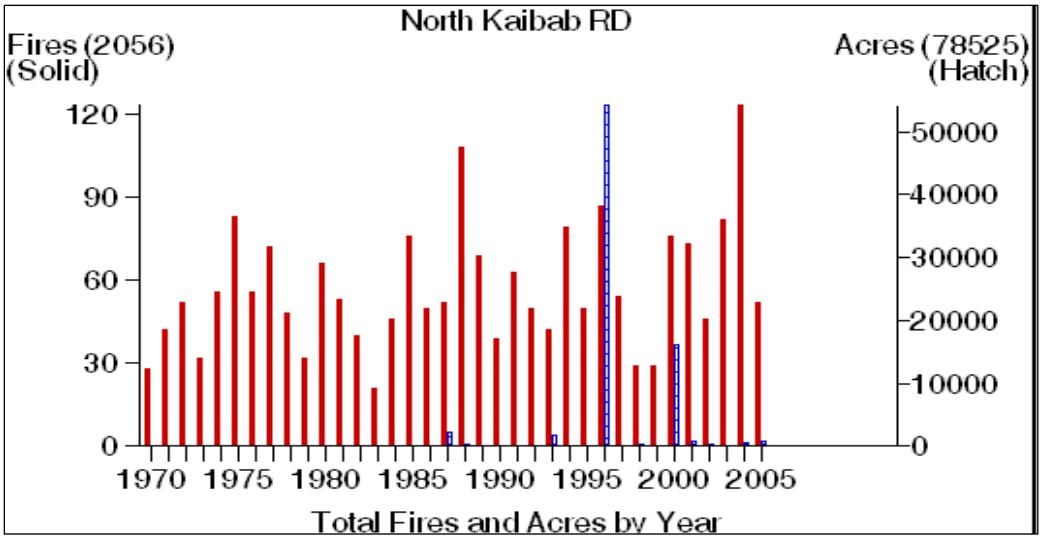

Figure 29. Acres of fire occurrence by year on the NKRD

Fuel Conditions

Vegetation Mortality

Fire effects to vegetation were measured by assessing specific factors at five levels of vegetation strata, from the ground through the overstory canopy. These data were then correlated to the Burned Area Reflectance Classification (BARC) map which displayed the change in reflectance of the Landsat satellite image before and after the fire. The following four levels of vegetation mortality were determined within the WFR project area:

Low Vegetation Mortality: In the low vegetation mortality class areas, there is light ground char where the litter was scorched, charred, or partially consumed. Most of the trees survived; however, there are pockets of seedlings and saplings that were killed or consumed. Many of the shrubs, forbs and grasses were burned under conditions that could be described as a "cool" burn. In these cases, much of this vegetation survived. The low vegetation mortality class was characterized by areas that were either unburned or burned in small patches resulting in less than 15 percent mortality of vegetation in the less than 16-foot height classes, and little to no scorching of subcanopy and upper canopy trees, and less than 5 percent of upper canopy trees were killed by fire effects.

Mixed-Low Vegetation Mortality: The mixed-low vegetation mortality class is characterized by fire effects slightly higher and with more variability than the low vegetation mortality class. The mixed-low class was characterized by approximately 10 percent mortality of upper canopy trees and 50 percent subcanopy scorch.

Mixed-High Vegetation Mortality: The mixed-high vegetation mortality class is characterized by fire effects less lethal and with more variability than the high vegetation mortality class. These areas experienced moderate soil heating. The surface litter layer was consumed and the duff layer was deeply charred by the fire. Small woody debris is mostly consumed; larger logs remain but are charred. Vegetative ground cover is patchy and not continuous. Much of the tree canopy remains; however, it was scorched, turning the needles brown. These needles will eventually fall to the soil's surface, providing immediate mulch and initiating the slow recovery process of re-establishing vegetative ground cover. The mixed-high mortality class was characterized by approximately 70 percent mortality of upper canopy trees and median values of 100 percent subcanopy scorch and 40 percent upper canopy scorch.

High Vegetation Mortality: High vegetation mortality class areas typically experienced a high degree of soil heating that killed the live vegetation. A large majority of the trees were killed with entire tree canopies totally consumed by intense heat and fire. Foliage, litter, and duff were completely consumed. Coarse, downed woody debris was deeply charred or totally consumed. This class was characterized by complete mortality of vegetation in the less than 16-foot height classes, 100 percent scorching of the subcanopy and upper canopy trees, and 100 percent mortality of upper canopy trees.

The post-fire Landsat image from which the vegetation mortality map was created was taken July 9, 2006, only 5 days after the fire was declared fully contained. Because of delayed vegetation mortality, a certain proportion of areas classified as mixed-high severity in this initial fire assessment would likely be classified as high severity by the 2007 growing season. Table 57 displays the percent of each cover type in each mortality class. The percentages indicate all the cover types experienced much higher mortality than would be expected based on historic fire regimes.

Table 57. Percent of cover type within each mortality class for the WFR project area

Cover Type	Mortality Class			
	Low	Mixed-Low	Mixed-High	High
Pinyon-juniper	3%	4%	12%	81%
Ponderosa pine	23%	18%	12%	47%
Mixed conifer	8%	7%	7%	78%
Aspen	15%	18%	15%	52%

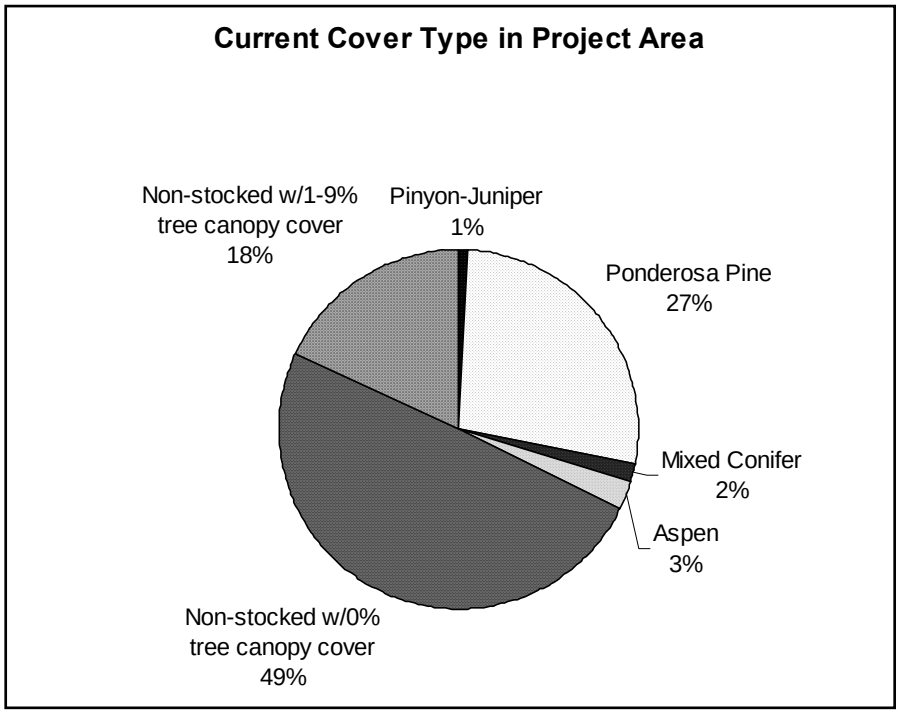

Figure 30. Acres of current cover type and percent within the WFR project area

Cover Type

An assessment of post-fire cover types indicates that approximately 50 percent of potentially forested (were forested prior to the Warm Fire) acres in the WFR project area are in completely non-stocked condition with an additional 18 percent considered nonstocked, but they do have 1 to 9 percent tree canopy cover. Of the remaining 32 percent, approximately 27 percent are in the ponderosa pine cover type, 3 percent aspen, 2 percent mixed conifer, and less than 1 percent pinyon-juniper. Figure 30 displays the acres of current cover type and percent within the project area.

Fire Behavior and Severity

Fire behavior is the manner in which a fire reacts to weather, topography and available fuels (Agee 1993). These three elements comprise the fire environment, the surrounding conditions, influences, and modifying forces that determine fire behavior. A change in any of these components results in a change in fire behavior (DeBano 1998). Fire behavior is most often characterized by fire line intensity, severity, flame length, and rate of spread and is important to determining firefighter strategies and tactics during fire suppression operations (Rothermel 1983).

While the terms fire intensity and fire severity are commonly used interchangeably, the two terms do refer to different aspects of wildfire occurrence. Fire severity is an important factor in shaping the vegetation in a forest. Fire severity describes an ecosystems response to a wildfire's effects on soil and water, flora and fauna, the atmosphere, and the human environment (Simard 1991). Fire

intensity is a term that is used to describe the rate at which a fire produces thermal energy and refers to the amount of energy released from fuels.

Weather is an important factor in wildland fire events. Fires are often influenced through both long-term climate and short-term weather. Weather influences fire growth, ignition of fuels, and resistance to control. However, land managers have no control over weather conditions.

Like weather, land managers have very little control over topography. Fire managers deal with adverse topography by choosing suitable topographic locations relative to fire spread and intensity.

Wildland fuels consist of organic material that could contribute to combustion. Land managers have the ability to modify fuels, which has a direct result on fire behavior. In a national survey, nearly 80 percent of all wildland firefighters identified fuel reduction as the single-most important factor for improving their margin of safety on wildland fires (Tri-Data 1996). Manipulating fuels allows firefighters and land managers the most control in wildland fire management. Fuels contribute to the rate of spread of a fire, the intensity/flame length, how long a fire is held over in an area, and the size of the burned area (Rothermel 1983; Agee et al. 2000). Fuels management is intended to modify fire behavior ameliorate fire effects and reduce fire suppression costs and fire danger. Common fuels management practices include reducing the loading of available fuels, converting fuels to those with a lower flammability or isolating or breaking up continuous bodies of fuels (DeBano 1998).

There are three categories of dead surface fuels that affect fire behavior. They are all a factor in the short- and long-term fire hazard in the Warm Fire analysis area. Fine fuels such as grass or forbs, small woody fuels less than 3 inches in diameter, and large woody fuels greater than 3 inches in diameter. “Hazard fuels” consisting of small woody fuels less than 3″ diameter and the fine fuels can be proactively managed before wildland fires occur, and such practices can effectively decrease fire spread, resistance to control, and resource impacts (Kalabokidis and Omi 1998; Pollet and Omi 2000). Fine fuels are the major contributors to fire spread, carrying the ignition and flaming front of a fire (Rothermel 1983). However, eliminating fine fuels is neither possible nor desirable. Small woody fuels influence a fire’s rate of spread and fire intensity, and lose their moisture faster, start easier and burn more readily than large woody fuels (Agee 1993).

In forested areas most of the biomass is contained in tree boles and generally unavailable to burn except where fuels are ideally arranged (Brown and See 1981). These large woody fuels greater than 3 inches in diameter do not normally contribute greatly to fire spread, and are not considered in the BEHAVE fire spread prediction model. However, when distributed properly, fuel size and loads can significantly affect fire behavior and fire line intensity. Brown et al. (2003) determined that large woody fuels do, however, contribute to the development of large fires and high fire severity, and that fire hazard and resistance to control reach high ratings when large woody fuels exceed 25 to 30 tons per acre in combination with small woody fuels of 5 tons per acre or more. Increased fire behavior and resistance to control resulting from these fuel loads can negatively influence firefighter safety by slowing suppression actions and increasing firefighter exposure to environmental hazards. In addition, fire line construction rates are lower in fuel models with larger diameter fuels than in the other common fuel types (NWCG 2004; Anderson 1982), which can substantially increase the time and effort required to contain a wildfire. Continuous acres of heavy mortality such as occurred as a result of the Warm Fire, will create heavy continuous fuel loads as a sizeable portion of the trees fall over.

According to Agee (1998), the various surface fuel categories interact with one another to influence fire line intensity and can have a significant effect on fire severity in addition to reducing rates of fire line construction.

Regardless of the physical size of the fuels, when high fuel accumulations occur across contiguous areas, wildfire resistance to control is higher and the effects of a fire tend to be more severe. This is in part because there are no relatively fast, easy locations to build fire line. To deal with this, fuels can be treated by reducing the volume, converting fuels to those with a lower flammability, and isolating or breaking up large continuous bodies of fuels (DeBano et al. 1998). Breaking up fuel continuity can change the behavior of a fire entering or starting in an area, which will allow suppression forces a higher probability of successfully attacking a wildland fire (Agee et al. 2000). Areas with significantly less fuel may also be used as anchor points for wildland fire control (Agee, et al. 2000). The associated lower fire intensities in these areas can enhance firefighter safety. In addition, areas with fewer fuels are generally easier to implement prescribed burning to control future fuel loads and potentially sever fire effects.

Flame Length

Flame length has significance for suppression strategy and tactics, and is a good visual indicator of fire line intensity at the head of the fire (DeBano et al 1998). It is also a measure of fire suppression difficulty. Table 58 displays fire line intensity and flame length as it relates to suppression difficulty. Ideally, flame lengths would be 4 feet or less across the entire project. In some cases this is not possible due to the fuel type. For instance, in some fuel types such as grass or shrubs, flame lengths tend to be relatively higher and need treatment on a regular basis to keep flame lengths low. Even if flame lengths are over 4 feet, it is important to try to limit them as much as possible, lower flame lengths result in fewer hazards.

Table 58. Fire line intensity interpretations

Intensity	Flame Length (Feet)	BTUs/Sec/Foot	Interpretations
Low	<4	<100	Direct attack at head and flanks with hand crews; hand lines should stop spread of fire.
Low–Moderate	4.1–8	100–500	Employment of engines, dozers, and aircraft needed for direct attack; too intense for persons with hand tools.
Moderate	8.1–11	500–1,000	Control problems, torching, crowning, spotting; control efforts at the head are likely ineffective.
High	>11.1	>1,000	Control problems, torching, crowning, spotting; control efforts at the head are ineffective.

Based on Rothermel (1983)

Fire Hazard

Fire hazard generally refers to the difficulty of controlling potential wildland fire. It is commonly determined by fire behavior characteristics such as rate of spread, intensity, torching, crowning, spotting, fire persistence, and resistance to control. Fire severity is considered to be an element of fire hazard for this analysis. Fire severity refers to the effects of fire on the ecosystem. It depends on fuel consumption and heat flux into all living components. Small and large down woody fuels (fuel loading) contribute differently to the various elements of fire hazard (Brown et al. 2003).

There is controversy on the subject of harvesting fire-killed trees for the purpose of reducing the potential fire behavior, severity and effects (Odion et al. 2004). However, information specific to southwestern forests is more limited. Still, information from dry forest types may be a useful aide in thinking about treatments to areas that have burned in wildfires. Donato et al. (2006) and McIver and Ottmar (2007) found that small woody fuels immediately increased following salvage operations. Similarly Monsanto and Agee (2008) found that although coarse woody debris also increased immediately following salvage, they noted that by age 10, the large diameter fuels fell below the levels in unsalvaged stands, and that the pattern remained for at least 35 years. These results were similar to both large diameter and small diameter fuels modeled for the Warm Fire area. In their study of dry climate forests (more similar to the Warm Fire project area), Monsanto and Agee (2008) concluded that there may be some long-term advantages to reducing coarse woody debris early in the post-wildfire period and that active management may be desirable to reduce the potential intensity and severity of future fires. Thompson et al. (2007) note that considerations for deciding whether to log or not should include the potential for future high severity fire and reducing hazards to firefighters. Thus, reductions in fuel loading that could lower the potential fire severity reduce fire behavior, and lower resistance to control can indicate whether proposed treatments are beneficial to fire management.

Salvage logging to decrease the potential fire behavior and impacts to previously burned areas does have some controversy. Much of the debate about fire salvage for fuels treatment centers around the issue that larger fuels are not used in the fire spread model created by Rothermel (1972) that is utilized in fire behavior modeling. However, as a general rule, more available fuels result in more intense and more severe fires. For instance although they are not part of the fire spread model he created, Rothermel (1991) states that “personal observation of severe fires has shown the important contribution made to fire intensity by accumulations of larger sizes of dead and downed fuel.” For this reason, when looking at the fire potential in areas where heavy loads of larger diameter fuels are possible it is important to examine not only fire behavior outputs from the fire spread model, but other outputs as well.

Small Woody Fuels

The influence of small woody fuels (less than 3 inches in diameter) on spread rate and intensity of surface fires and associated torching and crowning is substantial and can be estimated using widely accepted fire behavior models (Andrews 1986; Finney 1998; Rothermel 1983; Scott and Reinhardt 2001). Brown et al. (2003) suggest that once small woody fuel loadings exceed 8 to 10 tons per acre, fire hazard increases substantially especially when larger quantities of CWD are present. Levels of small woody fuels were stratified into fire regimes for analysis as per Brown et al. (2003) and described on page two of the fuels report. Table 59 displays current and maximum desired small diameter (less than 3-inch diameter) fuel loading averaged across the entire project area. Note that the mixed high and high severity portions where the surface fuels were completely consumed are averaged with the low severity portions where not all the material on the ground was consumed.

Table 59. Estimated average of current and desired maximum small woody fuel loadings in the project area

Current Less than 3″ Fuels (tons/acre)	Maximum Desired Less than 3″ Fuels (tons/acre)
3.5 to 5	3 to 5

Coarse Woody Debris

Coarse woody debris (CWD) is typically defined as standing and down pieces larger than 3 inches in diameter, which corresponds to the size class that defines large woody fuel. CWD is an important component in the structure and function of ecosystems. A dead tree, from the time it dies until it is fully decomposed, contributes many ecological processes as a standing snag or as fallen woody material lying on or in the soil. Once standing dead trees fall, they become part of the available fuels for fires.

The fire hazard of large fuels is often overlooked. While large woody fuels in isolation typically burn with little vigor, those in close proximity to other fuels can burn with considerable vigor (Albini and Reinhardt 1997). Large woody fuels may have little influence on spread and intensity of the initiating fire; however, they can contribute to development of large fires and high fire severity. Fire persistence, resistance to control, and burnout time (affects to firefighter and public safety, soil heating and tree mortality) are significantly influenced by loading, size, and decay state of large woody fuel. Torching, crowning, and spotting contribute to large fire growth and are greater where large woody fuels have accumulated under a forest canopy. Large woody fuel, especially containing large decayed pieces, are a suitable fuel bed for firebrands and can hold smoldering fire for extended periods of time (Brown et al. 2003). Spot fires can also be started in rot pockets of standing snags. The distance firebrands travel is dependent on size of the firebrand, wind speed, and height above ground of the source. In the past, most concerns regarding salvage logging have focused on short-term issues (McIver and Star 2000, Bestchta et al. 2004). More recently studies such as Donato et al. (2006) continued this trend. However, Monsanto and Agee (2008) have shown that longer term effects such as the adverse effects from high levels of coarse woody debris should be considered when considering management options.

The amount of CWD that provides biological benefits, without creating an unacceptable fire hazard or potential for high burn severity, is an optimum quantity that can be useful in guiding management actions. To arrive at this optimum, various sources of information about the roles of CWD in the forest and its historical dynamics should be considered. The probability of reburn occurring is not addressed in Brown et al. (2003) or in this analysis. Brown et al. (2003) integrated various sources of information to identify an optimum range of CWD that provides an acceptable risk of fire hazard while providing benefits to soil and wildlife (see table 60). Although quantitative information is limited, it does provide a good basis on which to plan. Consideration of positive and negative aspects indicates that the optimum quantity of CWD is about 5 to 20 tons per acre for Fire Regime I, and 10 to 30 tons per acre for Fire Regime III. The CWD optimum quantities for acceptable fire hazard is appropriate if small woody fuel loadings are at or below desired levels (as defined in table 60). Acceptable CWD for fire hazard is slightly less for the warm, dry sites because they occur in a more flammable fire environment where generally less soil organic materials are necessary for maintaining soil productivity (Brown et al. 2003).

Any attempts to re-introduce the natural fire cycle to the Warm Fire area will need to consider the potential effects of coarse woody debris on young vegetation. During prescribed fire operations designed to reduce wildfire potential, Monsanto and Agee (2008) suggest that higher levels of coarse woody debris could significantly damage young stands due to root damage even if crown damage was minimal.

Using these fuel loadings, the recommended acceptable and historical ranges of CWD quantities were used to assign CWD classification to stands in the WFR project area. Stands were classified as below (below desirable range), historical (within acceptable range and historical range),

acceptable (within acceptable range but higher than historic range) and above (above acceptable and historical range).

Table 60. Estimated historical and acceptable ranges of CWD by fire regime

Historical Fire Regime	Historical Range Less than 3″ Fuels (tons/acre)	Acceptable Range Less than 3″ Fuels (tons/acre)
Low Severity (Fire Regime I)	5 to 10 Tons per Acre	5 to 20 Tons per Acre
Mixed Severity (Fire Regime III)	10 to 27 Tons per Acre	10 to 30 Tons per Acre

Acceptable and historic CWD fuel loadings are based on predictions of ground fuel loadings that may have occurred under the natural fire regime (Brown et al. 2003).

Table 61. Current CWD classifications for stands in the WFR project area

CWD Class	Percent of Project Area
Above	0%
High	0%
Historical	<1%
Below	99.9%
Total:	**100%**

Fuel loadings were determined using FVS-FFE, based on projected estimate of materials fallen.

Resistance to Control

Resistance to control is generally viewed as an estimate of the suppression force required for controlling a unit of fire perimeter. The USDA Forest Service Pacific Southwest Region developed a resistance to control rating scheme based on difficulty of hand line construction and an inventory of downed woody fuel loadings by size classes. Fire hazard, including resistance to control and fire behavior, reaches high ratings when large fuels exceed about 25 to 30 tons per acre in combination with small woody fuels of 5 tons per acre or less. Excessive soil heating is likely at approximately 40 tons per acre and higher (Brown et al. 2003). As fuels loads increase, the effect of additional fuels increases the likelihood that even large fuels will burn. Albini and Reinhardt (1997) found that dry wood would have an enhancing effect on the burning of another piece of dry wood of the same size if the two are near each other. Monsanto and Agee (2008), found fuel loading as low as 24 tons per acre poses a risk to roots and soils for future wildfire events. Table 62 illustrates the combination of small and large woody fuels it would take to reach high and extreme resistance to control ratings.

Post-fire fuel loads were used within the WFR project area to assign a resistance to control rating for current post-fire stand conditions. The results are displayed in table 63.

Table 62. Resistance to control rating scheme as determined by USDA Forest Service Pacific Southwest Region

0-3 inch Diameter Fuels (tons per acre)	3 to 10 inch Diameter Fuels (tons per acre)	
	High	Extreme
5	25	40
10	15	25
15	5	15

Table from Brown et al. 2003.

Table 63. Current resistance to control ratings for the WFR project area

Resistance to Control Rating	Post-fire 2007	
	Acres	Percent
Extreme	0	0%
High	0	0%
Low to Moderate	39,123	100%

Fuel loadings were determined using FVS-FFE.

The current 100 percent low to moderate resistance to control rating reflects the high number of acres that burned with high intensity across the project area. Almost all of the vegetation and CWD present at the time of the fire was consumed. In the areas that burned with moderate and low intensity, the small diameter surface fuels were significantly reduced in most places.

Environmental Consequences

Future fire activity and severity in the Warm Fire area will depend on a number of interacting factors including fire severity experienced during the Warm Fire, prefire vegetation, and species adaptations to fire, environmental conditions, and elapsed time since the fire. Keeping these things in mind, some general statements about future fire behavior and severity during high to extreme burning conditions with low fuel moistures can be made (Brown et al. 2003).

0 to 10 Years after Warm Fire: High severity fire is unlikely because duff and downed woody fuels that support prolonged burning would be absent. Large woody fuels would still be accumulating through fall down and would not have decayed enough to support smoldering combustion. If salvage operations leave concentrations of small woody fuels, high severity burning could occur where the fuels are concentrated. A study (Fulé et al. 2008) of a fire on the Coconino National Forest indicated CWD was less on the salvaged areas than on non-salvaged. This situation would be aggravated where stand-replacement fire did not consume foliage, thus allowing a layer of scorched needle to accumulate as surface fuel. Surviving onsite herbs and shrubs should dominate the recovering vegetation. In some areas, there is already considerable grass cover that would carry fire.

Newly established trees that regenerate by producing seeds could be lost. Even seedlings of species having sprouting capability could die if their root systems are not well established.

10 to 30 Years after Warm Fire: Downed CWD would exhibit some decay and support a longer period of burning; however, a duff layer would not be well established and would be unable to contribute to soil heating. Thus, high burn severity would primarily occur where large woody material was lying on or near the soil surface. High severity fire could be substantial where a large proportion of the soil surface was directly overlain by large woody material, which could accumulate from fall down of a large amount of tree basal area, creating large areas of continuous fuelbed. A limited amount of conifer regeneration might be possible from young cone-bearing trees established onsite after the previous fire.

30 to 60 Years after Warm Fire: Large woody pieces would probably exhibit considerable decay, and a forest floor of litter and duff would be established to variable extent depending on the density of overstory conifers. Burnout of large woody pieces and duff is assisted by the interaction of these two components (Brown et al. 2003). Higher severity burning than would typically occur during earlier periods is possible depending on extent of soil coverage by large woody pieces, creating a continuous fuelbed. If a conifer overstory exists, crowning coupled with burnout of duff could amplify the burn severity. Prescribed fire during this period could greatly reduce the severity of a reburn wildfire. However, a reburn involving optimum quantities of CWD should not lead to unusually severe fire effects. Historically, fires probably often occurred in the understory and mixed fire regime types when large, downed woody fuels were in optimum range.

Fire severity is the product of fire intensity and residence time (duration) of heat from a fire. Fire intensity is primarily decided by fine fuels less than 3 inches in diameter, although larger fuels can result in higher overall flame lengths when they are dry. The residence time of the fire is dependent on several factors, but in terms of fuels management, it is largely the result of the amount of large woody fuels available for burning. When these larger diameter woody fuels ignite, they will produce more heat for a longer period of time than smaller fuels.

The potential for higher heat output for a long period of time is more likely to result in adverse effects to soils and onsite vegetation.

In the fire adapted ecosystems of the Warm Fire Recovery project, there is an anticipated need to re-introduce low severity fire over time in order to maintain these systems. For this reason, fuels conditions that allow prescribed burning with the least amount of negative effects to vegetation and soils are desired.

Climate Change Considerations

As previously discussed in the “Vegetation” section, climate change predictions for the Southwest area are for a dryer and warmer climate. This anticipated long-term change could have an affect on future fire size and intensity. Most predictions are for larger, more intense fires. While it is not conclusive that the current drought being experienced in the area is a natural cycle or related to climate change, the Warm Fire itself is an example of recent experiences in the West of larger, more intense fire events. Common to all of the action alternatives, reduction of fuels and break up of fuel continuity is responsive to anticipated climate change. In the context of warmer and dryer conditions, no action will create higher probability for future severe fire effects and green house gas emissions. Working toward reduced fuel load conditions would result in lower risk of uncharacteristically severe wildfire for those treated acres. Breaking up fuel continuity improves the ability to suppress fires when conditions create uncharacteristically intense fire effects. The

ability to keep these types of fires out of adjacent untreated areas and/or to reduce the size of these fires in untreated areas is improved. Treating fuels in the project area may improve the capability of this landscape to better withstand climate change stresses.

Alternative 1 — No Action

Direct, Indirect, and Cumulative Effects

Under the no action alternative, no salvage of fire-killed trees and no reforestation would occur. Under this alternative, fuel would continue to accumulate as branchwood, tops, and whole trees fall and accumulate on the ground surface, creating and increasing continuous fuelbeds. This effect would not be unlike the addition of activity fuels following harvest; however, there are some differences. In the no action alternative, the fuels would come down at a different rate and would accumulate slower. They would have no treatment such as lop and scatter to reduce fuelbed height, and the fuels would persist longer due to reaching contact with the ground later. They would also tend to accumulate after other fuels such as grasses, shrubs, and other herbaceous material becomes more continuous, increasing the overall flammability of the fuels and ability of a fire to spread.

The project area will accumulate surface fuels and increase fuelbed depth as fire-killed trees start to break off or fall over. Higher fuel loadings in both small diameter (<3″ diameter) and large diameter (>3″ diameter), would not be typical of the relatively frequent, low intensity and low severity fire regimes that dominate the project area. Historically, periodic surface fire would consume existing woody and fine herbaceous fuels, and limit heavy accumulations of large diameter fuels. These conditions can result in undesirable fire effects during either prescribed fire or wildfire events. Sackett and Haase (1996) found that although heavier material may not have a lot to do with extreme fire behavior, they do contribute to fire severity when burned. It is likely that fire exclusion and the associated buildup of fuels prior to the Warm Fire played an important role in the eventual size and severity of the fire. In the absence of management activities, the trend is for both fuel loading and severity to increase within most vegetation types over time.

Over time, the re-growth of vegetation mixed with heavy logs and small woody fuels would diminish the firefighter's ability to construct and hold fire line used for wildfire and prescribed fire. Hand fire line construction is significantly slowed where fire lines intersect numerous large logs because fire lines then have to be relocated.

Fuel Loading

Small Woody Fuels

Current: Duff and downed woody fuels that support high severity fire are absent. Surviving onsite herbs and shrubs dominate the recovering vegetation. Where stand replacement fire did not consume foliage, a layer of scorched needles will accumulate as surface fuels. Modeling shows that small, woody fuel loading is predicted to be at or slightly above the desired maximum of 3 to 5 tons per acre as noted in Brown et al. 2003.

5 Years Post-fire: The duff layer will not be well established; however, the grass layer will become established and may provide continuous fuels in portions of the project area. A limited amount of conifer regeneration is possible, but fuels as a result would be minimal. A limited shrub component on some sites would contribute to overall fuel loading. Dead fuel loading is expected to rise substantially from the current condition as the branchwood from snags fragment and fall to

the forest floor. Some of the small woody fuels from live trees were consumed in the Warm Fire; although the majority of these fuels are still present on the now dead trees. The small woody fuel that accumulates from branchwood of large trees and from fall down and breakage of small trees is above the desired maximum levels; however, overall these fuels are not continuous.

20 Years Post-fire: The duff layer would not be well established. A limited amount of conifer regeneration is possible from existing seed source adjacent to and within the burn area. Onsite herbs and shrubs would dominate the recovery vegetation. The accumulation of small woody fuels is fairly well offset by decay in fuels that have dropped earlier, resulting in similar loading to year 5.

40 Years Post-fire: A forest floor of litter and duff would be established to a variable extent depending on the density of overstory conifers. By this time, small woody fuel accumulation as a result of the Warm Fire is past its peak and fuel loading in this category has dropped due to decay.

Table 64. Alternative 1 - Estimated average current, 5, 20 & 40 years post-fire small woody fuel loadings in the project area

Less than 3 Inch Fuels (tons/acre)			
Current (2007)	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
5 to 6	16 to 18	15 to 18	7 to 9

Fuel loadings were determined using FVS-FFE and are based on an average of representative stands within each fire regime.

Coarse Woody Debris

For the purpose of this analysis, acceptable levels of coarse woody debris are as defined by Brown et al. (2003). Desired fuel conditions are 5 to 20 tons per acres in ponderosa pine sites (fire regime I) (Brown et al. 2003). For this analysis, these levels were used for all stands classified as fire regime I.

Current: Large woody fuels are just starting to accumulate through fall down and would not have decayed enough to support smoldering combustion. Coarse woody fuel loading is below or within the historical range throughout the project area. High severity fire is unlikely because downed woody fuels that support prolonged burning are absent.

5 Years Post-fire: CWD is starting to accumulate, with 27 percent of the area at higher than historical but at acceptable levels of CWD. Forty-one percent of the stands are above acceptable levels at this point in time.

20 Years Post-fire: Accumulation of downed CWD is progressing and it is beginning to exhibit decay that would support a longer period of burning. At this point in time after the Warm Fire, 20 percent of the area is above acceptable levels, and an additional 87 percent is at high but acceptable levels. High severity fire is possible and could be over substantial areas. Areas that might have natural conifer regeneration are at risk of mortality from fires burning under these conditions.

40 Years Post-fire: Accumulation of large woody pieces has peaked and will probably exhibit considerable decay. Approximately 89 percent of the area is still considered above acceptable,

and 51 percent is at high but acceptable levels. Higher severity burning is possible depending on extent of soil coverage and fuel continuity by large woody pieces. Conifer mortality is likely to be high in these areas.

Table 65. Alternative 1 - CWD classifications and percent within the project area for current, 5, 20 & 40 years post-fire

CWD Class	Current	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
Above	0%	41%	87%	89%
High	0%	4%	1%	1%
Historical	<1%	45%	8%	9%
Below	99.9%	10%	4%	1%
Total:	**100%**	**100%**	**100%**	**100%**

Resistance to Control

Current: The combination of small woody fuels and CWD has not accumulated to the point beyond desired levels. Fire hazard is in the low to moderate range throughout the project area.

5 Years Post-fire: Approximately half the area remains in the low to moderate resistance to control category, but due to the increasing load of both small diameter woody fuels and CWD, 28 percent of the area has moved into the high category and 23 percent of the area is now considered extreme.

20 Years Post-fire: Decomposition of some small woody fuels has offset some of the accumulated fuels and is at close to 5-year levels; however, the increasing amount of CWD places 42 percent of the area in the extreme category. Slightly over half is now in the moderate category.

40 Years Post-fire: Decay has lowered the loading of CWD somewhat, but has had a substantial effect on small woody fuels. Only 12 percent of the area remains extreme, and 4 percent is high. The majority of the area has moved into the low to moderate category.

Table 66 displays the resistance to control ratings based upon the combination of large woody fuel loading and small (<3″) woody fuels based upon the parameters in Brown et al. (2003).

Table 66. Alternative 1 - Current, 5, 20 & 40 years post-fire resistance to control ratings in project area

Resistance to Control Rating	Current (2007)		5 Years Post-fire (2012)		20 Years Post-fire (2027)		40 Years Post-fire (2047)	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Extreme		0	1,966	23	3,561	42	990	11
High		0	2,374	28	105	1	315	4
Low to Moderate		100	4,175	49	4,848	57	7,210	85

It is predicted that surface fuel loading associated with the break off or fall down of dead trees could increase in 40 years if left untreated in high and mixed severity areas of the Warm Fire area. The expected fuel loading increase in areas of lower severity is projected to be substantially less.

Fire behavior characteristics are tied directly to fire fuel models. A display of acres of predicted flame lengths of the models representing the Warm Fire area are summarized in table 69.

Projected fuel loading and distribution was also compared to standard fuel models to determine if an appropriate model existed. Fuel models were found to be similar to fuel models projected in the Warm Fire Assessment (USDA Forest Service 2007c), and corresponded fairly well with what Passovoy and Fulé (2006) found in other southwestern forests. These two documents were utilized as the starting point for selection of fuel models for each of the alternatives. Fuel models varied someone from these two papers based upon the most recent site-specific information available.

Fire effects are tied to the overall fuels complex, including needlecast, duff, and both large and small diameter woody fuels.

Based on these assumptions, the focus of concern is primarily associated with stands where severe fire is most likely to occur. The action alternatives would increase the amount of acres with flame lengths over 4 feet in the short term after salvage activities. However, by 2027 the action alternatives would have fewer acres in the flame length classes above 4 feet when compared to the no action alternative. This translates to fewer acres with potential for severe soil heating in 40 years under the action alternatives.

The fire behavior, resistance to control and potential soil heating effects of the no action alternative are projected to become more severe over time. Much of the area would experience increasing fuel loads and the potential for more severe fire behavior and effects associated with the higher fuel hazard.

The available fuels and fuelbed depth would increase in the absence of fire or treatment. With no modification of fuels, fire behavior and effects would continue to increase as described. The ability to return to historical fire regimes and conditions would be more difficult without the reduction of potential fire behavior, resistance to control, and fire severity.

In the absence of any kind of human-caused or natural disturbance, indirect effects would occur from the natural progression of forest growth and change. The result would be an increase in available fuels and fuelbed depth that affects flame length, large amounts of heavy fuels that affect fire severity and resistance to control, and a decreased ability to implement prescribed fire as a future management action.

Alternative 2 — Proposed Action

Direct, Indirect, and Cumulative Effects

Alternative 2 represents the proposed action from scoping. The proposed action has been modified slightly; reducing proposed salvage acres from what was presented during scoping to remove areas that were included in separate hazard tree removal projects along roads and trails to address immediate public safety concerns. Reforestation planting acreage was also revised to allow for additional natural regeneration of aspen.

Treatments are located in areas such as ridgetops and areas with good access where it is likely that suppression resources can effectively and safely apply tactics that would slow fire spread. These treatments are not intended to fireproof the forest, as this is neither attainable nor desirable from an ecological standpoint. It is expected that there will be an immediate increase in fuel loading following harvest. However, activity fuels will be treated using lop and scatter to reduce the fuelbed height and increase decomposition rates due to soil contact (Weatherspoon and Skinner 1995). Science has shown that the effect of harvest debris is mitigated as it decays (McIver and Ottmar 2007) and (Thompson et al. 2007).

Modeled results show that over the long term, treatments would reduce the fuels and decrease the amount of material needed to be removed during fire line construction as well as reduce the burnout time for firing operations. This fits with McIver and Ottmar's (2002) statement that logging on post-fire sites can result in lower fuel levels over the long term and burn with less intensity. Treatments conducted now will also enhance the ability to use low intensity prescribed fire as a tool in the future.

The areas proposed for treatment in all the action alternatives are located where high mortality will result in high fuel loading in the future. A study done by Thompson et al. (2007) found that areas that burned at higher severities in an earlier fire burned with more severity in the Biscuit Fire. Fuel loading, resistance to control, flame length and soil heating are good indicators of the potential effects of treatment because the proposed treatment in all the action alternatives is located in areas where high mortality will result in high fuel loading in the future. These indicators can show what fuel reductions would occur and how they relate to creating better opportunities for fire management efforts and reducing adverse fire effects.

Some conifer planting would occur under all the action alternatives. Young conifer plantations can represent an increase in fire hazard due to their small size and tight spacing. Under such conditions, these plantations provide ladder fuels and dense, continuous canopies that may increase fire behavior when combined with a pulse of additional fuels from salvage logging (Thompson et al. 2007). However, logging slash is only part of the fire hazard, and may not be the most important after a few years (Thompson et al. 2007). The planting proposed in the project area is variable and much lighter density than more traditionally planted areas and would not meet the description of "plantations" that create dense, continuous fuels in Thompson's study. While the planted conifers will represent ladder fuels at certain times, the open density and lack of an overstory will substantially reduce the effect these trees may have on overall fire behavior and resistance to control. The planted trees will not have sufficient density to carry a crown fire, and although occasional torching of individual trees would be possible under some circumstances, it would not likely have a substantial effect on fire behavior. In addition, in the future prescribed fire can be used to prune lower branches from the trees, thus reducing the effect of ladder fuels. Detailed information on planting density and arrangement is available in the "Vegetation Resources" section.

There is a concern that chipping (masticating) fuels could result in adverse effects to soils when burned. The potential does exist for soils heating as well as damage to small trees. However, Busse et al. (2005) found that from a practical standpoint, their results suggest that most roots and soil organisms will be unaffected by burning of masticated fuels in all but the driest of soils. Further, Busse et al. (2005a) state that the masticated fuel levels (60 tons per acre) are fairly extreme and not likely to occur in most locations.

Fuel Loading

Small Woody Fuels

Small woody fuels projected under this action include fuels accumulated due to breakage and fall down of standing dead woody material and activity fuels created from harvest operations.

5 Years Post-fire: The duff layer would not be well established. Planted conifer seedlings would be present, but fuels as a result would be minimal. A limited shrub component on some sites would contribute to overall fuel loading. Dead fuel loading is expected to rise substantially from the current condition as activity fuels from treatment are deposited on the ground. Small woody fuel is projected to be above the desired maximum levels and is higher than under alternative 1. However, overall fuels are not likely to be continuous.

20 Years Post-fire: The duff layer would not be well established. A limited amount of conifer regeneration is possible from existing seed source adjacent to and within the burn area. Onsite herbs and shrubs would dominate the recovery vegetation. Small woody fuel is above the desired maximum levels but is somewhat less than under alternative 1.

40 Years Post-fire: A forest floor of litter and duff would be established to a variable extent depending on the density of overstory conifers. However, decay has reduced the loading of the accumulated small woody fuels. Planted trees would be beginning to exhibit fire resistant characteristics. Small woody fuel loading is still above the maximum desired level, but at or below levels identified by Brown et al. (2003) when CWD loading is high. These fuels include those generated by harvest activities. Activity fuels will be lopped and scattered to reduce the effect of the fuels. Note all acres are averaged across the project area.

Table 67. Alternative 2 - Estimated average current, 5, 20 & 40 years post-fire small woody fuel loadings

Less than 3 inch Fuels (tons per acre)			
Current (2007)	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
4.5 to 5	22	12 to 24	5 to 8

Fuel loadings were determined using FVS-FFE and are based on an average of representative stands within each fire regime.

Coarse Woody Debris Salvage Areas

For the purpose of this analysis, acceptable levels of coarse woody debris are as defined by Brown et al. (2003). Desired fuel conditions in ponderosa pine are 5 to 20 tons per acre in ponderosa pine sites (fire regime I) (Brown et al. 2003). For this analysis, these levels were used for all stands classified as fire regime I in all of the action alternatives as well as alternative 1.

Current: Large woody fuels are just starting to accumulate through fall down and would not have decayed enough to support smoldering combustion.

Coarse woody fuel loading is below or within the historical range throughout the project area. High severity fire is unlikely because downed woody fuels that support prolonged burning are absent.

5 Years Post-fire: CWD would be starting to accumulate, with 29 percent of the area above acceptable levels of CWD. About 4 percent of the stands are at high but acceptable levels at this point in time.

20 Years Post-fire: Accumulation of downed CWD is progressing and it is beginning to exhibit decay that would support a longer period of burning. At this point in time after the Warm Fire, 52 percent of the area would be above acceptable levels, and an additional 2 percent is at high but acceptable levels. High severity fire is possible but 35 percent less of the area would be above acceptable levels than under alternative 1. Less area that has natural conifer regeneration is at risk of mortality from fires burning in heavy fuels than under alternative 1.

40 Years Post-fire: Accumulation of large woody pieces has peaked and will probably exhibit considerable decay. Approximately 40 percent of the area would still be considered above acceptable, and 2 percent is at high but acceptable levels. Higher severity burning would be less than alternative 1, and is dependent on the extent of soil coverage by large woody pieces. Conifer mortality is less likely under these conditions. Planted areas have a variable planting density that is much more open than traditional methods and would not have a continuous canopy; therefore, they would be less flammable than a traditional plantation. Details of planting density are located in the "Vegetation" section.

Table 68. Alternative 2 - Current, 5, 20 & 40 years post-fire CWD in the WFR project area

CWD Class	Current	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
Above	0%	29%	52%	40%
High	0%	4%	02%	02%
Historical	<1%	51%	38%	48%
Below	99.9%	16%	09%	10%
Total	**100%**	**100%**	**100%**	**100%**

Fuel loadings were determined using FVS-FFE

Resistance to Control

Current: The combination of small woody fuels and CWD has not accumulated to the point beyond desired levels. Fire hazard is in the low to moderate range throughout the project area.

5 Years Post-fire: Just over half the area proposed for treatment has moved into the high category. Approximately 24 percent is rated as extreme. This is due to almost two-thirds of the area achieving historical CWD levels in combination with high amounts of small woody fuels that are deposited at the same time due to salvage activities.

20 Years Post-fire: Decomposition of some small woody fuels has offset some of the accumulated fuels and is less than at 5 years; however, the increasing amount of CWD places 25 percent of the area in the extreme category. Decay of smaller fuels and removal of larger fuels due to salvage activity results in 70 percent of the area being categorized as low to moderate resistance to control.

40 Years Post-fire: Decay has lowered the loading of CWD somewhat, but has had a substantial effect on small woody fuels. Only 6 percent of the area remains extreme, and 1 percent is high.

The majority of the proposed treatment area (93 percent) has moved into the low to moderate category.

Much of the proposed treatment areas are on ridgetops that are often used as strategic locations for fire line construction during suppression action. Breaking up the fuel continuity on the 9,114 acres of treatment in this alternative provides for locations of lower resistance to control, which can result in smaller overall fire size due to higher probability of success in containing the fire.

Table 69. Alternative 2 - Current, 5, 20 & 40 years post-fire resistance to control ratings by percentage in areas proposed for treatment

Resistance to Control Rating	Current (2007)		5 Years Post-fire (2012)		20 Years Post-fire (2027)		40 Years Post-fire (2047)	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Extreme		0	2,060	24	2,115	25	493	6
High		0	4,625	54	432	5	88	1
Low to Moderate		100	1,830	21	5,968	70	7,933	93

The effects of the proposed treatments based upon fuel loading and arrangement were modeled for each of the alternatives in the Behave Plus program. Fire behavior was modeled based upon weather conditions based upon “average worst” conditions for the nearby Warm Springs weather station (see appendix for detailed weather parameters). Outputs from the modeling show the changes in flame length across the project area by each alternative for 3 different time intervals. Based upon projected stand information, modeling results were limited to surface fire because the data showed that the limited overstory with higher canopy base heights in stands projected for treatment were sufficient to limit the potential for active crown fire activity. The nontraditional planting method proposed for the WFRP would limit the amount of ladder fuels and, where present, the planted trees would not typically be located near stands with a well stocked overstory. Still, these planted trees would result in some torching under the right conditions. However, due to the relatively wide spacing of tree planting and the natural mortality expected with any planting operation, the effect of these planted trees would be limited and not typical of the results from dense plantations noted in reports such as Odion et al. (2004) and Huff et al. (1995). Table 70 show a comparison of flame length between the no action and the three action alternatives.

Carrying out proposed treatments would result in a reduction in the overall predicted flame lengths within the project analysis area over the long term. These changes would only occur in those proportions of the WFRP proposed for treatment. Fire behavior under each of the action alternatives rises in 2012 as expected following harvest activities. However, this effect is only for a relatively short timeframe and is offset by the natural accumulation of fuels under no action in 2027. In 40 years, the removal of some of the fuels and the increased rate of decay associated with treatment shows lower flame lengths over a greater area. This fits with the findings of Reinhardt and Ryan (1998) who found that a salvage simulation predicted smaller fuels in the short term in a salvage operation, but from 8 to 40 years following treatment, flame lengths were lower in the salvaged stand. The number of acres in 40 years with flame lengths 4 foot or less is somewhat misleading in terms of reduction of fire behavior hazard. Stands that originally burned at lower severities and started out as lower fire risk have progressed to the point where they are

near or just over the 4-foot flame length threshold for direct attack by hand crews. This fits with the historic Fire Regime I portions of the project (the vast majority of the project). Under the historic regime, most of these sites will have missed at least two fire return intervals by year 40. This emphasizes the need to re-introduce prescribed fire between now and 40 years from now.

Removal of dead trees that will contribute to fuel loading would reduce the overall fuel loading in the long term, resulting in lower flame lengths, less severe fire effects, and less effort to contain any future fires. Suppression operations and future prescribed fire operations would occur under all alternatives. However, alternative 2 would have the greatest effect on reducing the project area fire line intensity (flame length) allowing suppression resources to more safely use direct suppression tactics (Rothermel 1983). Since the 9,114 acres of proposed treatment in alternative 2 would be dispersed throughout the project analysis area, they would help break up fuel continuity and reduce the likelihood of wildfires gaining momentum over the landscape.

Table 70. Number of acres by predicted flame length by alternative.

Acres by Flame Length Class ▪ 2012			
	0-4 ft.	**4-8 ft.**	**Over 8 ft.**
Alternative 1	34,240	4,870	0
Alternative 2	27,988	11,028	94
Alternative 3	29,758	9,332	20
Alternative 4	30,734	8,366	10
Acres by Flame Length Class ▪ 2027			
	0-4 ft.	**4-8 ft.**	**Over 8 ft.**
Alternative 1	16,653	16,860	5,597
Alternative 2	21,479	12,696	4,935
Alternative 3	20,549	13,550	5,011
Alternative 4	20,149	13,365	5,596
Acres by Flame Length Class ▪ 2047			
	0-4 ft.	**4-8 ft.**	**Over 8 ft.**
Alternative 1	12,397	24,376	2,337
Alternative 2	16,819	20,615	1,676
Alternative 3	16,152	21,206	1,752
Alternative 4	14,773	22,000	2,337

Monsanto and Agee (2008) suggest that returning dry forests to a more historical fire regime should consider the effects of soil heating by the increased levels of coarse woody debris (large diameter fuels). They noted that although “concern has been raised about damage to ecological values (Beschta et al. 2004; Lindemayer et al. 2004), and a review of the available literature on salvage logging (McIver and Starr 2000) found almost all studies dealt with short-term effects.”

To display the potential effects of future fuel loading on soil heating in the WFRP area, projected fuel loading was input into the modeling software package FOFEM. Stands that were classified as mixed conifer and ponderosa pine were focused on for modeling because they make up the vast majority of the area proposed for treatment, and they are the stands that show a substantial difference between action and no action. The action alternatives were modeled as the same because the treatments are the same. Lethal soil heating was defined as per Monsanto and Agee (2008) as 60 degrees Celsius for a time period of 1 minute, which is the threshold for vegetative tissue death. The difference between the action alternatives is the number of acres treated. Outputs of the potential soil heating effects for all the action alternatives versus no action are displayed in the following tables.

Table 71a. Soil heating temperatures

Soil Heating Maximum Temperature Celsius									
Year	2012			2027			2047		
	Alt. 1	Alts. 2 & 3	Alt. 4	Alt. 1	Alts. 2 & 3	Alt. 4	Alt. 1	Alt. 2 & 3	Alt. 4
Mixed Conifer	295	263	295	343	282	343	343	271	343
Ponderosa Pine	263	264	264	265	265	265	282	265	265

Table 71b. Lethal soil heating depths

Maximum Lethal Soil Heating Depth Centimeters									
Year	2012			2027			2047		
	Alt. 1	Alts. 2 & 3	Alt. 4	Alt. 1	Alts. 2 & 3	Alt. 4	Alt. 1	Alt. 2 & 3	Alt. 4
Mixed Conifer	5	3	5	7	4	7	7	4	7
Ponderosa Pine	3	2	2	4	2	2	5	2	2

Under the action alternatives, both the maximum temperature and the maximum depth of lethal soil heating are reduced substantially. This is important because there is no one critical temperature for tissue death (Agee 1993). Because tissue damage to the crowns, boles, and roots of aboveground vegetation is a time-temperature relationship, the maximum temperature is important as well as depth. Temperatures of 275 degrees Celsius and above are considered excessive. A definitive goal for soil heating depth is not given, however, Agee (1993) notes that in 1934 Heyward reported that fire root kill to 2.5 cm resulted in little harm. Modeled soil heating for the action alternatives is either at or very near this depth. And in particular is much improved over the long term over no action. However, it is important to note that the percentage of ground covered with coarse woody debris would be less under the action alternatives as well. Monsanto and Agee's (2008) experiment found that lethal coverage of coarse woody debris was doubled when comparing unsalvaged areas to previously salvaged areas.

Alternative 3 — Winter Logging

Direct, Indirect, and Cumulative Effects

The effects for alternative 3 will be similar to alternative 2 as the treatment prescriptions are the same, but the acreage differs. This alternative restricts ground-based skidding operations to snow covered or frozen soil conditions on areas classified as "severe erosion hazard." Ground-based skidding on soils with low to moderate erosion hazard would be restricted to existing roads and designated skid trails, using existing skid trails where possible. Size and location of salvage operations proposed were factored in with areas naturally regenerating to aspen to create strategic breaks in fuels. Reforestation would be the same as described for the proposed action.

Actions include: salvage logging of fire-killed trees on approximately 5,756 acres resulting in removal of approximately 52.8 MMBF of timber products; planting of ponderosa pine on 7,625 acres, and planting of mixed conifers (ponderosa pine and Douglas-fir) on 2,353 acres; and lop and scatter would occur on the salvage units and chipping, masticating, or pile burning would be conducted on approximately 73 acres of salvage logged areas to protect future regeneration, connect stands that contain low fuel loadings and scenic values. Size and location of salvage operations proposed were factored in with areas naturally regenerating to aspen to create strategic breaks in continuous fuelbeds. Reforestation and fuels treatments to protect regeneration and address scenic values are the same as described for the proposed action.

Fuel Loading

Small Woody Fuels

Small woody fuels for the purpose of this analysis include fuels accumulated due to breakage, fall down of standing dead woody material, and activity fuels created from harvest operations.

5 Years Post-fire: The duff layer will not be well established. Planted conifer seedlings would be present, but fuels as a result would be minimal. A limited shrub component on some sites would contribute to overall fuel loading. Dead fuel loading is expected to rise substantially from the current condition as the branchwood from treatment activities are deposited on the ground. Small woody fuel is above the desired maximum levels and is higher than under alternative 1. However, overall fuels are not likely to be continuous.

20 Years Post-fire: The duff layer would not be well established. A limited amount of conifer regeneration is possible from existing seed source adjacent to and within the burn area. Onsite herbs and shrubs would dominate the recovery vegetation. Small woody fuel is above the desired maximum levels but is lower than under alternative 1.

40 Years Post-fire: A forest floor of litter and duff would be established to a variable extent depending on the density of overstory conifers. However, decay has reduced the loading of the accumulated small woody fuels. Planted trees would be beginning to exhibit fire resistant characteristics. Small woody fuel loading is near the maximum desired, but at or below levels identified by Brown et al. (2003) when CWD loading is high. At this point, small woody fuels are less than levels found under alternative 1.

Table 72. Alternative 3 - Estimated average current, 5, 20 & 40 years post-fire small woody fuel loadings

Less than 3 Inch Fuels (tons per acre)			
Current (2007)	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
4.5 to 5	21	10 to 11	5 to 6

Fuel loadings were determined using FVS-FFE.

Coarse Woody Debris Salvage Areas

Current: Large woody fuels are just starting to accumulate through fall down and would not have decayed enough to support smoldering combustion. Coarse woody fuel loading is below or within the historical range throughout the project area. High severity fire is unlikely because downed woody fuels that support prolonged burning are absent.

5 Years Post-fire: CWD is starting to accumulate, with 31 percent of the project area above acceptable levels of CWD. Approximately 3 percent of the stands are above historical levels but acceptable at this point in time.

20 Years Post-fire: Accumulation of downed CWD is progressing and it is beginning to exhibit decay that would support a longer period of burning.

At this point in time after the Warm Fire, 56 percent of the area would be above acceptable levels, and an additional 42 percent is at high but acceptable levels. High severity fire is possible where heavy fuels are continuous. Areas that might have natural conifer regeneration are at risk of mortality from fires burning under these conditions. Approximately 4 percent more of the area analyzed would be above acceptable levels than in alternative 2.

40 Years Post-fire: Accumulation of large woody pieces has peaked and will probably exhibit considerable decay. Fifty-two percent of the area would still be considered above acceptable, and 2 percent would be at high but acceptable levels. Higher severity burning is possible depending on extent of soil coverage by large woody pieces. Conifer mortality is likely to be high in these areas. Approximately 12 percent more of the area analyzed would be above acceptable levels than in alternative 2.

Table 73. Alternative 3 - Current, 5, 20 & 40 years post-fire CWD classifications for salvage areas by percentage

CWD Class	Current	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
Above	0%	31%	56%	52%
High	0%	3%	2%	2%
Historical	<1%	50%	34%	37%
Below	99.9%	16%	8%	9%
Total:	**100%**	**100%**	**100%**	**100%**

Fuel loadings were determined using FVS-FFE.

Resistance to Control

Current: The combination of small woody fuels and CWD has not accumulated to the point beyond desired levels. Fire hazard is in the low to moderate range throughout the project area.

5 Years Post-fire: Just less than half the area has moved into the high category. Approximately 27 percent is rated as extreme. This is due to approximately two-thirds of the area achieving historical CWD levels in combination with high amounts of small woody fuels that are deposited at the same time because of salvage activities.

20 Years Post-fire: Decomposition of some small woody fuels has offset some of the accumulated fuels and is slightly less than at 5 years; however, the increasing amount of CWD and fewer acres treated than alternative 2 places 28 percent of the area in the extreme category. Decay of smaller fuels and removal of larger fuels due to salvage activity results in 68 percent of the area being categorized as low to moderate resistance to control. Both of these numbers are slightly higher than alternative 2 and are a direct reflection of fewer acres being treated.

40 Years Post-fire: Decay has lowered the loading of CWD somewhat, but has had a substantial effect on small woody fuels. Only 8 percent of the area remains extreme, and 3 percent is high. The majority of the modeled area (93 percent) has moved into the low to moderate category.

Much of the proposed treatment areas are on ridgetops that are often used as strategic locations for fire line construction during suppression action. Breaking up the fuel continuity in these areas provides for locations of lower resistance to control, which can result in smaller overall fire size due to higher probability of success in containing the fire. Alternative 3 proposes to treat 5,756 acres, or 3,358 acres less than alternative 2 and, thus, has a smaller effect on breaking up the fuel continuity.

Table 74. Alternative 3 - Current, 5, 20 & 40 years post-fire resistance to control ratings by percentage in areas proposed for treatment

Resistance to Control Rating	Current (2007)		5 Years Post-fire (2012)		20 Years Post-fire (2027)		40 Years Post-fire (2047)	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Extreme		0	2,288	27	2,338	28	707	8
High		0	3,975	47	390	5	213	3
Low to Moderate		100	2,201	26	734	68	7,543	89

Alternative 4 — Maintain Designated Mexican Spotted Owl Habitat

Direct, Indirect and Cumulative Effects

The effects for alternative 4 will be similar to alternative 2 as the treatment prescriptions are the same, but the acreage differs. This alternative was developed in response to issues regarding salvage logging effects to wildlife and wildlife habitat. It was developed by modifying the proposed action to maintain all snags in stands designated Mexican spotted owl critical habitat. This alternative includes: salvage logging of fire-killed trees on approximately 5,541 acres resulting in removal of approximately 42 MMBF of timber products; planting of ponderosa pine on 7,625 acres, and planting of mixed conifers (ponderosa pine and Douglas-fir) on 2,353 acres;

lop and scatter would occur on the salvage units and chipping, masticating, or pile burning would be conducted on approximately 214 acres of salvage logged areas to protect future regeneration, connect stands that contain low fuel loadings and scenic values. Reforestation and fuels treatments to protect regeneration and address scenic values are the same as described for the proposed action.

Fuel Loading

Small Woody Fuels

Small woody fuels projected under this action include fuels accumulated due to breakage and fall down of standing dead woody material, and activity fuels created from harvest operations.

5 Years Post-fire: The duff layer would not be well established. Planted conifer seedlings would be present, but fuels as a result would be minimal. A limited shrub component on some sites would contribute to overall fuel loading. Dead fuel loading is expected to rise substantially from the current condition as the slash from treatment activities are deposited on the ground. Small woody fuel is above the desired maximum levels; however, overall fuels are not likely to be continuous.

20 Years Post-fire: The duff layer would not be well established. A limited amount of conifer regeneration is possible from existing seed source adjacent to and within the project area. Onsite herbs and shrubs would dominate the recovery vegetation. Small woody fuel is above the desired maximum levels for all fire regimes, but slightly lower than in alternative 1.

40 Years Post-fire: A forest floor of litter and duff would be established to a variable extent depending on the density of overstory conifers; however, decay has reduced the loading of accumulated small woody fuels. Planted trees would be beginning to exhibit fire resistant characteristics. Small woody fuel loading is still above the maximum desired level, but at or below levels identified by Brown et al. (2003) when CWD loading is high. At this point, small woody fuels are very similar to the levels found in alternative 2. Note all acres are averaged across the project area.

Table 75. Alternative 4 - Estimated average current, 5, 20 & 40 years post-fire small woody fuel loadings by historical fire regime

<3-Inch Fuels (tons per acre)			
Current (2007)	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
4.5 to 5	16 to 21	12 to 17	6 to 9

Fuel loadings were determined using FVS-FFE and are based on an average of representative stands within each fire regime.

Table 76. Alternative 4 - Current, 5, 20 & 40 years post-fire CWD classifications for salvage areas by percent

CWD Class	Current	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
Above	0%	1%	4%	5%
High	0%	25%	45%	38%

CWD Class	Current	5 Years Post-fire (2012)	20 Years Post-fire (2027)	40 Years Post-fire (2047)
Historical	<1%	63%	44%	49%
Below	99.9%	11%	7%	8%
Total:	**100%**	**100%**	**100%**	**100%**

Fuel loadings were determined using FVS-FFE.

Coarse Woody Debris Salvage Areas

Current: Large woody fuels are just starting to accumulate through fall down and would not have decayed enough to support smoldering combustion. Coarse woody fuel loading is below or within the historical range throughout the project area. High severity fire is unlikely because downed woody fuels that support prolonged burning are absent.

5 Years Post-fire: CWD is starting to accumulate, with 25 percent of the area at higher than historical levels, but at acceptable levels of CWD. Approximately 1 percent of the stands are above acceptable levels at this point in time.

20 Years Post-fire: Accumulation of downed CWD is progressing and beginning to exhibit decay that would support a longer period of burning. At this point in time after the Warm Fire, 61 percent of the area would be above acceptable levels, and an additional 1 percent would be at high but acceptable levels. High severity fire is possible where heavy fuels are continuous. Areas that might have natural conifer regeneration are at risk of mortality from fires burning under these conditions. At this point in time, approximately 9 percent more of the area analyzed would be above acceptable levels than under alternative 2.

40 Years Post-fire: Accumulation of large woody pieces has peaked and will probably exhibit considerable decay. Five percent of the area is still considered above acceptable, and 38 percent is at high but acceptable levels. Higher severity burning is possible depending on extent of soil coverage by large woody pieces. Conifer mortality is likely to be high in areas with high CWD ratings.

Resistance to Control

Current: The combination of small woody fuels and CWD has not accumulated to the point beyond desired levels. Fire hazard is in the low to moderate range throughout the project area.

5 Years Post-fire: Approximately 38 percent of the modeled area has moved into the high category, with 23 percent in the extreme category. This means that alternative 4 has approximately the same amount of area in the extreme category as alternatives 1 and 2 at year 5. At this point in time there is approximately 10 percent more of the area in the extreme category than under alternative 1, but places 16 percent less than alternative 2; scale differences between the action alternatives are a result of which stands are treated, and the amount of acres treated.

20 Years Post-fire: Decomposition of some small woody fuels has offset some of the accumulated fuels and is less than at 5 years; however, the increasing amount of CWD and fewer acres treated than alternatives 2 and 3 places 36 percent of the area in the extreme category. Decay of smaller fuels and removal of larger fuels because of salvage activity results in 61 percent of the area being categorized as low to moderate resistance to control.

40 Years Post-fire: Decay would lower the loading of CWD somewhat, but would have a substantial effect on small woody fuels. Approximately 11 percent of the area is rated as extreme, which is comparable to alternative 1 at 11 percent. An additional 5 percent is rated as high. The majority of the modeled area (84 percent) has moved into the low to moderate category. This makes this alternative very similar to no action at 40 years.

Much of the proposed treatment areas are on ridgetops that are often used as strategic locations for fire line construction during suppression action. Breaking up the fuel continuity on 5,541 acres provides for locations of lower resistance to control, which can result in smaller overall fire size due to higher probability of success containing the fire. Alternative 4 proposes to treat 215 acres less than alternative 3 and 3,573 acres less than alternative 2 and, thus, has a smaller effect on breaking up the fuel continuity.

Table 77. Alternative 4 - Current, 5, 20 & 40 years post-fire resistance to control ratings by percentage

Resistance to Control Rating	Current (2007)		5 Years Post-fire (2012)		20 Years Post-fire (2027)		40 Years Post-fire (2047)	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Extreme		0	2,000	23	3,092	36	941	11
High		0	3,228	38	224	3	391	5
Low to Moderate		100	3,293	39	5,194	61	7,191	84

Cumulative Effects Analysis Area

For fire/fuels management, the cumulative effects area is limited to the area burned in the suppression area. A review of past, present and future activities concluded that:

- Past timber sale activities are included in the forests data that was used in this analysis and, therefore, included in summaries of effects.
- Given management constraints and forest plan direction, grazing allotments and their management have no effect directly or indirectly on forest regeneration or structural stage development and, therefore, has no cumulative effect.
- The condition of past wildfire sites are included in the stand database and was considered in analyzing direct, indirect and cumulative effects.
- Fire suppression activities have no effect on the regenerating forest and are not considered in cumulative effects.
- Burned area emergency response including aerial seeding of grasses for erosion control, have no effect on forest regeneration or structural stage development, and were not considered in cumulative effects.
- Noxious weed control has no effect on the overall conditions relating to forest vegetation and is not considered.
- Other past, present and ongoing activities, foreseeable future activities, as listed, are not considered to have direct or indirect effects on forest vegetation, and are not considered in cumulative effects.

- Other foreseeable activities as listed, except the Warm Fire reforestation activities planned for the spring of 2008 under a separate decision, have no direct or indirect effect on forest vegetation and are not considered.

The Warm Fire reforestation activities have a direct effect on the project area and are included in simulations for analysis of future species and fuel conditions.

Post-Wildfire Management Action and Potential Fire Behavior/Severity

The increasing frequency and extent of fires in the Western United States has raised concerns over post-fire management actions (Shatford et al. 2007).

There are several studies concerning the effect post-fire management has on the fuels profile and potential fire behavior/severity. The study by Donato and others (2006) explores the changes in dead woody fuels due to salvage logging after wildfire. The McIver and Ottmar (2007) study evaluated the change due to logging in stand structure and fuels after a typical post-fire logging operation, and modeled predictions of potential future reburn severity.

Thompson et al. (2007) examined a forest landscape in southwest Oregon that burned in 1987 and then was subject, in part, to salvage logging and conifer planting before it reburned during the 2002 Biscuit Fire. They found that areas that burned severely in 1987 tended to reburn at high severity in 2002. Areas unaffected by the initial fire tended to burn at the lowest severities in 2002; areas that were salvage logged and planted after the initial fire burned more severely than comparable unmanaged areas.

Donato and others (2006) studied the initial effects of logging on fuels accumulation within the 2002 Biscuit Fire. This study found that both fine and coarse wood was higher in the burned and logged units than in the unburned or burned units with no logging.

In a study conducted 2 years after the 1996 Summit Wildfire on the northern end of Malheur National Forest in a ponderosa pine dominated area, McIver and Ottmar (2007) found that logged units experienced higher amounts of slash fuel (less than 3 inches) compared to the unlogged control. Model projections of the fuelbed indicate that the disparity in slash fuel mass between fuel reduction and unlogged units would be sustained until about 15 years post-logging. They also report that a reburn of moderate intensity occurring during this time would likely kill all young trees, even in unlogged units, because of the influence of other components of the fuelbed, such as grasses and shrubs. Model projections of large woody fuels (greater than 3 inches) in this study indicate that standing structure in all stands would collapse quickly, with the result that unlogged stands would contain twofold or threefold greater masses at 25 and 50 years post-logging, leading to much higher consumption rates of fuel in the event of a reburn in the same place.

Consequences of Post-fire Management Actions Discussion

Shatford et al. (2007) conducted a study considering the return of forest vegetation after disturbance and the need for planting. Donato et al. (2006) conducted a study addressing the initial effects of salvage logging on natural regeneration.

Two things that were considered in the Shatford paper as it relates to the WFR project are:

1. The study occurred in the Klamath/Siskiyou which are generally brush habitat types and have a strong brush response after fire compared to the Kaibab Plateau which generally has grass/forb habitat types and a strong aspen regeneration response. Aspen and locust are both resprouting in the Warm Fire area; both of the species tend to be more succulent than conifers. In general, these species are less flammable and have less crown mass than conifers. The responses of these two differing communities are quite different in terms of fuels and flammability. In such a case, managers should exercise caution in extrapolating the results of this study to the Warm Fire Recovery project area.
2. In the paper, when referring to natural regeneration it states that "managers must face the challenge of long regeneration periods." In the purpose and need for the WFR project, it is stated that the Kaibab National Forest is not willing to tolerate long regeneration periods in areas that have a low potential for natural regeneration and where there is a reasonable potential of planting success. The paper also states that "managers must be able to accommodate high levels of variation across the landscape of a fire." It is recognized that there is going to be high levels of variation across the landscape after the Warm Fire due to aspen sprouting, variable and sometimes heavy natural regeneration adjacent to existing seed sources, variable planting densities and survival in areas identified for planting, and slow (in some cases 100+ years) recolonization of conifers in harsher areas with no seed sources. In reference to the Donato study, it is recognized that salvage logging after a fire can have a negative affect on natural regeneration.

While it is difficult to make precise estimates of the extent of natural conifer regeneration after a wildfire (see natural regeneration assumptions in the "Methodology" section of the "Vegetation" section of this FEIS), the WFR project was designed to decrease the risk of salvage operations disturbing natural regeneration by: (1) salvaging only in areas that have a low probability of natural regeneration (i.e. salvage operations will occur within high and mixed-high fire mortality areas of the project area); (2) limiting the salvage to fire-killed trees without green needles; (3) restricting skidders and other fuels treatment equipment to designated skid trails during non-winter harvest and fuels reduction activities; and (4) using existing skid trails where available, and limiting the operation of equipment to a single pass (entry and exit) to any area that is not located on a designated skid trail.

Conclusions Relevant to the Warm Fire Recovery Project

- Units salvage logged after a wildfire initially experience higher levels of slash fuel (less than 3 inches). Modeling suggests that this influx will decrease after about 10 years post-logging. Breaking up continuous fuelbed through the salvage and associated fuels treatments on 5,541 to 9,114 acres will contribute greatly to control abilities, which will lessen acres impacted by other reburns.
- Young vegetation—whether managed or unmanaged—is likely to be at risk of a high severity reburn. A reburn of moderate intensity occurring in young, post-fire vegetation would likely kill all young trees, even in unlogged units, because of the influence of other components of the fuelbed, such as grasses and shrubs.
- There is an increased potential for root damage from the consumption of coarse woody debris from prescribed fires intended to reduce fuels (Monsanto and Agee 2008).

Discussion

Alternatives 2, 3, and 4 similarly would reduce fuels, changing the fuel profile and resulting in reduced fire line intensity and severity through fuelbed continuity breakup, as well as reducing resistance to control. Although much of the change to each element is incremental, when taken together they do result in measurable differences between action and no action. Differences between the action alternatives are essentially the number of acres treated. While having more acres treated is an advantage, all of the action alternatives result in reduced potential for adverse effects, and increase future management options.

The proposed activities help make the area more suited for future low intensity prescribed fire applications; therefore, progress is made toward initiating the restoration of ecological processes and allowing more opportunities to help trend the area toward a more natural fire regime. The proposed treatment areas are dispersed throughout the project analysis area and are of a sufficient size and location to break up fuel continuity, reducing the likelihood of wildfires gaining momentum over the landscape. They are also intended to reduce potential fire behavior within the units and, thereby, increase the probability that a fire can be contained within them.

Conditions within the project area would create a problem in the future for both fire suppression and prescribed fire operations. Heavy fuel loadings on untreated stands would be largely continuous with few natural breaks. The proposed treatments are located along ridgelines and roads that provide natural locations for fire lines and future prescribed fire blocks. Salvage operations would reduce fuel loading and continuity primarily along ridges with existing road systems. From an operational perspective, the reduction in large fuels next to roads (which can function as an already constructed fire line) provide easier access by firefighters either during wildfire events or while implementing prescribed fire. Due to the strategic location and (located mostly near the top of the ridge or along roads) the potential for adverse fire behavior in untreated areas to escape control would be reduced. The more ridges with reduced fuel loading and continuity throughout the project area would provide for more effective areas for future fire management.

Overall, alternative 2 would have the greatest impact to reduce fire hazard in the project area over the long term. Reducing overall fuel loading would increase the likelihood that prescribed fire operations in planted and natural regenerated areas can be applied. Alternative 2 would result in less fuel loading, making it more feasible to maintain the critical role of fire as an ecosystem process. Under this alternative, the indicated fuel loading peaks around 5 to 7 years, and then begins to drop off as the removed or treated material is not deposited on the ground due to breakage of the standing snags. This material would continue to accumulate under alternative 1, and to a lesser extent under alternatives 3 and 4, due to more acres of standing dead that will eventually fall. The higher loading at 5 years under the action alternatives is somewhat offset by the fact that a duff layer would not be well established, and fine fuels required to carry the fire through the woody fuels would not likely be continuous. Overall, the fuel continuity would be less under alternative 2 because more acres would be treated. This means that alternative 2 is the most advantageous for long-term fire hazard reduction, followed by alternative 3. Resistance to control is also less under the action alternatives than under alternative 1. Again, alternative 2 has the most reduction, followed by alternative 3 and then 4.

Air Quality

The Warm Fire area is located in a designated Class II Airshed. Grand Canyon National Park is directly south of and adjacent to the North Kaibab Ranger District and is designated a Class I Airshed. Air quality on the Kaibab Plateau and within the planning area is good to excellent.

No Action

Alternative 1 would implement no burning activities, so there would be no smoke from intentionally set fires.

Action Alternatives

Air quality within the analysis area would be temporarily affected by smoke from slash pile burning and dust from road maintenance. The burning seasons determine the most likely success of smoke dispersal that reduces negative effects to sensitive receptors. Probability for inversions is highest from October through March, which traps smoke resulting in poor visibility and hazy conditions. Smoke is also funneled downslope and toward lower elevations, making smoke a public irritant.

Burning would be done only after receiving notification from the Arizona Department of Environmental Quality (ADEQ) that burning can proceed. ADEQ is the regulatory agency for air quality (including smoke) in Arizona. Federal law restricts emissions of particulate matter. Due to the relatively small size of any burning operations and the location of the project, little impact is expected from smoke.

To minimize any potential impacts from smoke, burning would follow direction in an approved burn plan. Burn plans prepared by the North Kaibab Ranger District are required to contain a smoke management prescription, and predict daytime and nighttime smoke paths for 15 miles from the burn site, determine lift heights, and acceptable smoke dispersal directions. Modeling of smoke impacts for burns greater than 250 acres per day or greater than 50 acres per day if within 15 miles of a Class I or smoke sensitive area is required. Authorization for implementation of a burn is regulated by the ADEQ who evaluates smoke dispersion.

ADEQ has also established best management practices (BMPs) for reducing smoke impacts. It is desirable to implement as many BMPs as feasible for each burn. The BMPs that will apply to reduce the adverse effects of smoke are listed under air quality in chapter 2.

Air quality within the analysis area would be temporarily affected by smoke from slash pile burning and dust from road maintenance. The most likely success of smoke dispersal is determined by the burning seasons, reducing negative effects to sensitive receptors. Probability for inversions is highest from October through March.

Typically inversions are common during clear, calm, settled weather when warm air lies above the cool air surface layer. This condition traps smoke resulting in poor visibility and hazy conditions. Smoke is also funneled downslope and toward lower elevations creating a public irritant. Due to the relatively small size of burning operations and the location of the project, little impact is expected from smoke.

Cumulative Effects

Air quality within the project area is primarily affected by conditions and situations outside the area. The predominant surface and transport winds are from the southwest. Pollutant creation such as coal-burning power plants and industrial and vehicle emissions west and/or southwest of the area can degrade the air quality in the project area. Similarly, activities that occur in the project area can impact air quality to the northeast. Emissions from these sources cause periodic degradation of the airshed primarily during long periods of regional high pressure weather patterns or heavy regional winds from the south and southwest, which add dust to the atmosphere. Other air degradation occurs on a temporary basis when fires occur in the area or region. During the Warm Fire, most of the generated smoke dispersed 50 to 150 miles to the northeast of the fire. California fires occurring during the same period influenced the project area and Grand Canyon National Park.

Because most burning in northern Arizona occurs in the fall, short-term cumulative impacts from simultaneous ignitions from other projects could occur. ADEQ tracks which agencies and other parties are proposing to burn fuels, and it limits the accumulation of smoke by refusing approval of applications for burning that exceed the predicted potential of the atmosphere to disperse the smoke.

Economic Efficiency

Introduction

Recovery of some of the economic value of burned timber could occur before all commercial value of the wood is lost to deterioration. Jobs supported from the sale of salvage material could provide positive benefits to the local community. Salvage harvest would also help reduce the costs associated with meeting desired fuel conditions in portions of the burned area through removal of some of the large fuels. Revenues from the sale of wood products could also be applied to defray some of the costs of needed fire restoration work, such as reforestation.

Methodology

Jobs and Income

Estimates of the economic contribution of forest programs and activities were developed through the use of IMPLAN, using data for 2004. IMPLAN is an economic modeling program originally developed by the Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management. IMPLAN has since been privatized and is now provided by Minnesota IMPLAN Group (MIG). IMPLAN utilizes a database of basic economic statistics constructed by MIG. Information for this database was obtained from major government sources such as the Bureau of Economic Analysis, County Business Patterns, REIS, Bureau of Labor Statistics, U.S. Census, etc., and converted to a consistent format using widely accepted methodologies.

To estimate job and labor income impacts of current Forest Service activities, an IMPLAN model was used to estimate “response coefficients,” or rates of economic activity for the following project related activities:

- **Timber:** Economic activity per thousand cubic feet of stumpage flowing through logging companies and sawmills.

- **Restoration and Stewardship Activities (planting and mastication):** Economic activity per acre of treatment flowing into the local economy.
- **Payments to States:** Returns to counties under the "Secure Rural Schools Act" can foster significant economic activity at the local level. This response coefficient is a prediction of the local economic activity per million dollars returned to the counties.
- **Forest Service salary and non-salary expenditures:** Economic activity per million dollars of wages (disposable income spent locally by Forest Service employees, and economic activity per million dollars spent locally on materials, contracts, and services by the Forest Service).

These response coefficients, as well as baseline economic data, were exported from IMPLAN models and read into "FEAST," a spreadsheet designed to pair IMPLAN response coefficients with resource data to generate an economic contribution report. The following data was used in "FEAST" to generate an estimate of the forest's economic contribution to the local economy.

- Timber:
  - Direct effects response coefficients came from Timber Mill Survey from Chuck Keegan at the University of Montana (Direct jobs and income per thousand cubic feet of stumpage harvested) (Keegan 2003).
  - Indirect and induced employment and income effects came from the IMPLAN model.
- Planting and Mastication Activities:
  - Average costs per acre were obtained from the forest (Drury, J.; personal communication, 2007*;* USDA Forest Service 2006c).
  - Indirect and induced employment and income effects came from the Minnesota IMPLAN model (IMPLAN 2007).
- Forest Service salary and non-salary expenditures:
  - Budget expenditure data was obtained from the USDA National Finance Center (USDA Forest Service 2006d).
  - The data was split into salary and non-salary expenditures.
- Non-salary information was bridged to IMPLAN economic sectors.
- Estimated salary expenditures were converted to disposable income.

Financial Efficiency

Present net value is defined as the value of discounted benefits (or revenues) minus discounted costs. A present net value analysis includes all outputs to which monetary values are assigned. In deriving PNV figures, costs are subtracted from benefits to yield a net value. "Future values" (i.e., benefits received in the future) are discounted using an appropriate discount rate to obtain a "present value." The present net value of a given alternative is the discounted sum of all benefits minus the sum of all costs associated with that alternative. Present net value estimates attempt to condense a large amount of information into a single value. This value must be used with caution.

Affected Environment

The economic and social aspects analyzed include cost efficiency and potential job and income impacts to the local economy. In addition to these aspects, some nonquantified values and costs are evaluated.

The region is sparsely populated and is separated from the remainder of Arizona by the Grand Canyon and Colorado River. The analysis area considered for economic effects is all of Kane, Washington, and Garfield Counties in Utah, and the zip code areas for Fredonia and Marble Canyon within Coconino County, and Colorado City within Mohave County, Arizona. This region was chosen in order to examine a contiguous, functional economic area. The closest mill for processing of harvested wood products is located within Garfield County, Utah. The closest full-service communities to the analysis area are Kanab and St. George, Utah, within Kane and Washington Counties.

Industry capacity in the working circle around the Kaibab Plateau has diminished significantly compared to 20 years ago when there was a larger sawmill in Fredonia, and several elsewhere in southern Utah. Currently there is a small and diverse wood products manufacturing facility operating in Fredonia, Arizona, as well as sawmills operating in Panguitch and Escalante, Utah. The mill in Fredonia processes lumber, shavings for livestock bedding, and other products. Additional small businesses exist in the working circle such as log home construction facilities and commercial firewood businesses. The working circle can also be expanded using rail and trucking.

Management Direction

The Forest and Rangeland Renewable Resources Planning Act of 1974, as amended (88 Stat. 476; 16 U.S.C. 1600-1614) states that harvesting systems should not be selected primarily because they will give the greatest dollar return or the greatest unit output of timber.

The forest plan identifies appropriate uses and management practices by designation of GAs. The majority of the Warm Fire Recovery project falls within GA 13 (36,041 acres), with a lesser amount in GA 16 (3,069 acres). There is an existing memorandum of understanding (MOU 04-MU-11046000-060) between the USDA Forest Service, Southwestern and Intermountain Regions, and the State of Utah for building “the capacity to accomplish restoration projects” and encouraging “local employment in order to benefit the management of the national forests and communities of the Central Colorado Plateau and Great Basin.”

Thousands of acres of suitable timber land burned in the Warm Fire area are now occupied by dead and dying trees. The “Kaibab National Forest Land and Resource Management Plan” includes the goal to “manage suitable timberland to provide a sustained level of timber outputs to support local dependent industries.” The Kaibab forest plan includes a guideline for GA 13 to “salvage stands, or parts thereof, that are severely damaged by dwarf mistletoe, insects, fires, or windthrow.”

There are no forest plan thresholds for economic consideration.

Jobs and Income

An analysis of IMPLAN data for the project area for 2006 provides an estimate of 73,512 jobs within the local economy (IMPLAN 2007). The breakdown by industry is displayed in table 78. The sectors presented in the table are aggregated totals to simplify the display, and within each sector listed are a number of smaller industries. The sectors containing wood products processing and forest restoration industries are agriculture, forestry, fish and hunting and manufacturing. Table 78 has been updated. Wood products processing and forest restoration industries are estimated to support approximately 1 percent of area employment, or approximately 569 jobs. Employment estimates include all full-time, part-time, and intermittent jobs (IMPLAN 2007).

Estimated labor income in 2006 was $2,420 million (IMPLAN 2007). Labor income by industry is also displayed in table 78. Labor income for wood products processing and forest restoration represents less than 1 percent of labor income, or $14 million within the analysis area (IMPLAN 2007).

Table 78. Analysis area employment and labor income by industry (IMPLAN 2007)

Sector	Employment		Labor Income	
	Jobs	Percentage	Million Dollars	Percentage
Agriculture, Forestry, Fish, and Hunting	1,004	1.4%	$7	0.3%
Mining	189	0.3%	$11	0.4%
Utilities	151	0.2%	$12	0.5%
Construction	10,548	14.3%	$418	17.3%
Manufacturing	3,315	4.5%	$136	5.6%
Wood Products Processing and Forest Restoration	569	0.8%	$14	0.6%
Wholesale Trade	1,372	1.9%	$56	2.3%
Transportation and Warehousing	2,922	4.0%	$127	5.2%
Retail Trade	9,517	12.9%	$266	11.0%
Information	1,057	1.4%	$41	1.7%
Finance and Insurance	3,341	4.5%	$104	4.3%
Real Estate and Rental	3,555	4.8%	$65	2.7%
Professional, Scientific and Technical Services	3,086	4.2%	$128	5.3%
Management of Companies	124	0.2%	$3	0.1%
Administrative and Waste Services	2,623	3.6%	$58	2.4%
Educational Services	730	1.0%	$8	0.3%
Health and Social Services	8,130	11.1%	$306	12.6%
Arts, Entertainment, and Recreation	1,823	2.5%	$32	1.3%
Accommodation and Food Services	7,440	10.1%	$130	5.4%
Other Services	3,839	5.2%	$136	5.6%
Government and non-NAICs	8,176	11.1%	$363	15.0%
Total	**73,512**	**100.0%**	**$2,420**	**100.0%**

However, table 78 does not represent an accurate reflection of each segment's total effect on the economy. It does not display all of the impacts that ripple through the economy as a result of a given sector's existence and level of production. In addition to direct impacts, each sector produces indirect and induced effects, in varying degrees, depending on the spending patterns within each industry. A sector's total economic impact is made up of its direct, indirect and induced effects, as well as other factors.

In response to the demand for goods and services, a sector such as "Timber" responds by producing an appropriate level of output to meet the demand. The output produced and the employment required to produce that level of output are the direct effects of that sector on the economy. In order to produce the output included in the direct effects, the timber sector must purchase supplies and services from other industries. The output and employment stimulated in other sectors by these purchases are the indirect effects of the timber sector. In addition to the direct and indirect effects, induced effects represent the output and employment stimulated throughout the local economy as a result of the expenditure of new household income generated by direct and indirect employment.

Another factor considered when estimating economic impacts of various sectors is commonly referred to as leakage. Part of the monies spent by businesses and individuals is spent within the local economy, while a portion of those monies is spent outside the local economy.

The money expended outside the local economy is referred to as leakage and occurs when goods or services are imported from outside the local area, with the result that the money used to purchase these items is spent outside the local economy. By the same token, economic activity is introduced when good or services are exported to those from outside the area, thereby introducing new money into the local economy.

IMPLAN attempts to estimate these complex economic relationships in order to approximate the effect on each sector on the economy as a whole. Multipliers are developed as a means to estimate the change in direct, indirect, and induced effects as a result of an adjustment in the level of final demand for the goods or services provided by a given sector of the economy. These multipliers also take into account the effects of leakage (imports) and exports. Some sectors may have a large multiplier, while others may have a very small one. The size of a sector's multiplier, however, is not a direct indicator of the significance of its economic impact.

Economic Analysis

The indicators for economics are:

- Jobs
- Labor Income
- Present Net Value
- Benefit Cost Ratio

The no action (alternative 1) and three action alternatives (alternatives 2, 3, and 4) were analyzed in detail for the Warm Fire Recovery project.

Additional alternatives were considered, but eliminated from detailed analysis when determined they would not meet forest plan direction or the project purpose and need.

Jobs and Income

Employment and labor income opportunities potentially supported under the alternatives are displayed in table 79 based on the gross material removed from the project area. Impacts are shown as though they all occur in 1 year; in actuality, they would occur over the life of the project, approximately 7 years. These effects include direct, indirect, and induced impacts. The employment estimate includes full-time, part-time, and intermittent jobs. The projected effects represent the jobs potentially supported by implementation of each alternative; they do not necessarily represent new jobs introduced into the local economy.

The estimated job impacts by industry are displayed in table 80. Estimated labor income impacts are displayed in table 81.

Table 79. Estimated direct, indirect, and induced job and income impacts by alternative (IMPLAN 2007)

Alternative	Number of Jobs Supported*	Income (in thousands)
Alternative 1 (No Action)	0	$0.0
Alternative 2	1,402	$39,378.6
Alternative 3	1,004	$28,065.6
Alternative 4	801	$22,601.5

* Includes full-time, part-time, and intermittent jobs.

Table 80. Estimated employment supported over the life of the project by alternative (IMPLAN 2007)

Sector	Employment (Number of Jobs*)			
	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Agriculture	0	490	350	279
Mining	0	0	0	0
Utilities	0	3	2	2
Construction	0	7	5	4
Manufacturing	0	475	342	270
Wholesale Trade	0	42	30	24
Transportation and Warehousing	0	46	33	26
Retail Trade	0	52	37	30
Information	0	7	5	4
Finance and Insurance	0	43	30	24
Real Estate and Rental and Leasing	0	28	20	16
Professional, Scientific, and Technical Services	0	34	24	19
Management of Companies	0	2	2	1
Admin., Waste Mgmt. and Removal Services	0	18	13	10
Educational Services	0	5	3	3

Sector	Employment (Number of Jobs*)			
	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Health Care and Social Assistance	0	52	37	30
Arts, Entertainment, and Recreation	0	10	7	6
Accommodation and Food Services	0	44	32	25
Other Services	0	35	25	20
Government	0	11	8	7
Total	**0**	**1,402**	**1,004**	**801**

* Includes all full-time, part-time, and intermittent jobs over the life of the project

Table 81. Estimated labor income by industry over the life of the project (IMPLAN 2007)

Sector	Labor Income (in thousands)			
	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Agriculture	$0.0	$9,712.5	$6,944.0	$5,534.2
Mining	$0.0	$82.3	$59.0	$46.8
Utilities	$0.0	$299.3	$214.6	$170.6
Construction	$0.0	$294.6	$207.5	$173.9
Manufacturing	$0.0	$10,819.2	$7,779.8	$6,144.8
Wholesale Trade	$0.0	$2,036.1	$1,461.8	$1,159.3
Transportation and Warehousing	$0.0	$2,800.0	$2,010.5	$1,593.7
Retail Trade	$0.0	$1,555.6	$1,107.4	$894.4
Information	$0.0	$343.2	$245.3	$196.5
Finance and Insurance	$0.0	$1,678.1	$1,202.3	$957.7
Real Estate and Rental and Leasing	$0.0	$601.6	$429.9	$344.4
Professional, Scientific, and Technical Services	$0.0	$1,557.7	$1,114.1	$893.9
Management of Companies	$0.0	$68.1	$48.9	$38.8
Admin., Waste Mgmt. & Removal Services	$0.0	$471.9	$337.6	$269.9
Educational Services	$0.0	$59.7	$42.6	$34.2
Health Care and Social Assistance	$0.0	$2,191.3	$1,560.8	$1,258.6
Arts, Entertainment, and Recreation	$0.0	$195.5	$139.6	$112.2
Accommodation and Food Services	$0.0	$877.5	$626.6	$502.7
Other Services	$0.0	$1,181.6	$845.7	$675.0
Government	$0.0	$2,552.8	$1,687.7	$1,600.0
Total	**$0.0**	**$39,378.6**	**$28,065.6**	**$22,601.5**

Cumulative Effects

Tourism is the main industry in the area with destinations including the North Rim of the Grand Canyon, Grand Staircase-Escalante National Monument, as well as Zion National Park. Tourism related industries (e.g., lodging, restaurants, shops, tours) have increased in the area with active construction of additional lodging. If non-local employment occurs (e.g., through contracting), there would be a temporary increase to the local community industries. The jobs and income for outfitter guides may be enhanced by the ongoing hazard tree removal project that is clearing the Arizona Trail and main Forest Service roads in the Warm Fire area. This project would further contribute to restoration of the area, which is anticipated to have a beneficial effect on area jobs and income.

Financial Efficiency

Financial efficiency (present net value) examines revenue and cost implications from the perspective of the Forest Service. It could also be said that this is the perspective of the taxpayer. Only those revenues and costs recorded in financial records are included in this analysis.

When considering quantitative issues, financial efficiency analysis offers a consistent measure in dollars for comparison of alternatives. This type of analysis does not account for non-market benefits, opportunity costs, individual values, or other values, benefits and costs that are not easily quantifiable. This is not to imply that such values are not significant or important, but to recognize that non-market values are difficult to represent with appropriate dollar figures. The values that are not included in this part of the analysis are often the center of disagreements and interest people have in forest resource projects. Therefore, present net value should not be viewed as a complete answer, but as one tool the decision maker may use to gain information about resources, alternatives, and tradeoffs between costs and benefits.

Benefits

Timber Volumes

Timber volumes per acre were calculated by the logging specialist based on removal of dead trees greater than 14 inches in diameter. Volumes were calculated on an average volume per acre by forest type since product value varies by forest type. The 14-inch diameter was used as the interdisciplinary team acknowledged the potential for defect prior to implementation. The intent of this analysis was to offer a consistent and reasonable comparison of costs, benefits, and cash flows, based on past experience. The volumes were estimated for salvage under the action alternatives using available district stand information. Commercial value of fire-killed trees decreases over time as insects and decay affect the wood and have been revised since the release of the DEIS to acknowledge estimated defect losses. Over time, more of the outside portions of the logs are trimmed at the processing plant and not usable for dimensional lumber.

Table 82. Commercial volume by alternative*

Product	Alternative 2	Alternative 3	Alternative 4
Mixed conifer** sawtimber	22,112 CCF	17,343 CCF	6,067 CCF
Ponderosa pine sawtimber	49,217 CCF	36,186 CCF	38,875 CCF

*Commercial volumes have been adjusted to reflect estimated defect. ** Includes white fir, Douglas-fir and Engelmann spruce.

Timber Values

Timber values used in this analysis were based on the Region 3 T.E.A. Appraisal Bulletin No. 04 for calendar year 2008 (USDA Forest Service 2008b), and were used by each product group.

Table 83. R3 base rate for timber values by species and product category

Product	Value per Unit
Mixed conifers*	$6.00 per CCF
Ponderosa pine pulp	$10.00 per CCF

*Includes white fir, Douglas-fir and Engelmann spruce.

Costs

Costs and benefit values were derived from local realized costs, Region 3 TIM and FACTS data and the R3 T.E.A. Appraisal Bulletin No. 04 for calendar year 2008. Information on the values used for this analysis is located in appendix A of the economic and social report.

Analysis

The scope of this incremental analysis was limited to consistent general comparisons. A financial efficiency analysis was completed using the Forest Service Quick-Silver Program (USDA Forest Service 2003). The analysis included the incremental benefits and costs for which the Forest Service has values. The benefits and costs are those directly associated with this project.

Other non-market benefits may be realized under the different alternatives, but quantitative differences and monetary values are not available for this analysis (e.g., temporary changes in recreational use, changes to visual appearance of reforested areas, reforestation rate to conifers in areas lacking adequate conifer seed sources). This analysis assumes non-market values would not be adversely impacted measurably over the analysis period. Given local use and past experience, this is a reasonable assumption. Recreation in the project area is mainly hunting, riding, hiking, and sightseeing. The activities proposed in this project have occurred in other areas on the district that experienced wildfires and have not resulted in specific concerns regarding non-market losses in the past.

Economic costs are those incurred by the forest for items such as planting, reforestation surveys and road work costs. The cost of the environmental analysis is viewed as a fixed sunk cost. This cost would be the same across all alternatives and it is difficult to obtain an accurate estimate of the final cost. Since this analysis is an incremental analysis of the economic efficiency of implementation of the project, these costs were not included. Ten years was used as the analysis period since that is the estimated timeframe of activities to be completed (e.g., third year regeneration surveys after planting).

All action alternatives would result in a below-cost timber sale; some wood products would be supplied to a variety of users if the sale was purchased. Reforestation efforts may be accomplished with Knutson-Vandenberg (K-V) funds generated by the salvage sale, if stumpage prices were higher than estimated. The economic values are displayed in table 84 as present net value in 2006 dollars for all project actions. Economic values are also displayed when

considering only those actions related to the timber salvage operations (e.g., without reforestation planting) (see project record for the Quick-Silver program output information).

Table 84. Economic consequences for all project activities and timber salvage operations Only

Perspective	Alt. 1 (No Action)	Alt. 2	Alt. 3	Alt. 4
Values for All Proposed Project Activities				
Present Net Value	0	-$2,021,756	-$1,530,732	-$1,571,098
Present Value Benefits	0	$589,256	$439,383	$400,938
Present Value Costs	0	$2,611,011	$1,970,115	$1,972,036
Benefit/Cost Ratio	0	0.23	.22	0.20
Values Related to Timber Salvage Operations Only				
Present Net Value	0	-$992,108	-$559,332	-$560,589
Present Value Benefits	0	$589,256	$439,383	$400,938
Present Value Costs	0	-$1,581,364	-$998,715	-$961,527
Benefit/Cost Ratio	0	0.37	0.44	0.42

Summary of Effects

All action alternatives support the memorandum of understanding (MOU 04-MU-11046000-060) between the USDA Forest Service, Southwestern and Intermountain Regions, and the State of Utah by building "the capacity to accomplish restoration projects" and encouraging "local employment in order to benefit the management of the national forests and communities of the Central Colorado Plateau and Great Basin." Alternative 2 provides the highest level of support. Alternatives 3 and 4 support the memorandum of understanding to a lesser extent than alternative 2 due to less volume removed.

All action alternatives also support the goal of the Kaibab forest plan to "manage suitable timberland to provide a sustained level of timber outputs to support local dependent industries." Alternative 2 provides the highest level of support, followed by alternatives 3 and 4.

Although negative, alternative 3 provides the highest present net value among the action alternatives at -$559,332, followed by alternatives 4 and 2 when considering the salvage values. Alternative 3 limits operations on soils rated with severe erosion hazard to winter conditions, whereas operating in the winter is an option under alternatives 2 and 4. There could be additional value loss if access into the stands is delayed due to unfavorable winter conditions (e.g., too much snow making plowing infeasible or too dry). Net public benefit is an important concept in the current regulations for carrying forest management activities (benefits minus all the associated Forest Service inputs and negative effects (costs), whether they can be quantitatively valued or not). Thus, net public benefits, conceptually are the sum of this economic analysis plus the net value of non-priced outputs and costs. It is not the result of economic analysis alone. Many relevant factors cannot be quantified or expressed in monetary terms. The Agency endeavors to maximize net public benefit through public participation in the planning process. The Agency's primary mechanism for achieving the maximum net public benefit is to seek public input, analyze

effects relative to the issues and concerns identified, and then ultimately design alternatives and mitigation measures to achieve the desired condition while minimizing adverse effects. This economic analysis is but one element of that process and must be considered together with the analyses of other resources.

Social

Environmental Justice

Affected Environment

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low income populations. CEQ guidance for the consideration of environmental justice provides the following definition:

> "Minority population: Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis…" (CEQ 1997).

Table 85 displays the racial/ethnic composition of the analysis area population by percent. Census Bureau statistics cited suggest that none of the counties in the analysis area have populations that meet either environmental justice population criterion. Table 86 displays the poverty levels within the analysis area by county.

Table 85. Racial/ethnic composition of county and state populations by percentage, 2000 Census

Race/ Ethnicity	Coconino County, AZ	Mohave County, AZ	Kane County, UT	Washington County, UT	Garfield County, UT	Arizona	Utah
American Indian or Alaska Native	28.51%	2.41%	1.55%	1.47%	1.84%	4.99%	1.33%
Asian or Pacific Islander	0.88%	0.78%	0.26%	0.87%	0.40%	1.93%	2.34%
African American or Black	1.04%	0.54%	0.03%	0.21%	0.17%	3.10%	0.79%
Multiple Races	6.49%	6.13%	2.15%	3.88%	2.64%	14.49%	6.30%
White	63.09%	90.06%	96.00%	93.57%	94.95%	75.50%	89.24%
Non-white	36.91%	9.94%	4.00%	6.43%	5.05%	24.5%	10.78%
Hispanic	10.94%	11.08%	2.32%	5.23%	2.87%	25.25%	9.03%

Source: University of Arizona School of Natural Resources. 2005 and U.S. Census 2000a and 2000b.

Table 86. Poverty levels by county, 2000 Census

Location	Percent Below Poverty Level
Arizona	13.9%
Utah	9.4%
Coconino County, AZ	18.2%
Mohave County, AZ	13.8%
Kane County, UT	7.9%
Washington County, UT	11.2%
Garfield County, UT	8.1%

Source: U.S. Census 2000c.

Effects Analysis

All Federal actions are required by Executive Order 12898 to address questions of equity and fairness in resource decisionmaking. The immediate populations were considered for this analysis. Alternatives were reviewed to determine whether proposed actions would disproportionately impact minority or low income populations.

The alternatives do not differ from one another in their effects on minorities, Native Americans, women, or the civil liberties of any American citizen. Any significant cultural properties identified by Native American groups will be protected. There is no indication that the Warm Fire Recovery project would adversely or disproportionately affect American Indians, other racial minorities, or low income groups.

The action alternatives may provide additional job opportunities in the analysis area economy.

The district would offer salvaged timber for bid, and the salvaging and wood processing could create economic and job-related opportunities potentially benefiting low income populations. The indirect and induced effects of salvaging and processing wood products would stimulate labor and income throughout the local and regional economy. Even wood processed at locations far from Fredonia, Arizona, and Kanab, Utah, could be expected to provide jobs and stimulus to the local economy, such as the purchase of food and fuel, and the possibility that the work might be subcontracted to a local operator.

Visual, Recreation and Roadless Resources

Introduction

The purpose and need of this project is not driven by the recreation and scenery resources; however, both resources exist within the project units and can be affected by implementation of any of the alternatives. This section summarizes describes the visual and recreation resources within the project area. More detailed information, definitions and maps pertaining to recreation and scenic resources are available in the specialist report in the project file, including maps of the scenic integrity objectives (SIOs).

Management Direction

Management direction for visual and recreation resources is derived from the "Kaibab National Forest Land and Resource Management Plan." In addition, standards and guidelines taken from the "Kaibab National Forest Recreation Opportunity Spectrum and Scenery Guidebook" apply.

There will be specific design features applied to proposed management activities when necessary to achieve the SIO and the ROS class for both the recreation and visual/scenery resources for this project.

The Recreation Opportunity Spectrum class (ROS class) for the entire Warm Fire project area is Roaded Natural. The scenery scenic integrity objectives (SIOs) are both High (SIO 2) (Retention) and Moderate (SIO 3) (Partial Retention). The guidebook suggests that Roaded Natural is compatible with both SIO 2 (Norm in all sensitive foregrounds) and SIO 3 (Norm in all but sensitive foregrounds and recreation sites) objectives (see "Guidebook," page 9).

More detailed information regarding management direction for visual and recreation resources in the Warm Fire Recovery project area is available in the visual and recreation specialist's report located in the project record and available upon request from the Kaibab National Forest.

Affected Environment

Background Information

In preparation for forest management planning, the Southwestern Region of the Forest Service contracted with the Nature Conservancy to produce a series of ecological assessments. The purpose of these assessments was to provide continuity among the forests in use of terminology, basis for analysis, and use of the best science. The assessments began with Bailey's ecoregions.

This project lies within the Colorado Plateau Ecoregion (page 7, "Colorado Plateau Ecoregion Assessment"). There are five ecological zones within the Colorado Plateau: Alpine, Subalpine, Upper Montane, Lower Montane-Plateau, and Canyon-Desert zones. The occurrence of these zones results from a combination of elevation, latitude, slope, exposure and rock type, which influence precipitation and natural disturbance processes.

A detailed report describing the landscape character types of the Southwestern Region was developed a number of years ago to provide context for visual quality mapping. These descriptions are useful as they describe the landscape in terms of the elements of visual quality and scenery management: landform, waterform, vegetation. The cultural characteristics were not included in this report (scenery management added this component) and need to be added as supplemental materials when human manipulation of the landscape is considered.

The project area falls within the broader Grand Canyon Landscape Character Type and within the subtype Plateau. It is an area of desert and forested plateaus bisected by a deep rugged canyon. North of the Grand Canyon are a series of north-south trending plateaus that stairstep up from the west to east approximately 1,000 feet for each plateau. The easternmost plateaus attain an elevation of over 9,000 feet. The overall topography is gentle rolling elevations from 6,500 to 7,000 feet. Sagebrush, plains grass, and pinyon-juniper woodland dominate the plateaus although the Coconino and Kaibab Plateaus have coniferous forests. On the Coconino Plateau the coniferous forest is primarily montane conifer while on the Kaibab Plateau it is about half montane conifer and half subalpine conifer.

Mountain meadow grassland and aspen are common to parts of the Kaibab Plateau. Stringers of riparian deciduous forest and woodland are common along watercourses. The plateaus are generally drained by broad, dry washes that deepen into small canyons as they empty into the Grand Canyon. The Colorado River is the only perennial watercourse in the area. The higher plateaus have seasonally flooded basins or flats, fresh meadows, fresh marshes and bogs.

Upon adoption of a plan, the landscape character type description becomes a goal for the scenery resource, and the scenic integrity levels become scenic integrity objectives (SIOs) (page 8, Summary, Landscape Aesthetics, "A Handbook for Scenery Management"). The ROS class is the objective for recreation and can be found in map 4 of the recreation and scenic resources report available in the project record.

Scenic Integrity Objectives and Recreation Opportunity Spectrum

The desired condition for recreation and scenery in the pinyon-juniper and ponderosa pine vegetation types is to have these forests be within their historic range of variation including density of trees, presence of understory shrubs and forbs, and fire frequency. Multiple use and fire may be integrated as part of a healthy ecosystem (USDA Forest Service 2007c).

Scenery management will be compatible with the Scenery Management System scenic integrity objective. The entire project area falls within the scenic integrity objectives of High and Moderate. High scenic integrity refers to landscapes where the valued landscape character "appears" intact. Deviations may be present but must repeat the form, line, color, texture and pattern common to the landscape so completely and at such scale that they are not evident. Moderate scenic integrity refers to landscapes where the valued landscape character "appears slightly altered." Noticeable deviations must remain visually subordinate to the landscape character being viewed.

The forest guidebook and the ROS 1986 book calls for recreation management to be compatible with the Recreation Opportunity Spectrum objective of the area. The ROS class for the entire project area is Roaded Natural. The components of Roaded Natural are based upon the experience opportunities provided by the physical, social, and managerial settings of the land and the recreation activities which occur in those settings (ROS Book 1986, page II-13). The physical criteria include remoteness, size, and evidence of human alteration (ROS Book 1986, page IV-2). The remoteness criteria and the size criteria will not be affected by the alternatives presented in this project. However, the evidence of human alternation criteria could be affected. Therefore, the portion of the desired condition of the Roaded Natural objective that will be focused on is the evidence of human alternation. The definition of the natural setting criteria which is used to define the evidence of human alternation follows. The setting characterization for Roaded Natural is described as: "Area is characterized by natural appearing environments with moderate evidences of the sights and sounds of man. Such evidence usually harmonizes with the natural environment. Interaction between users may be low to moderate, but with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with natural environment. Conventional motorized use is provided for in construction standards and design facilities" (ROS Book 1986, pg. II-32).

In addition to these requirements, the desired condition of the project area is to maintain a historic and natural appearing landscape, and to preserve landscape views from the scenic byways and use areas over time.

Existing Condition

High burn severity as it pertains to recreation and scenery resources, and defined by the Warm Post-fire Assessment is where "…a large majority of the trees were killed with entire tree canopies totally consumed by intense heat and fire. Foliage, litter, and duff were completely consumed, and coarse, downed woody debris was deeply charred or totally consumed" (USDA Forest Service 2007c).

Moderate burn severity is defined as "the surface litter layer was consumed and the duff layer was deeply charred by the fire. Much of this ash has moved offsite due to wind and water. Small woody debris is mostly consumed; larger logs remain but are charred. Vegetative ground cover is patchy and not continuous. Much of the tree canopy remains; however, it was scorched, turning the needles brown. These needles will eventually fall to the soil's surface, providing immediate mulch and initiating the slow recovery process of re-establishing vegetative ground cover" (USDA Forest Service 2007c).

Low burn severity is defined as "there is light ground char where the litter was scorched, charred, or partially consumed. The duff is largely intact, although it may be charred on the surface. Woody debris accumulations are partially scorched or charred. Vegetative ground cover remains intact and is adequate to protect soils from accelerated soil erosion" (USDA Forest Service 2007c).

In forested areas, much of the tree overstory is green with some scorch at the base of the trees and in the lower branches. Most of the trees survived; however, there are pockets of seedlings and saplings that were killed or consumed. Many of the shrubs, forbs and grasses were burned under conditions that could be described as a "cool" burn. In these cases, much of this vegetation survived (USDA Forest Service 2007c).

The scenery resources in the area are Arizona State Scenic Road Highway 67 and the Three Lakes Historic Sites area. In addition, the following forest roads are within the project area and are important because they lead from State Highway 67 to a travel way or a use area (i.e. a trail or dispersed camping area): 221, 462, 282, 429, 224, 225, 205 (from Highway 67 to 224 (Great Western Trail)), 284 and 217. These form the primary travel ways or use areas (Landscape Aesthetics page 4-8, Landscape Visibility).

Areas of scenic interest that surround the proposed project area include Highway 89A, which leads to Highway 67. The route on Highway 89A from Bitter Springs to Fredonia is called the "Fredonia-Vermilion Cliffs Scenic Road" (USDA Forest Service 2007c). Highway 67 to Grand Canyon National Park North Rim has been designated as the "Kaibab Plateau-North Rim Parkway." It is a national scenic byway and a national forest scenic byway. The Jacob Lake area is found at the junction of Highways 89A and 67 and is the approximate north boundary of the project area, while the De Motte area is the approximate south boundary. The scenic integrity objectives for the area as assigned by the forest GIS layer are High SIO2 (Retention) and Moderate SIO3 (Partial Retention).

The recreation resources within the project area and in the cumulative effects boundary are the Great Western Trail, Arizona Trail, and Mile and A Half Lake dispersed camping area. These resources were obtained from the forest visitor's map and the Great Western Trail map published by the USDA. The recreation opportunity spectrum (ROS) class for the project area is Roaded Natural (RN), which is defined in the "Definitions" section of this report.

There are no congressionally designated wild and scenic rivers or wilderness areas within or in the immediate foreground (0 to 300 feet) of the project area. A portion of the Red Point Roadless Area is within the northeastern portion of the project area.

The majority of the area has moderate relief with rolling hills except the northeast part of the area which has steep cliffs and deeper valleys. The elevation of the area ranges from 5,000 to 7,000 ft.

The visual characteristics that make up these areas are vegetation, slope, rock outcropping, and water features. There are a few rock outcroppings found scattered throughout the project area. There are no rivers and no perennial streams within the project area but there are some areas where water pools during snowmelt in the spring and during heavy summer thunderstorms. The remaining vegetation varies depending on the severity of the fire. Most of the scenery and recreation resources listed above fall into the moderate to high fire severity category (see figure 5). In these areas most, if not all, of the vegetation was burned. This means that the vegetative characteristics of line, form, color, and texture were changed due to this fire event, and the scenic and recreation resources were affected by the fire. The live vegetation that can be found in the area consists of mixed conifer which is primarily composed of ponderosa pine, white fir, Douglas-fir and quaking aspen (USDA Forest Service 2007c) at higher elevations and pinyon, juniper, and Gambel oak at mid-elevation ranges. The lack of green trees and understory plants deprives the area of greater expression of diversity in line, form, color, and texture and, in turn, reduces the visual quality of the area. Black-barked trees with little to no leaves or needles are found throughout the project area and can been seen from important scenery travel ways and trails.

The scenic integrity objective of high and the variety class of B in the project area is not met due to the recent fire activity. Even though fire is part of the characteristic disturbance patterns in the vegetation types associated with the ecosystems in this landscape, the burn severity is not, especially to the extent it is found in the project. Currently, the desired condition of the foreground is not met for any of the scenery and recreation resources.

Scenic Class

The units which are in the immediate foreground of the recreation and scenery resources generally fall in the scenic class of 1 with few falling into scenic class 3. Scenic class 1 indicates very high public concern with scenic class 3 being of lower public concern.

Detailed information and maps for each unit by alternative are provided in the specialist report available in the project record.

Environmental Consequences

Scenic Integrity Objective/Recreation Opportunity Spectrum

In the Warm Fire area, the effects of different management actions were analyzed for scenery and recreation resources. The extent and intensity of the fire was uncharacteristic for the vegetation types that have been analyzed. All of the alternatives would result in recovery from the fire, but the rate and vegetation mixture varies by the management action proposed.

To determine whether the management activity would move the area toward or away from the SIO or ROS class assigned to the scenery and recreation resources respectively, an increase or

decrease in the line, form, color, and texture associated with the vegetation, rock outcropping, slope, and water found in the project area was established. The increase or decrease was assigned either a positive or negative value by comparing the management activity's expected outcome using the silviculture report, historic range of variation, fuel loading modeling pictures, and past experiences of the landscape architect compared to the appropriate SIO pictures found in "Landscape Aesthetics, A Handbook for Scenery Management" or the written description of the ROS class found in the ROS 1986 handbook for each resource. The fuel loading modeling for mixed conifers, aspen regeneration, and ponderosa pine can be found in the project record. The simulations also predict the various plant types 5, 20, and 40 years from now.

Only seen units in the immediate foreground (within 300 feet of roadway, trail or dispersed recreation site) were analyzed. These are the areas most visible and most likely to be utilized by forest visitors, and the value of treating viewsheds in the project area that span into the middle ground or the background from concern level 1 or 2 travel ways or use areas is diminished by the quantity of burned vegetation. In addition, the following guidelines from page 40 of the forest plan were addressed: "for each analysis area, predict the expected effects and resultant forest-site conditions for the 5-year, 20-year, and 40-year time marks."

Table 87 lists the total acres per SIO in the project area for each alternative: SIO 2 = High, SIO 3 = Moderate

Table 87. Acres of scenic integrity objective (SIO) affected by proposed activities by alternative

Alternatives	Acres-SIO 2	Acres-SIO 3	Total Acres
Alternative 1	0	0	0
Alternative 2	5,253	3,861	9,114
Alternative 3	3,814	1,941	5,756
Alternative 4	2,824	2,717	5,541

The entire project area has been assigned the ROS class of Roaded Natural (RN). Therefore, alternative 2 has the potential to affect 9,114 acres of RN class, alternative 3 could affect 5,756 acres of RN class, and alternative 4 could affect 5,541 acres of RN class within the project area.

Scenic Attractiveness

The scenic importance of a landscape is based on human perceptions of the intrinsic beauty of landform, rockform, waterform, and vegetation pattern. Attractiveness classification reflects varying visual perception attributes of variety, unity, vividness, intactness, coherence, mystery, uniqueness, harmony, balance, and pattern. It is classified as: A-Distinctive, B-Typical or Common and C-Undistinguished (Glossary 5, "Landscape Aesthetics, A Handbook for Scenery Management"). Table 88 lists the amount of acres that will have effects to scenic attractiveness from proposed management activities by action alternative.

Table 88. Acres of scenic attractiveness by action alternative

Alternatives	A	B	Total Acres
2	165	8,949	9,114
3	138	5,618	5,756
4	91	5,450	5,541

Table 89 lists the total acres per alternative for distance zones and concern levels found in the project area.

Table 89. Acres of distance zones and concern levels by action alternative

Alternative	Acres per Rank				Total Acres
	FG 1	FG 2	MG 1	MG 2	
Alternative 2	4,248	1,749	1,774	1,343	9,114
Alternative 3	3,376	353	1,738	289	5,756
Alternative 4	2,084	1,169	1,243	1,045	5,541

FG = Foreground; MG = Middle ground; Numbers 1, 2 = concern levels.

When analyzing the units within the project area, no visual effects to sense of place for both scenery and recreation resources were determined for the elements of line, form, color, and texture of the slope, water, and rock outcroppings for all alternatives because none of these characteristics would be disturbed by the various management activities proposed by each alternative. The elements of line, form, color, and texture of the vegetation, which is a component of "sense of place" could be affected by the various alternatives and will, therefore, be analyzed.

Effects by Alternative to Scenery and Recreation

The scope of the effects analysis (direct and indirect) is limited to the scenery and recreation resources within the project area. The cumulative effects boundary for the project is a 3-mile buffer out from the project boundary. All effects were measured by determining if an alternative or activity increased (arrow pointing up in the table) or decreased (arrow pointing down in the table) the attributes for a resource (slope, rock outcropping, vegetation and water feature) element (line, form, color, and texture). It was then further determined if this increase or decrease had a positive or negative effect to the resource. A positive effect is defined as meeting or going toward meeting the scenic integrity objective (SIO) or the ROS class, while the opposite holds true for a negative effect. In addition, cumulative effects for the proposed alternatives in the project area were determined by using forest data available (see scenery and recreation resource report available in the project record) of past, present, and future projects.

Alternative 1 — No Action

The scenic resources found within the project boundary include State Highway 67 and Three Lakes Historic Site. The following forest roads (FR) are also important because they lead from State Highway 67 to a trail or dispersed camping area: 221, 462, 282, 429, 224, 225, 205 (from Highway 67 to 224 (Great Western Trail)), 284 and 217. The recreation resources found within

the project boundary are the Great Western Trail (FR 225, 224 284 and 284C), Arizona Trail, and Mile and A Half Lake dispersed camping area. Table 90 shows the predicted direct effects to the landscape upon implementation of the no action alternative for both scenery and recreation resources.

Table 90. Changes in the existing landscape from implementing alternative 1

Landscape	Line	Form	Color	Texture
Slope	No Change	No Change	No Change	No Change
Rock	No Change	No Change	No Change	No Change
Vegetation	No Change	No Change	No Change	No Change
Water	No Change	No Change	No Change	No Change

Direct and Indirect Effects

Implementing alternative 1 (no action) would have the slowest recovery rate since the area does not meet the current assigned SIO or ROS class. This would allow for potentially negative effects to the scenery to continue for the longest time and the project area would move at a very slow pace toward the desire future condition for both scenery and recreation resources which were altered by the wildfire.

The site would continue to have the appearance of a burned forest. The overall appearance of the forest would have uniform form and black color of the burned trees, along with blackened ground and blackened woody material on the forest floor.

The overall appearance of the scenery has been decreased and would continue to stay this way for 20 to 40 or more years until the majority of the burned trees fall to the ground (see appendix B of the recreation and scenic resources report available in the project record for fuel loading simulations for mixed conifers, aspen regeneration and ponderosa pine) and new vegetation grows large enough to add variety to the ground plane. Over the next 1 to 5 years, new grass and shrub growth would add a positive layer of vegetation on the ground that will begin to enhance the landscape. The understory vegetation growth would provide a sharp contrast enhancing the visual effect of the horizontal dominant component of the dying trees and positive elements of line, form, color, and texture would be introduced into the landscape at the shrub level. In less than 1 year, positive line, form, color, and texture would increase in areas where aspen regeneration is already occurring. These areas include scenic corridors, along the trail and in pockets throughout the project area.

Over 5 to 10 years some noticeable pine would naturally sprout and eventually add positive line, form, color, and texture to some areas within the project area (see appendix B of the recreation and scenic resources report available in the project record for fuel loading simulations mixed conifers, aspen regeneration and ponderosa pine). In 40 years it is expected that burnt trees will have fallen, decreasing the dominant line of burnt black trees added to the area. By then some new trees should be well on their way to begin the diversification of vegetation and to some extent, age classes, throughout the area. This should add line, form, color, and texture to the area that is generally positive to the viewer.

Any trees along trails or in dispersed campsites that have burned and are not being removed by the roadside hazard tree project, or dying trees nearby the roadside hazard tree project, may pose a safety hazard to the users if these trees are left. It is anticipated that use of the trails and campsites by forest visitors will be substantially reduced for a number of years, and that users will be displaced to other locations on the district. The sheer quantity of burned trees falling down will be a deterrent to many recreation opportunities, including cross-country travel with motorized vehicles throughout the project area.

No change to effects to the Red Point Roadless Area would occur under this alternative since no disturbance activities are proposed.

Cumulative Effects

All the burned trees beyond the current hazard tree removal areas would be left untreated under alternative 1. This would affect the sense of place of the area which, in turn, affects the SIO or the ROS class of the area if untreated per alternative 1.

In the short term there are no cumulative effects from this proposal because no management activity is proposed under this alternative. However, hazard trees that have the potential to fall on a main travel way or the Arizona Trail would be removed immediately adjacent to main travel ways under an existing decision. In the long term there are cumulative effects. Management of past activities throughout the project area has been completed in a manner to meet the long-term SIO and current ROS class of the area. However, implementing alternative 1 allows for the land to naturally progress toward regeneration of aspen, pine, mixed conifers, grasses and other vegetation. This alternative would put the maximum amount of available timber debris on the ground as black trees burned by the fire fall (see appendix B of the recreation and scenic resources report available in the project record fuel loading simulations for mixed conifers, aspen regeneration and ponderosa pine). The falling burned material would dominate the landscape.

In much of the area that burned, vegetation in the lower, middle, and upper stories of the canopy is gone or has decreased drastically. This alternative does not move the project area toward meeting the SIO or the ROS class in the short term.

It would take over 40 years to see a recovery toward meeting the long-term SIO and ROS class for the area under this alternative. The total possible area that could be negatively impacted by this alternative is one quarter of the project area. This alternative would have a negative cumulative impact on the scenery and recreation resources in the project area. Recreation use would decrease and be displaced to other areas for the longest period of time with this alternative.

Alternatives 2, 3 and 4

The scenic resources found within the project boundary include State Highway 67 and Three Lakes Historic Site. The following forest roads are also important because they provide major corridors leading from the highway to the forest and recreation opportunities: 221, 462, 282, 429, 224, 225, and 205 (from Highway 67 to 224 (Great Western Trail)), 284 and 217.

Developed recreation resources include the Great Western Trail (Forest roads (FR) 225, 224 284 and 284C), Arizona Trail, and Mile and A Half Lake dispersed camping area.

Table 91 shows the predicted direct effects to the landscape upon implementation of the salvage activities for scenery and recreation resources.

Table 91. Change in landscape for salvage activities

Landscape	Line	Form	Color	Texture
Slope	No Change	No Change	No Change	No Change
Rock	No Change	No Change	No Change	No Change
Vegetation	↓+	↓,+	↓,+	↓,+
Water	No Change	No Change	No Change	No Change

Increase "↑", Decrease "↓", Negative Effect "-", Positive Effect "+"

Table 92 shows the predicted change in the landscape upon implementation of the slash disposal activities for scenery and recreation resources.

Table 92. Change in landscape for slash disposal activities

Landscape	Line	Form	Color	Texture
Slope	↑,-	↑,-	↑,-	↑,-
Rock	No Change	No Change	No Change	No Change
Vegetation	↓,-	↓,-	↓,-	↓,-
Water	No Change	No Change	No Change	No Change

Increase "↑", Decrease "↓", Negative Effect "-", Positive Effect "+"

Table 93 shows the predicted change in the landscape upon implementation of the reforestation activities for scenery and recreation resources.

Table 93. Change in landscape for reforestation activities

Landscape	Line	Form	Color	Texture
Slope	No Change	No Change	No Change	No Change
Rock	No Change	No Change	No Change	No Change
Vegetation	↑,+	↑,+	↑,+	↑,+
Water	No Change	No Change	No Change	No Change

Increase "↑", Decrease "↓", Negative Effect "-", Positive Effect "+"

Direct and Indirect Effects

Implementing the action alternatives would decrease the duration of time the area would not meet the current assigned SIO or ROS class when compared to alternative 1. These alternatives would move the project area toward the desire future condition at a faster pace than the no action for both scenery and recreation resource objectives. Along main roads, trails and recreation sites in the project area, alternative 2 would affect approximately 5,997 acres in the foreground and 3,117 acres in the middle ground; alternative 3 would affect approximately 3,729 acres in the foreground and 2,007 acres in the middle ground; and alternative 4 would affect approximately 3,253 acres in the foreground and 2,288 acres in the middle ground.

Burned trees in the immediate foreground would be decreased. In areas of lower severity burn, the visual focus of the viewer may shift to the remaining green trees in the forest. In areas of moderate to high severity burn that are currently dominated by dead trees, the proposed activities would result in an open setting initially throughout the area providing for a clearing-like experience once the burnt trees are removed. This would enhance the rest of the overall appearance of the remaining forest vegetation's elements line, form, color, and texture. Over the next 1 to 5 years, new shrub growth would add a positive additional layer of vegetation on the ground further enhancing the landscape's elements. In less that 1 year positive line, form, color, and texture would increase in areas where aspen regeneration is already occurring. These areas include scenic corridors, along the Arizona Trail and in various pockets through the project area. Over a longer period of time, the reforestation efforts would speed up the process of adding new positive line, form, color, and texture to some areas within the project area when compared to the area naturally regenerating.

Any burned or dying trees that pose a safety hazard to forest recreation users would be removed, increasing safety for recreation and scenery users. Lopping and scattering slash debris, as well as piling and burning slash, would initially decrease scenery values close to trails and some heavily used roads. The slash may be a deterrent to some recreation opportunities such as cross-country motorized travel. There may be a possibility that a larger number of forest users may be displaced from the area.

Effects on the Red Rock Inventoried Roadless Area were reviewed in the context of the four requisite attributes of wilderness as defined in the 1964 Wilderness Act: natural integrity, apparent naturalness, outstanding opportunities for solitude, and opportunities for primitive recreation. Salvage logging is not proposed within the roadless area under any of the alternatives. Hand planting of conifer seedlings is proposed within the roadless area where seed sources are now lacking. Planting activities would occur without road work. Effects from proposed activities under all action alternatives would be the similar. Planting of native conifer species is proposed to result in approximately 30 to 160 seedlings per acre with irregular spacing to mimic historic conditions. Short-term impacts to solitude and primitive recreation opportunities are anticipated during salvage logging activities in adjacent areas with some noise from operations and temporary increases in travel on existing roads. Short-term impacts from hand planting activities may occur on the sites proposed for planting with crews walking and planting the seedlings, and followup survival surveys for the next three to five years. In the longer term, planting native conifer species would lead to restoration of forested conditions and improve natural integrity and apparent naturalness of the Roadless Area.

Over a 5- to 40-year period the reforestation would add positive line, form, color, and texture to the project area.

In addition, aspen stands that have come in naturally would be plentiful throughout the project area including along the scenic corridor, trails, and roads leading to campsites. Some aspen stands could be trampled due to salvage activities.

However, the overall regeneration of aspen would add considerable variety in the line, form, color, and texture that can be found through the project area. In 40 years it is expected that diverse vegetation types and some variation in the age classes would put the area well on its way to its expected desired condition, thereby meeting its long-term SIO and helping retain the sense of place character associated with the assigned Roaded Natural ROS class.

There may be indirect effects to scenery from open vistas along trails, dispersed campsites, and scenic byways when trees are salvaged, as any obstruction of the view of the fire effects would be removed. Over time, these open vistas would be less noticeable as revegetation occurs.

Cumulative Effects

The area being analyzed for cumulative effects is the project boundary totaling approximately 39,000 acres. Figure 29 depicts the management activities that have occurred in the past and are occurring presently, and shows the area that this alternative may impact in the future. All units identified for salvage consist of burned trees from the fire. These areas could increase or decrease, positively or negatively, the vegetation or slope line, form, color, and texture, thereby affecting the sense of place of the area that in turn affects the SIO or ROS class of the area. A visual inventory of disturbances from past and ongoing management activities within the project area, including the hazard tree removal project, was completed. In addition to past and current management activities causing disturbance on the land, there is evidence that individual stands, up to 160 acres in size, may have experienced a high severity burn.

Upon visual inspection of past activities within the scenery and recreation resources in the project area, the current assigned SIO and sense of place component of the ROS class has been met in areas where there is no burnt vegetation. In the moderate to severely burned areas, due to current proposed activities, short-term (1 to 5 years) cumulative effects are positive with respect to decreasing the amount of burnt trees on some acres, and negative with respect to lop and scattering debris, and piling and burning slash, which would increase line, form, color, and texture of the dead trees on the forest floor. In the long term (6 to 40 years), negative cumulative effects of the debris on the ground, including residue left from burned piles, would decrease due to the growth of grasses and ground cover that is expected in the area. Areas that show the possibility of 50 to 60 tons of debris per acre possibly added to the ground would not recover in the same 40-year period as the other areas with less debris per acre. The regeneration of aspen and the reforestation of pine and mixed conifers will add line, form, color, and texture in the middle and upper stories of the forest. All action alternatives would move the project area toward meeting the SIO and sense of place for the Roaded Natural ROS class in the short term in some aspects, but more so in the long term.

The activities proposed in the action alternatives may make some recreation opportunities more available (hazard trees and slash would be removed from selected areas). Some opportunities would be reduced such as cross-country motorized use. It is anticipated that there may be less displacement of users than in alternative 1.

Conclusion for Scenery and Recreation

Currently, the project area does not meet the objectives for scenery of “High” and “Moderate” SIOs and the sense of place designated for the Roaded Natural ROS Class in any of the units where moderate to severe fire burned all trees in vast areas. Even within a low intensity fire there may be patches where all or most trees were killed. It is acknowledged that the pine and dry mixed conifer vegetation types are adapted to frequent, low intensity fires; however, the difference in the case of the Warm Fire is the scale at which the moderate to high severity burn occurred.

The scenic attractiveness of the landscape inspection was completed prior to the burn. This fire depleted the landscape of its major attribute (vegetation) that contributed to the land’s scenic

attractiveness. The land is capable of supporting this vegetation again and is expected to meet the SIOs of both “Moderate” and “High” and sense of place for the Roaded Natural ROS Class over time. The alternatives provide different timeframes and, in turn, rates of revegetation to eventually meet the SIO and ROS classes desired.

Overall, the landscape effects to the viewsheds found in the project area would recover the fastest in the long term upon completion of alternative 2, 3 or 4. Applying the design features for scenery and recreation would reduce potential adverse effects ensuring that the project would comply with forest plan standards. It is likely that this alternative will allow for the fastest visual recovery in the long term because more acres are being treated in alternative 2. However, in both the short term and long term, all units that would have 50 to 60 tons of fuels per acre would not meet the SIOs of High and Moderate and the sense of place for the Roaded Natural ROS class even after 40 years. In order to make those units meet the scenery and recreation goals, a combination of lop and scattering with mastication or chipping would need to be completed in the foreground of these units.

Alternative 1, the no action alternative, would have the least positive impact to the land as the land currently stands and would take the longest of all the alternatives for the area to reach its long-term goal. The sense of place, scenic attractiveness and visibility for the area would be the most negatively impacted over the next 40 years and would potentially displace users for the longest time. Alternative 1 would have the most short-term and long-term negative effects to both scenery and recreation.

Project activities in alternatives 2, 3 and 4 have been designed to meet the long-term SIOs of High and Moderate with implementation of the recommended design features, except where fuel loading goes above 40 tons per acre. Alternative 2 would rehabilitate the most acres of scenery and recreation resources in the long term the fastest. However, alternative 2 would have the most negative short-term effect to the scenery and recreation resources when compared to alternatives 3 and 4.

Alternative 2 has the ability to impact the landscape the most negatively in the short term, but would move the landscape toward its long-term goal the quickest by decreasing the burnt trees within the landscape. Impacts to the land could be reduced upon implementation of the design features and allow the landscape to reach the SIOs of High and Moderate the quickest of all alternatives.

Alternative 3 would be preferable over alternative 1 but not over alternative 2 or 4. Alternative 3 does not allow the area to move as fast as alternative 2 toward the long-term SIO and ROS class “sense of place” goals.

Alternative 4 would impact the least number of acres when compared to alternatives 2 and 3, and would take longer for the area to reach its long-term SIO goals when compared to alternatives 2 and 3.

Heritage Resources

Introduction

This section summarizes possible effects to heritage resource sites, resources significant to the Hopi Tribe, Kaibab Band of Southern Paiute Indians, and Navajo Nation, and recommended mitigation measures to avoid adverse effects to resources within the Warm Fire Recovery project.

Laws, Regulations, and Policy

Under the National Environmental Protection Act (NEPA) and 36 CRF 800 as per section 106 and 110 of the National Historic Preservation Act (NHPA), Federal agencies are required to consider the effects and impacts of associated projects on heritage resources and, where possible, make reasonable and good faith efforts to mitigate for either no effects or no adverse effects. Heritage resource sites are defined as nonrenewable physical and natural objects associated with past human activities and also include locations of traditional importance to interested tribes. In order to implement any Federal undertaking and comply with Federal laws and regulations, Federal agencies are required to identify and document the location, condition, and type of existing heritage resource sites. Significant resources are then protected through avoidance or other mitigation measure developed in consultation with the State Historic Preservation Office (SHPO), culturally affiliated tribes, and the Advisory Council on Historic Places (ACHP).

Laws such as NHPA, NEPA, and the American Indian Religious Freedom Act (AIRFA) require Federal agencies to consult with culturally affiliated tribes and determine possible effects to sites and other culturally significant resources resulting from activities within a proposed project area. The Kaibab National Forest has initiated consultation with the Kaibab Band of Paiute Indians and Hopi Tribe as per the existing memoranda of agreement concerning government-to-government consultation procedures in place between the Kaibab National Forest and each tribe. The Navajo Nation Bodaway/Gap, Coppermine, and Lechee Chapter Houses of the Navajo Agency of the Navajo Nation were also consulted.

Forest representatives met with the Kaibab Paiute Tribe resource specialists on October 25 and December 6, 2006, to discuss the Warm Fire Recovery project. The tribe requested that any salvage proposals take into consideration the need to leave debris onsite for nutrient cycling and was supportive of reforestation efforts. The tribe questioned the forest's policy for disseminating sensitive cultural resource locational data to the public. The forest assured the tribe that the heritage program would protect any sensitive information provided and that locational data would not be subject to public disclosure. The tribe also expressed concern that cultural resource sites be protected during project implementation activities. The tribe said that they would submit any additional comments after other members of the council and tribe had an opportunity to study the maps and proposed action. No additional comments were made.

Forest representatives also met with the Hopi Tribe on February 21, 2007. The Hopi Tribe was informed about the effects of the Warm Fire on cultural and natural resources and notified that an EIS would be developed for the Warm Fire Recovery project. Hopi tribal representatives asked if funding was available to conduct cultural resource surveys of the Warm Fire area at that time.

On May 21, 2007, the Hopi Tribe, Kaibab Band of Paiute Indians, Navajo Nation, and Bodaway/Gap, Coppermine, and Lechee Chapter Houses of the Navajo Agency of the Navajo Nation were sent a consultation letter regarding the proposed project.

On May 30, 2007, during a consultation meeting with the Navajo Nation, tribal representatives stated that the Navajo Nation is interested in the Warm Fire Recovery project and requested to be updated as the EIS is developed. Navajo Nation Historic Preservation Department personnel stated that the Navajo Nation does not support any further disturbance, including rehabilitation or stabilization efforts at Navajo cultural sites within the burned area. Furthermore, the Navajo Nation has requested that the Kaibab National Forest inform the tribe of the locations of salvage logging units when these are identified. They also requested that they be informed of any bids seeking reforestation work as the Navajo National Forestry Department has native tree seedlings available for such projects. No other questions, comments or concerns about the project were submitted.

Affected Environment

Within the 40,000-acre Warm Fire Recovery project, 40 heritage resource inventories have been conducted since 1975 and cover approximately 35 percent of the area. The majority of heritage resource inventories have been small in scale in response to fuels reduction projects, timber sales, and road and trail installations. Larger scale more recent block surveys include Telephone Hill (Snyder and Reid 2004), Billy West (Synder 2005; Betenson 2007), and the Warm Fire Recovery project area (Nichols and Betenson 2007). Surveys within the project area and other adjacent surveys indicate medium to low site densities within the ponderosa pine and mixed conifer vegetation zones (Betenson 2005; Haynal and Reid 2002; Reid and Hanson 2006; Snyder 2003, 2005; Snyder and Reid 2004).

All treatment units within each alternative identified in the Warm Fire Recovery EIS were surveyed following the guidelines specified in the “Proposed Survey Strategy for the North Kaibab Ranger District” (Reid and Hanson 2006). Thirty-three sites are located within, adjacent, or just outside proposed treatment units (Nicholas and Betenson 2007). Documented sites within the Warm Fire Recovery EIS area date from the archaic period through the historic period. Prehistoric sites span from the Archaic through the Neo Archaic periods and include rock art, camps and rock shelters comprised of artifact scatters, pueblo habitation sites and agricultural features. Historic sites are most commonly associated with FS administration and fire management operations, logging, livestock grazing, and Native American pinyon gathering. Site types include log cabins, can/bottle refuse scatters, livestock corrals, dendroglyphs, fire lookout trees dating from the late 19th through mid-20th centuries, and Paiute and Navajo brush structures and corrals.

Avoidance of these sites is required during implementation of the selected alternative. Specific site protection requirements are identified in the cultural resource clearance for the project (Nicholas and Betenson 2007).

Direct and Indirect Effects by Alternatives

Alternative 1 — No Action Alternative

The no action alternative would employ current management plans to guide management of the project area. Heritage surveys are conducted as ground-disturbing activities are proposed and incorporate design criteria protection measures to avoid impacting sites. The no action alternative would not alter existing conditions.

Alternative 2 — Proposed Action

The activities associated with treatments listed in the proposed action alternative have the potential to directly impact heritage resource sites. Many of the techniques utilized during timber salvage, reforestation, and fuels treatments are associated with ground-disturbing activities. In order to protect heritage resource sites, all sites have been identified and documented using cultural resource survey standards as per the North Kaibab Survey Strategy (Reid and Hanson 2006). The sites will be flagged for avoidance prior to project implementation. The standard survey procedures are designed to identify and document sites visible on the surface of the ground, so in the event that an undocumented site is unearthed during ground-disturbing activities, implementation activities will cease and a North Zone archeologist will be contacted to assess the remains. With the design criteria implemented, the proposed action alternative would have no direct or indirect effects to heritage resource sites.

Alternative 3

The activities associated with treatments listed in the winter harvest alternative will be the same as those listed under the proposed action alternative with the exception of less surface area. To protect heritage resource sites, the same survey, identification, documentation, and flag and avoid strategy and standards will be implemented for the winter harvest alternative. With the design criteria implemented, this alternative would have no direct or indirect effects to heritage resource sites.

Alternative 4

The activities associated with treatments listed in the MSO exclusion alternative will be the same as those listed under the proposed action alternative. To protect heritage resource sites, the same survey, identification, documentation, and flag and avoid strategy and standards will be implemented for the winter harvest alternative. With the design criteria implemented, this alternative would have no direct or indirect effects to heritage resource sites.

Cumulative Effects by Alternative

The cumulative effects analysis will be confined to the project vicinity since ground-disturbing activities will be limited to the project area during the implementation period, and heritage sites are stationary. Actions to protect heritage resources from direct and indirect impacts from project implementation have been described in the above sections. Based on the design criteria, there will be no changes to the physical integrity of heritage resource sites and no cumulative effects within the analysis area.

Alternative 1 — No Action Alternative

Heritage sites are avoided during ground-disturbing activities to avoid impacting sites. There would be no cumulative effects to heritage resources from the no action alternative because no ground-disturbing activities associated with salvage, reforestation, or fuels treatments would occur within the analysis area.

Action Alternatives

If the recommended design criteria protection measures to avoid sites are employed during project implementation, there would be no cumulative effects to heritage resources from ground-disturbing activities.

Consistency with Regulatory Framework

National Historic Preservation Act (16 U.S.C. 470

Federal agencies are required to consider the effects and impacts of associated projects on heritage resources and, where possible, make reasonable and good faith efforts to mitigate for either no effects or no adverse effects. Heritage resource sites are defined as nonrenewable physical and natural objects associated with past human activities and also include locations of traditional importance to interested tribes. In order to implement any Federal undertaking and comply with Federal laws and regulations, Federal agencies are required to identify and document the location, condition, and type of existing heritage resource sites. Significant resources are then protected through avoidance or other mitigation measure developed in consultation with the State Historic Preservation Office (SHPO), culturally affiliated tribes, and the Advisory Council on Historic Places (ACHP).

Laws such as NHPA, NEPA, and the American Indian Religious Freedom Act (AIRFA) require Federal agencies to consult with culturally affiliated tribes and determine possible effects to sites and other culturally significant resources resulting from activities within a proposed project area. The Kaibab National Forest (KNF) consulted with the Kaibab Band of Southern Paiute Indians, Hopi Tribe and Navajo Nation. The Kaibab Paiute stressed the importance of all resources on the Kaibab Plateau, but expressed particular concern in regards to heritage sites, other cultural resources, cliffrose regeneration, Kaibab mule deer, and noxious weeds (Reid 2006). The Hopi Tribe has expressed concerns that all heritage resource sites within the proposed project area be protected. The tribes have requested that they be kept abreast of any developments that may occur during the entire span of the project. The Forest Service will continue consultation efforts with the Kaibab Band of Paiute Indians, Hopi Tribes, and Navajo Nation on a government-to-government basis, accommodating concerns when possible.

Heritage resource surveys and an evaluation of potential impacts of proposed treatments were completed in 2007 in accordance with 36 CRF 800 and the programmatic agreements governing historic preservation requirements for Forest Service undertakings. Project administrators must work directly with the North Kaibab district archeologist to coordinate and develop implementation plans and guidelines that meet the mitigation design criteria protection measures to avoid effects to heritage resource properties from project implementation activities (Woodward and Reid 2007). This project complies with the NHPA and forest plan through the above consultation and incorporation of project design features to protect cultural resources.

Range Resources

Affected Environment

Ninety-five percent of the Warm Fire area was in the North Pasture of the Central Summer allotment (see figure 31). This allotment has two pastures, north and south, and is managed in a rest-rotation grazing system (USDA Forest Service 2006). The Central Summer allotment is permitted for 800 head of livestock during a season of use from July 1 to October 15. The north

pasture was greatly impacted by the fire with over half the 102,346 acres in the pasture burned. The fire burned just inside the boundary of the south pasture, damaging the northern boundary fence, but did not affect the potential for this pasture to continue to be grazed. The project area is mostly contained inside the north pasture.

Several range and wildlife structures in the Central Summer allotment were damaged to varying degrees during the fire and from post-fire water runoff. These structures include pasture fences, livestock handling facilities, dirt tanks, wildlife waters, and enclosures.

The Houserock allotment on the eastern side of the Central Summer allotment also had fire breach the edge of its boundary. The fire damaged parts of the boundary fence, which was repaired a few months later. Post-fire water runoff silted in three dirt tanks and washed out a section of fence. The capacity of the allotment was not affected, and the grazing strategy will continue without consequence through the salvage or reforestation efforts.

The bulk of the fully capable and potentially capable acres of the Central Summer north pasture are either outside of the burned area or in the low to moderate intensity burn areas where salvage and reforestation activities are not expected. The low intensity burn areas have responded with excellent cool season grass and forbs production following the monsoon rains post-fire. It is these areas that have traditionally seen the highest livestock use. The areas of high fire intensity will take longer to re-establish native vegetation. The process benefited to some degree from the BAER seeding that occurred in August 2006. The majority of the high intensity burn areas are located in portions of the allotment that have traditionally seen light use from livestock due to steep slopes, low forage availability, and few reliable water sources. This would indicate that light grazing pressure would resume once livestock are re-introduced to the pasture and impacts to re-establishing plants would be minimal.

Desired Condition

As per the Kaibab National Forest plan, a guideline in post-fire management is for areas impacted by fire to be excluded from livestock grazing for at least two growing seasons. This minimum rest guideline has been followed and livestock have been deferred from the Central Summer North Pasture since the fire. The North Kaibab Ranger District has also developed specific Warm Fire standards for understory vegetative condition, livestock handling facility infrastructure, and deferment for reforestation plantations that must be met prior to livestock re-entry.

The guideline of 2 years rest has been implemented for areas inside the fire boundary where plantation activities may be impacted by livestock grazing. In spring 2008, a small reforestation project was approved and implemented for areas not included in the Warm Fire FEIS. Livestock are planned to be deferred from the Central Summer North Pasture until at least 2010, to avoid adverse impacts to the 2008 plantations. Continued deferment of this pasture could extend past the 2010 grazing season, if monitoring indicates a need. This same policy of 2 years rest plus continued monitoring to determine livestock re-entry will also be applied to implementation of the FEIS.

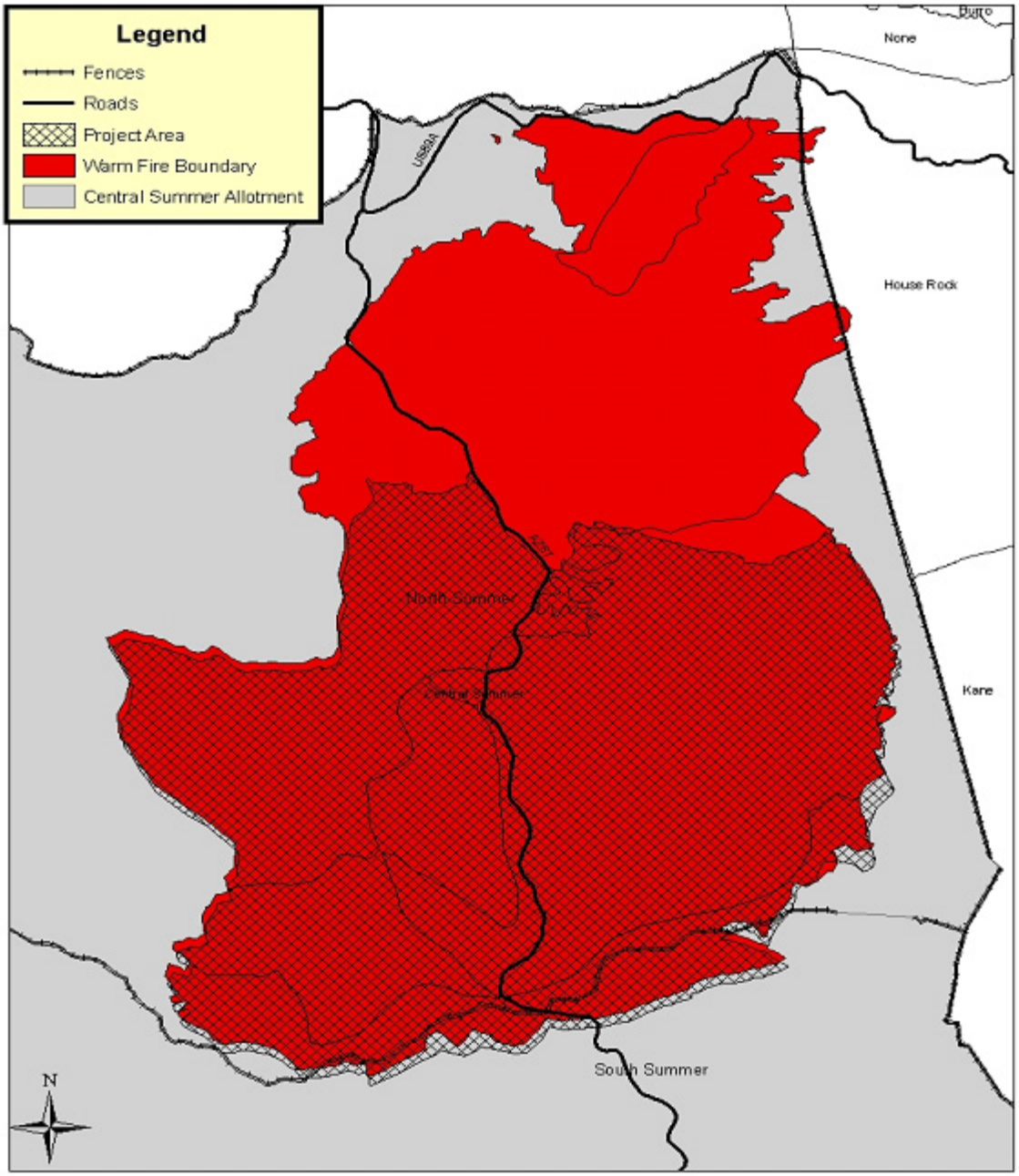

Figure 31. North pasture, Central Summer allotment

After the two growing seasons past implementation are over, the project area will need to be assessed as capable of sustaining grazing pressure prior to re-entry. Forest Service personnel have been assessing the understory vegetative condition inside the burned area since 2007. This effort will continue on an annual basis for several years. Criteria for determining when understory vegetative conditions are ready to resume grazing in the project area will be based on forage production of native perennials, plant vigor, noxious and invasive species, and species diversity

that is consistent with the potential for the soil type. The monitoring that occurred in 2008 indicated a few areas of the fire that are still not meeting the desired vegetative condition to appropriately sustain grazing pressure.

Effects Common to All Alternatives

The burned portion of the North Pasture would be rested until the Kaibab forest plan guideline of two growing season livestock deferment is met, and the pasture has been assessed as capable to sustain grazing pressure again. Portions of the burned area could continue to be deferred in the event that activities that address soil and watershed issues or re-establishing native forage were to occur that could be negatively affected by livestock grazing. Grazing deferment would be managed by either herding management to keep livestock out of the burn area or resting the pasture entirely. Monitoring of the allotment could lead to reducing livestock numbers during this period if resource conditions on the unburned portions of the allotment are declining.

Fire damaged range and wildlife fencing and water structures need to be functional prior to livestock entry to ensure that livestock can be managed appropriately. The majority of the livestock fences were repaired in 2007. Repairs to livestock corrals, water structures, and wildlife fencing exclosures are planned 2009 projects.

Plans to rebuild damaged or destroyed fences, livestock handling facilities, and wildlife waters and clean out silted in dirt tanks would be implemented over the course of several years with the intent of being rebuilt to Forest Service specification standards prior to livestock re-entry. The reconstruction of the fences and handling facilities will have no impact on any of the alternatives.

Cleaning of the dirt tanks will generate short-term increased sedimentation to lower elevation areas, but it will be minimal compared to the overall sedimentation currently occurring in the areas that burned with high intensity where vegetative ground cover is minimal. In most cases, cleaning the dirt tanks will wait until sufficient ground cover has been re-established around the tank to lessen the degree of sediment movement and improve the effectiveness of the cleaning activity.

Current Management: Alternative 1 — No Action Alternative

The project area will be assessed for grazing capability and livestock will be re-authorized to graze during the specified season of use. The high tree mortality inside the project area is expected to generate a considerable amount of fallen trees over time. The downed trees could limit access to forage and water for livestock in the project area to some degree. While the majority of the pasture's fully capable acres containing sufficient forage and water are located outside of the project area, the accessibility issues would increase grazing intensities in those areas of the North Pasture. If the grazing intensities rise to a level above the allowable utilization for the site, a change in management will need to occur. Combining the issues of livestock handling facilities that will not be repaired until 2009, a few areas that are not ready to sustain grazing pressure, and a required rest of current reforestation plantations until 2010, the earliest livestock grazing would occur is 2010. The actual date will depend on monitoring of range resources conditions and trends and adequate recovery progress.

Another issue with the high amount of fallen trees will be trying to manage the livestock that do enter the project area to graze. The additional time needed by the livestock managers to herd

cattle through the fallen trees could have an adverse effect on the efficiency of the livestock operations and increase expenses to the producer.

Effects Common to Alternatives 2, 3, and 4 (Action Alternatives)

All of the effects common for deferring livestock until the project area is assessed as capable for grazing pressure would continue to be maintained under the action alternatives. Livestock would be deferred from any plantations for two growing seasons after treatment if livestock grazing is impacting plantations. The vegetative condition of the affected plantations will be assessed prior to livestock re-entry to ensure that the treatment effectiveness is not compromised by grazing pressure. There are no expected effects on the livestock operations due to the plantations after cattle are authorized to re-enter the project area.

Combining the issues of livestock handling facilities that will not be repaired until 2009, a few areas that are not ready to sustain grazing pressure, a required rest of current reforestation plantations until 2010, and a required rest of the FEIS plantations, the project area will continue to be deferred from grazing until at least 2011. When all criteria for grazing sustainability are met, livestock will be authorized to return inside the Warm Fire boundary.

Once cattle are re-authorized in the project area, there will still be an issue with livestock management and the fallen trees. All three action alternatives propose salvage activities on areas that were accessible to livestock prior to the fire. Many of the dirt tanks that contain water for livestock use were built in these areas. Thus, removing any level of dead trees from the project area will reduce the amount that will fall and potentially limit livestock access to forage and water. These openings created by the salvage operations will provide improved access for the livestock and livestock managers versus no tree removal in alternative 1.

Cumulative Effects

When direct and indirect impacts of past and present actions and disturbances, and reasonably foreseeable actions are considered, continual improvement of range related resource conditions are expected over the next 10 years in the project area. Table 94 discloses those activities inside the Central Summer North Pasture.

Table 94. Acres of past and present actions and disturbances, and future activities (within the next 10 years) that speak to cumulative effects that may impact the project area

Activity	Past Acres	Present Acres	Reasonably Foreseeable Acres
Salvage Operations	0	0	5,541-9,114
Soil Stability Treatments	11,700	0	11,700
Vegetation Treatments	0	0	30,000
Reforestation Treatments	0	0	14,778
Noxious Weed Control	10	100	100
Wildland Fires	60,000	0	Unknown
Grazing AMP Revisions	102,346	0	102,346
Wildlife Habitat Improvement	0	0	Unknown

Past actions of light and moderate intensity wildland fires, soil stability treatments, and changes in allotment management have improved understory plant production across much of the Central Summer North Pasture. This means higher density grass and forbs production. Areas that burned with high intensity will take longer to improve, but with proper management implementing soil stability measures, vegetation treatments, and noxious and invasive weed control, this area has the potential to improve understory vegetation beyond prefire conditions.

Control of isolated cheatgrass populations that are forming in the pinyon-juniper area of the Warm Fire project area would have a large impact on the success of vegetation treatments. Without treatment, cheatgrass and other potential noxious and invasive weeds can rapidly spread across a large part of the fire area.

Short-term Uses and Long-term Productivity

NEPA requires consideration of "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR 1502.16). As declared by Congress, this includes using all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

Short-term use includes consumptive activities such as logging, hunting, fishing and non-consumptive activities such as sightseeing and photography, which can affect the landscape in the short term. These uses can be sustained in the long term if the productivity of the land is not impaired. It is believed that maintaining the productivity of the land is realized by maintaining ecosystem structure and function.

All action alternatives proposed in this EIS protect the productivity of the land to one extent or another through the application of:

- Standards and guidelines for resource management.
- Best management practices.
- Site specific mitigation measures.
- Design criteria incorporated into alternative development.

Productivity may be affected as a result of some management activities. A short-term loss of productivity from soil compaction is expected in some alternatives, but would be alleviated with decompaction after activities are completed.

Unavoidable Adverse Effects

Implementing any alternative would result in some degree of environmental effect that cannot be avoided. Management direction from forest plan standards and guidelines, best management practices, project design criteria, and mitigation measures are intended to keep the extent and duration of these effects within acceptable levels but effects cannot be completely eliminated. Sediment could be produced by surface erosion or channel erosion.

Even with design criteria in place, ground-disturbing activities may produce temporary effects that cannot be avoided, such as a temporary sediment increase to some streams, or a temporary effect to air quality from burning slash.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be regained, such as the extinction of a species or the removal of mined ore. Irretrievable commitments are those that are lost for a period of time such as the temporary loss of timber productivity in forested areas that are kept clear for use as a power line right-of-way or road.

Forest Vegetation

There are no anticipated long-term irreversible commitments of the forest vegetation.

For the action alternatives, there are irretrievable commitments of the growth of forest vegetation for about 5 years because of the new landings that would be built to facilitate the salvage operation. They would be rehabilitated after use, but there would be a lag in reforestation and growth since the sites are impacted more heavily than the surrounding forest land.