

D-6
Heritage

USDA United States
Department of
Agriculture

Forest
Service

Southwestern
Region



Record of Decision Santa Fe Municipal Watershed Project

Espanola Ranger District
Santa Fe National Forest
Santa Fe County, New Mexico



The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TTY).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice or TTY). USDA is an equal opportunity provider and employer.

Record of Decision Santa Fe Municipal Watershed Project

Santa Fe National Forest

**Southwestern Region
USDA Forest Service**



In cooperation with:

City of Santa Fe



New Mexico



~ Blank ~

Table of Contents

Introduction	1
Location and Project Area	1
Partnerships and Public Involvement	1
Public Comments on the Draft EIS	2
Purpose and Need	2
Issues	3
Selected Alternatives C1 and D1	3
Thinning and Slash Disposal	3
Fuel Breaks	3
Broadcast Burning	4
Reasons for My Selection of Alternatives C1/D1	4
Summary of Rationale for C1/D1	6
Selected Option A: No Roadside Wood Removal	6
Non-Selected Option B: Thin the Larger Conifers on 100 Acres	7
Alternatives Considered and Eliminated From Detailed Study	7
Mitigation and Monitoring Requirements	7
Prescribed Burning and Risk of Escape Fire	8
Air Quality	9
Soil and Water	9
Riparian Ecosystems and Aquatic Habitat	10
Terrestrial Habitat and Associated Wildlife	11
Heritage Resources	12
Permits and Agency Approvals Required	12
Findings Required By Other Laws	13
National Environmental Policy Act (NEPA) and 40 CFR 1500 Regulations	13
National Forest Management Act (NFMA) 36 CFR 219 Regulations	13
National Historic Preservation Act (NHPA) and 36 CFR 800 Regulations	14
Endangered Species Act (ESA) and 50 CFR 402 Regulations	15
Migratory Bird Treaty Act (MBTA)	15
Clean Water Act, 40 CFR 130 regulations and State Water Quality Standards	15
Floodplains and Wetlands, Executive Orders 11988 and 11990	16
Clean Air Act, 40 CFR 50 regulations and Air Quality Standards	16
Environmental Justice, Executive Order 12898	16
Administrative Appeal Provisions	17
Implementation	17
Contact	17

~ Blank ~

Record of Decision

Introduction

I am pleased to announce that we have completed the detailed analysis process and Final Environmental Impact Statement (EIS) for the Santa Fe Municipal Watershed Project. The Final EIS consists of the Draft EIS as published, along with an Errata Sheet comprising minor corrections and clarifications to the Draft EIS, an updated Appendix B: Monitoring Plan, and an Appendix C: Response to Comments. We did not write a new EIS because the changes in response to public comments on the Draft EIS were minor and confined to factual corrections, clarifications, and other responses that did not warrant further agency action (40 CFR 1503.4 (c)). Regulations require circulating only changes to the Draft EIS rather than rewriting and circulating the entire EIS when changes are minor (40 CFR 1500.4(m)). Based on a thorough review of public comments, I determined that there was no need to modify alternatives, develop and evaluate new alternatives, or supplement or modify the analysis in the Draft EIS in order to make an informed decision on this project in accordance with National Environmental Policy Act (NEPA) regulations.

As Forest Supervisor for the Santa Fe National Forest, I have made this fuel reduction project in the Watershed a top priority in an attempt to protect the City of Santa Fe and its water supply from the potentially devastating impacts of a large catastrophic fire. The Watershed supplies 40 percent of the City's water, and currently contains thousands of acres of exceptionally dense forests that are highly vulnerable to the kind of raging crown fires experienced last year in New Mexico and throughout the U.S. This is a very serious problem. If we do not substantially reduce the number of trees that blanket this area, we can expect a high severity fire that will decimate the Watershed, threaten the City with loss of homes and businesses, cause massive soil and debris flows into the Santa Fe River and its water supply reservoirs, and send muddy flood waters through Santa Fe's streets and downtown area. We know we cannot prevent a wildfire from ever burning in the Watershed. However, it would be irresponsible for me not to take immediate action to reduce the numbers of trees that form hazardous fuel loads in the Watershed, to the extent necessary to limit the magnitude and intensity of any fires that might occur.

It is my decision to implement fuel reduction treatments described in the EIS for the Santa Fe Municipal Watershed Project as Alternatives C1 and D1, together with Option A (No Wood Removal), along with all mitigation measures identified in the EIS (pp. 27-32) and the comprehensive monitoring and adaptive management plan outlined in Appendix B as updated.

Location and Project Area

This Record of Decision describes the selected alternatives and how I arrived at this selection after comparing the tradeoffs among the various alternatives and options, and considering public comments received on the Draft EIS.

This decision applies to national forest lands identified in the EIS as the "project area" (pp. viii, 1); situated in the upper Santa Fe River canyon that directly borders the City of Santa Fe, in northern New Mexico, Township 17 North, Ranges 10 and 11 East. The project area consists of 7,270 acres within the Watershed, just below the Pecos Wilderness boundary and south of Hyde Park Road (State Highway 475). The selected alternative may also be applied on City-owned land and private land within the project area, with the owner's consent.

This project area consists of primarily 80 to 90-year-old ponderosa pine forest with small patches of other vegetation types. It extends 7 miles up the Santa Fe River canyon to a steeper area where the vegetation changes to a moist, mixed conifer forest. Elevations range from 7,000 to 8,500 feet, and there are no perennial streams in the project area other than the Santa Fe River.

A Department of Agriculture Closure Order has kept the Watershed closed to public use since 1932. Direction in the 1987 Forest Plan along with the 1996 administrative closure order reinforce the 1932 order. The project area lies within an inventoried roadless area and is predominantly unroaded. An administrative access road runs through the canyon bottom, from the end of Upper Canyon Road—a narrow and winding residential road—to the wilderness boundary. The steep canyon slopes and lack of access roads within the Watershed, or suitable haul roads outside the Watershed, created a formidable challenge in planning for fuel reduction in this area. Options for disposing of the woody fuels were quite limited.

Partnerships and Public Involvement

The City of Santa Fe was a cooperating agency and partner in the planning of this project. The Mayor and City Councilors toured the project area and met with us on this project, and we worked closely with the City's Sangre de Cristo water department. We also took Santa Fe County Commissioners, State Senators and other government officials to the demonstration sites in the Watershed.

The planning team reached out extensively to solicit input from the public, as well as from scientists with specialized knowledge regarding thinning and burning treatments designed to reduce potential wildfire severity. I felt that by using the best available science, combined with a truly open and collaborative public participation process, I could make an informed decision about how to reduce fuel loads while maintaining the ecological integrity of the natural resources in the Watershed. The analyses for soil, water, and aquatic and terrestrial biota were contracted out to respected experts in those fields. The environmental contractors, together with over 16 resource specialists from the Forest Service, conducted a thorough analysis of the relevant issues and alternatives. They utilized over 200 published scientific research papers, as referenced throughout the EIS. Research scientists from colleges, universities, and research stations were enlisted to advise the project planning team, participate in a community forum, and independently review the Draft EIS.

In our collaborative process, we frequently met with interested agencies and organizations, including Santa Fe Watershed Association, Forest Watch, The Nature Conservancy, Forest Trust, Audubon Society, Sierra Club, Bosque del Rio, the State Environment Department, and many interested citizens. We met with over 15 civic groups and neighborhood associations in Santa Fe including Thousand Friends of New Mexico, Voices of Santa Fe, Network Neighborhood Association, and others. We presented information to the City Council, and they passed a resolution in support of the preferred thinning and burning alternatives. We engaged the public early in the process so citizens could participate in clarifying the problems and developing possible solutions. We created small thin-and-burn demonstration sites in the Watershed, and led monthly public field trips to those sites. We distributed informational brochures, held community meetings, provided an information website, and engaged the media in maintaining the community dialogue regarding this project.

The NEPA process officially began on July 17, 2000 when the Notice of Intent to prepare an EIS was published in the Federal Register. The Notice of Availability for the Draft EIS was published in the Federal Register on April 13, 2001. However, we released the Draft EIS on the internet and to the media in mid-March to allow for some additional public review time. The 45-day public comment period ended on May 29, 2001, and a specialized "content analysis team" systematically compiled, categorized and coded the comments. We then responded in writing to the comments received (see Final EIS Appendix C: Response to Comments).

Public Comments on the Draft EIS

In reviewing public comments, there appeared to be a clear understanding and support for the need to reduce fuel loads and the associated risk of a catastrophic crown fire. There was widespread support for the selected treatment of thinning the small trees, followed by burning the thinning slash and remaining hazardous fuels as necessary. Only a few individuals favored the no action alternative. A few who generally approved of the thinning and burning asked for a more limited approach, while others asked for more extensive and aggressive treatment. Most people gave recommendations about specific environmental protection or monitoring measures they would like to see included with the project. I found the vast majority of these suggestions to be consistent with the features described for the selected alternatives, such as using contour felling, retaining the largest trees, leaving some unthinned patches, not clearcutting the fuelbreaks, thinning to variable densities, restoring historic low-intensity fire regimes, staying out of the riparian zone, implementing in stages, and using monitoring results to adjust treatments over time. In general, there were only a few points of debate or concern over specific treatment methods or components, such as concerns about the use of feller-buncher machines and creation of fuelbreaks. We also received detailed recommendations about monitoring methods, which were either already in the monitoring plan or will be evaluated by the monitoring committee. Some comments were outside the scope of this fuel reduction project, such as those about recreational access, wilderness designation, and reintroduction of native wildlife species. The largest volume of comments came from east-side residents who favored Option A, expressing strong concerns about wood being hauled down narrow and historic residential roads. Most people were opposed to Option B. Along with the comments I've mentioned in this section, I carefully considered all the public comments before making this project decision. I did not treat them as votes, so the number of form letter copies and petition signatures had little bearing on my decision. I focused instead on the substance of the comments. Please review the public comments and responses in Appendix C.

Purpose and Need

The EIS (pp. 3-5) makes it clear that the primary purpose of the project is to reduce the hazardous fuel loading, consisting of hundreds of small trees per acre, in order to decrease the likelihood of a high-severity

crown fire. It states that this is needed to protect the municipal water supply and restore sustainable watershed conditions. It also states that the secondary purpose is to increase herbaceous ground cover to improve long-term soil stability and vegetative diversity. All of the action alternatives analyzed in the EIS addressed this purpose and need, and I compared each alternative to this purpose and need as a key criteria for my decision.

Issues

"Issues" are the concerns about effects of the proposed actions (EIS pp. 11-13). The following were identified as the significant issues, which were used to develop management alternatives, mitigation measures and monitoring requirements (40 CFR 1500.4g, 1500.5d, 1501.7(2,3), 1502.2b):

- Risk of escaped fire from prescribed burns.
- Risk of smoke impacts from prescribed burns.
- Traffic impacts from wood hauling trucks (accidents, noise, traffic delays, vibration damage to historic homes and properties, and road damage).
- Worker safety hazards and efficiency problems due to steep slopes, loose soil, and lack of road access.

Other issues (concerns) about the proposed treatments were not considered "significant" because the impacts were likely to be negligible once the mitigation and monitoring requirements are applied to minimize potential adverse effects (see EIS Comparison of Alternatives, pp. 33-40). Thus, the following issues were used to design specific mitigation and monitoring measures listed in this document, but they did not play a major role in the decision making process: insect infestations from slash piles; increases in soil erosion or stream sedimentation; reduction in soil productivity under burned slash piles; increases in the spread of invasive plants; reduction in shading near the river causing elevated stream temperatures; noise disturbance to wildlife species; reduction in closed canopies or other habitat features causing impacts to wildlife species; and damage to archaeological sites from thinning or burning.

Selected Alternatives C1 and D1

Thinning and Slash Disposal

The selected manual and machine thinning alternatives (C1 and D1 respectively) involve first cutting down the smallest trees from the slopes that are feasible to thin (not too steep), within a selected portion of the project area. The thinning will create a tremendous volume of slash. Hauling the slash out of the Watershed is not a viable option for most of this project area due to the steep slopes and lack of road access. Other slash disposal methods, such as chipping and spreading the chips, were also determined to be impractical or unfeasible (EIS pp.155-161). Thus, these alternatives involve piling or scattering the hazardous slash (woody stems and branches less than 6-inch diameter), and later burning the slash under appropriate weather and fuel conditions (EIS pp. 16, 53). After treatment, an average of 50-100 of the largest trees per acre will be left standing and the cut tree stems over 5-6 inch diameter, which are not considered hazardous fuels, will remain on the ground. These contour-felled down logs will aid in controlling erosion and runoff, and improve nutrient cycling, vegetative productivity and habitat diversity (EIS p. 53, 97).

In the first year, one portion of the project area will be thinned and slash piled manually by crews with chain saws, and another portion of the project area will be thinned with feller-buncher machines that cut the trees and then lay them on the ground. The relative safety, effectiveness and environmental effects of these two thinning methods will be monitored and evaluated prior to determining whether or not to continue using one or both of these methods in subsequent years. After the slash is burned, in piles or as scattered slash, monitoring results will again be used to compare any obvious differences between the various thinning and slash burning methods.

Riparian areas will not be thinned, and it is likely that several unthinned and unburned patches will remain after the entire Watershed has been treated. If surrounded by treated areas, untreated patches should not pose a significant fire threat to the Watershed.

Fuel Breaks

Fuelbreaks are considered a high priority component of the selected alternatives, particularly the fuel break on the southern ridge line. Some people expressed concerns about the width, number of trees to be cut, or potential impacts to soils, wildlife, or firefighter safety.

However, based on the scientific research and analysis in the EIS, and the type of "shaded" fuelbreaks proposed for this project, I firmly believe they are essential in meeting objectives for this area. Also, see the EIS Appendix C: Response to Comments, Comments 24-29.

The main points that I considered in approving the fuelbreaks are as follows, based on the EIS and EIS Appendix C. Fuelbreaks will primarily consist of narrow areas along some of the ridges in the project area where the trees will be thinned to a lower density than on the side slopes. The shaded fuelbreaks prescribed for the Watershed will not look like clearcuts or fragment wildlife habitat, as some people feared. They will contain approximately 20-30 of the largest trees per acre, along with grasses, forbs, shrubs and down logs. This post-treatment tree density will be within the historic range of variability for ponderosa pine forest ecosystems in the Southwest, particularly on ridges that tend to have fewer trees than the drainages. Ground vegetation is expected to increase—not be reduced—within these fuelbreaks, due to the increase in sunlight reaching the forest floor. Windthrow does not tend to occur in ponderosa pine fuelbreaks. Fuelbreaks have proven to be very effective in slowing down or stopping a running crown fire. They provide a safe area for fire suppression personnel and helicopters, and a good containment boundary for prescribed burns. Shaded fuelbreaks applied in New Mexico have not been found to cause detrimental impacts to soil or wildlife. The primary fuelbreak and highest priority for treatment in the Watershed is along the southern ridge, due to the topography, fuels, human activity areas along the perimeter (ignition sources), and prevailing southwesterly winds.

Broadcast Burning

Research studies and field experience have shown that low intensity broadcast burns can be used to effectively reduce surface and ladder fuels, and promote growth of ground vegetation (EIS pp. 53-54). However, broadcast burning poses a risk of an escaped fire outside the burn unit, and may create short-term smoke impacts down canyon from the project area. I take these issues quite seriously, and I asked the planning team to analyze alternatives that do not include broadcast burning. However, these alternatives (B2, C2, D2) were found to be substantially less effective in meeting fuel reduction objectives. Thus, to minimize the risks of escaped fire and smoke accumulations, numerous mitigation and monitoring requirements will be employed and strictly enforced (see those listed in this document).

Results from monitoring will be used to determine what modifications, if any, to make in the burn prescriptions, and whether any of the remaining unthinned patches should be broadcast burned in order to meet fuel reduction objectives. Unthinned patches will not be burned unless completely surrounded by pre-treated areas and other fuel breaks such as a road, river, or rock cliff. Portions of thinned and unthinned areas may be burned together if that improves our ability to control the burn and meet objectives. We will not conduct burns in the Watershed if there are any uncertainties about the appropriateness of the weather and fuel conditions, and the availability of qualified personnel and contingency resources.

Reasons for My Selection of Alternatives C1/D1

The treatments described in Alternatives C1 and D1 (EIS pp. 22-25) have been consistently demonstrated to be very effective in reducing fuel volumes and breaking up fuel continuity, thereby limiting the ability of a surface ignition to become a raging crown fire (EIS pp. 43-56). The more acres treated with these thinning and slash disposal actions, the lower the risk of a crown fire (EIS p. 55). Therefore, Alternatives C1 and D1 best meet the purpose and need for this project compared to other alternatives, by mechanically thinning the most acres, burning the slash residues, and allowing for low intensity surface burns where necessary to meet fuel reduction objectives (EIS pp. 43-56). By allowing for periodic, low intensity surface broadcast burns in this fire-adapted ponderosa pine ecosystem, we also improve our ability to establish herbaceous vegetation, stabilize the soil, encourage nutrient cycling and enhance habitat diversity.

Some people expressed concerns about the use of feller-buncher thinning machines (Alternative D1). They are concerned that this alternative may eliminate job opportunities for locals, and that the machines may cause excessive soil erosion, runoff, or other undesirable impacts. I understand the concerns expressed, however, I would like to allow for both manual and machine thinning to be done in the beginning under a short-term contract, so we can monitor and compare each method and determine which method(s) should continue to be used in this area. Machine thinning offers the most expeditious way to thin a large landscape area, thereby minimizing the chance of experiencing a severe fire prior to completing fuel reduction treatments. A feller-buncher operator can do as much thinning work in a day as 8 men with chain saws. It is also shown to

provide for better worker safety compared to manual thinning crews, particularly in steep roadless areas. Feller-bunchers are used on similar projects throughout the West including New Mexico, with good results and safety records. While it is true that forestry businesses in New Mexico do not currently own these machines, this situation may change as it has in other western states. We cannot guarantee that a manual or machine thinning contract will be awarded to an in state business, due to Federal contracting regulations. It is our goal to provide local employment opportunities whenever possible, and the numerous thinning projects we are offering throughout the forest should provide plenty of job opportunities for qualified local thinning crews.

To avoid impacts due to operator negligence, all thinning contracts will have strict provisions governing conduct, specifications and penalties for non-compliance. The machines may not drag the logs, and may often operate on frozen or snow-covered ground, which minimizes soil disturbance. The machines will disturb the soil to some degree, but studies reveal that they would not be expected to cause excessive compaction, erosion or reductions in long-term soil productivity (Final EIS, Appendix C, Comment 25). Noise from feller-bunchers is equal to or less than that from manual crews with chain saws. Scientific research, combined with field observations of feller-bunchers conducting thinning operations, and the determinations made in the EIS by the soil scientists, hydrologists, wildlife biologists and others who analyzed the potential impacts from the feller-bunchers, all indicate that these machines should not incur any significant adverse effects (See Final EIS Appendix C: Response to Comments, Comments 25-29, and EIS pp. 25, 33-37, 72, 78, 86, 97, 104, 112).

I weighed the advantages of Alternative D1 with the disadvantages, such as the fact that more smoke (smoldering time) is expected from burning the bundles of whole trees compared to burning scattered or piled slash (EIS p. 112), and the fact that we currently don't have thinning machine operators in New Mexico. After careful consideration, I decided that it is important to have the flexibility to use the machines to meet fuel reduction objectives as needed, and to be able to compare the actual effects of the two methods with effects predicted in the EIS.

The use of manual and machine thinning in Alternatives C1 and D1 provide for the greatest control over forest stand densities. These alternatives allow us to create a variable density mosaic that mimics natural fire disturbance patterns in ponderosa pine forests. Forest structure will shift from being dominated by

trees less than 12 inches in diameter, to one dominated by trees greater than 12 inches in diameter, resembling a more mature pine forest. The analysis in the EIS indicated that implementing these alternatives would be expected to have these additional benefits: improve nutrient cycling and nutrient availability thereby enhancing long-term soil productivity; increase coverage and diversity of ground vegetation thereby increasing soil stability and habitat diversity; enhance tree growth and vigor by reducing competition; reduce susceptibility to insects and disease; increase the abundance of down logs that provide moist microclimates for establishment of herbaceous vegetation; increase the structural diversity of the forest; promote mature forest characteristics that improve habitat for special status indicator species like goshawks; increase aspen regeneration that further enhances habitat diversity and resistance to wildfires, and other benefits. See EIS pp. 52-55, 69-72, 86, 96-97, 104-105 for details. The only unavoidable adverse effects anticipated to occur from implementation of these alternatives are temporary increases in noise disturbance, short-term smoke effects, and minor short-term increases in soil erosion and stream sedimentation (EIS p. 135).

The other management alternatives did not meet the project's purpose and need as well as Alternatives C1 and D1, for the following reasons:

Alternative B1: This alternative treats most of the project area with prescribed fire rather than manual or machine thinning, in order to complete the treatments in the shortest amount of time and with the least risk to worker safety. However, research and experience have shown that thinning with prescribed burns is not nearly as effective as mechanical thinning (with saws) in controlling the density of forest fuels. In addition, this alternative would have the highest risk of an escape fire and result in more days of nuisance smoke compared to other alternatives.

Alternative B2: This alternative excludes the use of prescribed broadcast burns to address the key issues of escape fire and smoke, and limits mechanical thinning to gentle slopes near the existing road to address the key issue of worker safety. This alternative does not treat enough acres to fully meet fuel management objectives, and was determined to be the least effective of the six action alternatives analyzed.

Alternatives C2 (manual thin) and D2 (machine thin): These alternatives also exclude the use of prescribed broadcast burns in order to address the key issues of escape fire and smoke, while mechanically thinning as many acres as possible in the project area. If I selected either or both of these alternatives, I forego

the option of using prescribed broadcast burns in this area as a tool to further reduce fuel loads, which could result in leaving unacceptable fuel loads that continue to create a crown fire risk. Alternatives that don't allow for low intensity surface burns are also less effective in establishing ground vegetation and improving soil qualities and habitat diversity.

I understand the public concerns and risks associated with conducting a prescribed burn in this Watershed adjacent to the City of Santa Fe. I do not discount the fact that prescribed burning in the Watershed is likely to create some undesirable smoke impacts for some people during the mornings following a burn day, and there is always a risk that a spot fire could potentially occur outside the defined burn unit. However, I had to weigh these potential risks against the high probability of a large uncontrolled wildfire that would create heavy, long lasting smoke accumulations and devastating impacts to the community and water supply (see EIS pp. 48-56, 109-112).

Summary of Rationale for C1/D1

In summary, I selected Alternatives C1 and D1 because I feel it is important to have some flexibility over the next 5 to 8 years to use either manual or machine thinning methods, based on the results from monitoring these methods in selected portions of the project area. I also believe it is critical to reduce the volume of thinning created slash through carefully planned and implemented burns, and to allow for the option of using low intensity surface burns where needed to further reduce forest fuels and encourage growth of ground vegetation. Based on the analysis described in the EIS, Alternatives C1 and D1, together with the comprehensive mitigation and monitoring requirements listed in this document, will provide the most effective fuel reduction methods to reduce the risk of a catastrophic fire and will incur minimal risk of any significant adverse environmental impacts.

Based on all the reasons stated for selecting Alternatives C1/D1 (with Option A) for implementation, I also consider these alternatives to be the "environmentally preferred alternatives" for this project (identified in accordance with 40 CFR 1505.2 (b)). Even though other alternatives are perhaps lighter on the land because they thin or burn fewer acres or do not use a machine to thin the trees, Alternatives C1/D1 will be the most effective in reducing the risk of experiencing a catastrophic fire in the project area. The analysis in the EIS shows that the greatest potential for environmental harm is from the no action alternative, and secondly from alternatives that are not as effective in reducing

hazardous fuels, due to the high probability of experiencing severe crown fires in this area. Options A and B each affect less than 2 percent of the project area, so they had no real bearing on my selection of the environmentally preferred alternative. The next sections describe my reasons for selecting Option A and not selecting Option B.

Selected Option A: No Roadside Wood Removal

The proposed action that generated the most public comment and concern was the removal of wood from the Watershed through the east-side neighborhoods of Santa Fe. The planning team originally estimated that 560 acres of the 7,270-acre project area were accessible to the service road, including both City and National Forest lands. Many people said they would like to see the wood put to a beneficial public use. Hence, we originally proposed removing the small wood products from those roadside acres in order to provide firewood and local jobs, rather than leaving all the logs on site. When the public voiced concerns about the potential impacts of hauling wood through their narrow residential roads and historic neighborhoods, the planning team identified this as a key issue and developed Option A-No Roadside Wood Removal to avoid the potential impacts (EIS pp. 12, 26 and 119-120).

Upon further field reconnaissance, we have determined that substantially less ground is feasible for wood removal. Of the 300-350 acres originally estimated for removal from City lands in the Watershed, it appears there are only approximately 50 roadside acres realistically available. The City's contractor is proceeding with removing woody fuels less than 6-inch diameter from those 50 acres. We currently estimate that there are only 50-120 acres on national forest land in the Watershed that may be feasible for wood removal (about 2 percent of the project area). The size and species of the wood to be thinned is of low value relative to other small wood products sold in Santa Fe (see Appendix C, Comment 43, "cost versus value"). In addition, we expect fuel reduction thinning in roaded portions of the national forest outside the Watershed will yield at least 10,000-15,000 cords of firewood annually, in addition to a million board feet of other small products.

I reviewed many letters of concern about hauling out the wood. There is an increased risk of traffic accidents associated with adding haul trucks to such narrow, low-standard roads that are used by pedestrians, school children, bicyclists, tourists, and commuters who live, work and recreate on these roads. There are no side-

walks or crosswalks, and there is a day care center and at least 3 schools along these roads. The potential hazards along Upper Canyon and adjacent roads are greater than those on most national forest haul routes. The Historic Santa Fe Foundation and others expressed major concerns about possible vibration damage from haul trucks to historic structures listed on national and state registers of historic places, as well as to old adobe homes along the road. According to our informal traffic counts and additional information from residents, residents are already experiencing traffic delays, road damage, safety hazards and other problems associated with current traffic loads relative to the design of the road. Upper Canyon Road is heavily used by residents, tourists, visitors to the Audubon Center, water treatment plant employees, as well as Forest Service and City employees, and others who work in the Watershed. Thus, I must consider the cumulative effects of incrementally adding to the truck traffic on these roads.

At this time, I do not believe it is prudent or necessary to approve additional wood removal from the minor acreage of accessible national forest land in this project area. This decision is based on considering: (a) public concerns and potential impacts associated with adding to the truck traffic in this area; (b) the small volume of low-quality wood products that could come from this area; (c) the large amount of wood products anticipated from roaded areas on the forest; (d) the 1-2 days of extra slash burning that may be needed if we leave the cut wood on these acres; and (e) leaving the logs and burning the slash on these acres rather than hauling the material out will not reduce our ability to meet fuel reduction objectives.

Non-Selected Option B: Thin the Larger Conifers on 100 Acres

This option was developed to address the project's purpose and need, in light of the fact that some very dense patches of conifers exist in the canyon bottom. I fully considered the tradeoffs involved in this option that involves thinning the larger trees (up to 24-inch diameter) on 100 acres scattered in small patches across the canyon bottom. The conifers are larger in the canyon bottom near the river due to the higher site productivity there compared to the side slopes. In order to open up these dense conifer patches such that they would discourage crown fire activity, numerous trees both large and small would need to be cut and the slash burned.

The EIS described the advantages of implementing this option, such as reducing the potential for severe crown

fire effects and enhancing re-establishment of soil stabilizing herbaceous vegetation by creating openings in the canopy (EIS pp. 51, 78). However, most of those who commented on the EIS expressed concerns with this option, and forest ecologists consulted believed that the disadvantages of cutting down these large trees outweighed the potential fuel reduction advantages. Trees over 16-inch diameter are a very rare habitat component in this area (EIS, pp. 86, 98). In addition, the planning team had some concerns about having exceptionally large volumes of down logs left in areas where wood removal is not feasible. Therefore, after considering the various tradeoffs expressed and considering the small acreage affected by this option, I decided not to select Option B.

Alternatives Considered and Eliminated From Detailed Study

Many alternatives were considered and eliminated from detailed study. Public comments received on the EIS asked that we reconsider the following alternatives that were described and eliminated in the Draft EIS: using horses or mules; chipping the slash; building new roads; using goats to reduce fuels, and the Forest Conservation Council alternative to limit thinning to trees 6-inch diameter or less along with prescribed burning. I reconsidered these alternatives and still believe the reasons previously described for their elimination are valid and well supported by scientific analysis, so there is no reason to analyze them any further. Please refer to the rationale for their dismissal in the EIS (pp. 155-162) and in Appendix C: Response to Comments (Comments 11-18).

Mitigation and Monitoring Requirements

I have selected all of the mitigation measures described in the EIS (pp. 27-32) and the monitoring requirements described in the EIS Appendix B, as summarized in this section, to be implemented as part of the selected alternatives. By incorporating these requirements with the design features of the treatment alternatives (from EIS pp. 15-19), I believe that all practical means to avoid or minimize environmental harm have been adopted. Monitoring items summarized in this section are identified with an asterisk (*). Monitoring provides a quality control and adaptive management strategy. By monitoring and evaluating the effects of treatments, we can make appropriate modifications, assess resource trends and apply new knowledge to future projects.

Prescribed Burning and Risk of Escape Fire

- Keep the size of slash piles generally less than 6 to 8 feet in diameter by 5 to 6 feet high.
- Burn slash piles during times of cool temperatures and high humidity when the fuels surrounding the piles have high fuel moisture.
- Avoid having tightly compacted piles in order to increase ventilation, combustion and fuel consumption. During the burning, tend the piles to assure that larger pieces of fuel are consumed.
- Consider covering the piles with plastic when they are built, to keep the piles dry for later burning.
- Develop detailed broadcast burn plans, and conduct broadcast burning only in accordance with those plans. Several Forest Service officials will review the burn plans. Burn methods must be those proven safe and effective, and be modeled using a fire behavior computer model to validate they will meet burn objectives with minimum risk of fire escape.
- Design burn units to reduce the risk of escape, based on size of unit, accessibility, topography, fuel type, fuel load, weather, time of year, etc.
- Ensure the perimeter of each broadcast burn unit is surrounded by existing openings such as reservoirs, streams, roads, or trails, or treated areas where fuels have been reduced. Firelines may be built around the burn unit by clearing the fuels to mineral soil with hand tools.
- Locate fuel breaks where they will be most effective in controlling the burns, such as along ridges, drainages or other topographic breaks, taking into consideration fuel type and fuel loading.
- Prior to burning, complete the "go/no go" checklist, risk assessments and daily review checklists in the burn plans.
- Prior to ignition, ensure that there are adequate fire engines and water tanker trucks on site and contingency suppression resources available, as indicated in the site-specific burn plan. Do not ignite broadcast burns when the Southwest Area's "preparedness level" is at III or higher. This indicates that contingency resources may not be available due to other fire activity in the Southwest.
- For some of the more complex broadcast burn units, consider having a helicopter with water dropping capability, and/or an air tanker available on standby. Also consider laying down fire (water) hose around the perimeter of the broadcast burn unit and having portable water tanks and pumps in place prior to ignition.
- Ensure that fire personnel implementing broadcast burns have the appropriate knowledge, skills and qualifications for a complex-rated burn. Personnel conducting the broadcast burns should also be qualified for fire suppression positions as a contingency in the event of an escape fire situation.
- Plan for and locate burn implementation personnel in safe and strategic areas for monitoring and containing the broadcast burn.
- Exclude certain areas from the broadcast burn unit where because of stand density or topography, there would be a risk of high intensity fire behavior and escaped fire.
- After the flames from the broadcast burn have subsided, mop-up (extinguish) any hazardous heat concentrations along or adjacent to the fireline that could threaten to cross the line.
- * Prior to ignition and during the burn, monitor the current and 3 to 10-day weather forecasts from the National Weather Service Fire Weather Forecaster in Albuquerque, NM, plus daily spot weather forecasts, for trends in temperature, relative humidity, wind, frontal passages, etc.
- * Prior to ignition, monitor (via computers) the forest's 5-day energy release component (ERC) from the forest's weather stations. The ERC is related to energy or heat that will be released in a fire. The ERC is an indicator of the relative dryness of the fuel, which dictates how hot a fire will burn. Do not broadcast burn when the ERC is above 65.

All large wildfires on the forest have occurred when the ERC has been above 68.

- * Prior to ignition and throughout burn implementation, monitor and record fuel moistures. Do not broadcast burn when live fuel moistures are below 100 percent. Do not broadcast burn complex burn units when the Palmer Drought Index (PDI) indicates a moderate or higher drought index. This will reduce the likelihood of an escape fire and lessen the chance of killing desired trees.
- * During prescribed burns, monitor and record the observed fire behavior, and compare it with predicted fire behavior in the burn plan. Evaluate the results to modify future burn plans and burns. Patrol the area during the burn to ensure that the fire stays within the burn unit. Monitor daily until the burn has been declared out. Have an aerial observer over the area when broadcast burning the complex units. If a fire should spread outside the burn unit, all ignitions will cease until the spot fire is controlled. The prescribed fire burn boss will decide if the burn should continue based upon prescription criteria and observed fire behavior.
- * After implementation, monitor the reduction in live fuel loads, including changes in canopy structure and ladder fuels, and compare with project objectives.

Air Quality

- Avoid broadcast burning on days when mixing heights are less than 1,641 feet and transport winds are less than 4 mph, in order to get the best lifting and dispersion of smoke. This should allow for burning to occur during periods of sufficient atmospheric instability, but not during instability, to improve smoke dispersal.
- Plan activities so that air quality will meet applicable Federal, state and local regulations, including protection of Class 1 air sheds such as the Pecos Wilderness (described in air quality section of EIS) (Forest Plan, page 80).
- The amount of soil in piles and windrows will be minimized to reduce smoldering.

- Notify the local agencies and the public through radio, TV, newspapers, and/or personal contacts at least a week in advance of the broadcast burns as well as a day before the burn.
- Obtain a burn permit from the State Environment Department at least a month before ignition as outlined in the New Mexico Smoke Management Memorandum of Understanding.
- Continue to provide educational materials on the benefits and tradeoffs of prescribed burning, including signs along Hyde Park Road, contacts in campgrounds, and so on. Include educational information in firewood permits on correctly storing and burning firewood to minimize smoke.
- * Monitor particulate matter from smoke. As a minimum, set up a particulate matter monitor device along Upper Canyon Road to record particulate levels of smoke that may drift down canyon into the city during the evening or morning hours after burning. If particulate matter approaches the National Ambient Air Quality Standards, take corrective measures to reduce smoke and notify the New Mexico Environment Department Air Quality Bureau.
- * Conduct visual monitoring continuously through the burn periods. Behavior of the smoke plume will be monitored as well as visibility conditions along all major roads in the area of the burn. If smoke becomes a serious problem, stop ignition or initiate fire suppression to reduce the generation of smoke. If smoke starts to settle and limit motorist visibility along Hyde Park Road, Canyon Road, U.S. Highway 84/285, or other major travel ways, take immediate measures to alert motorists of the danger, contact the appropriate state or local traffic control agencies, and close roads where necessary to avoid traffic accidents.

Soil and Water

- Directionally fell "contour logs" on steep slopes as soil erosion barriers.
- Do not exceed low to moderate fire intensity during broadcast burning (flame height of 1 to 4 feet) to help maintain soil productivity,

minimize erosion, and prevent detrimental amounts of ash, sediment, nutrients, and debris from entering water bodies (consistent with features common to all action alternatives).

- Prohibit vehicle use of roads or trails in the Watershed during periods of wet weather unless the roads have a stable surface and sufficient drainage to prevent undesirable erosion or sediment runoff impacts.
- If fire suppression becomes necessary, do not allow any fire retardant drops within 400 feet of surface water (Santa Fe River or reservoirs), to minimize risk of contaminating the water supply.
- *Before prescribed burning, monitor soil moisture levels. Soil moisture levels should be at least 11-15 percent to maintain long-term soil productivity and improve the chance for vegetative response after burning.
- * Monitor the change in soil erosion (movement) to ensure it is within acceptable limits. If soil erosion exceeds standards, take corrective action and modify treatments as needed. (Forest Plan, pages 76 and 80).
- * After two full growing seasons following a thinning and burning treatment, measure the amount of vegetative ground cover. Apply native grass seeds (or plantings) where determined necessary by the forest soil scientist to re-vegetate specific bare soil areas for erosion and sediment (runoff) control, such as where ground vegetation is less than 10-20 percent coverage. A realistic goal for the granitic soils in this area is to achieve 30-50 percent ground cover.
- *After the first growing season following slash pile burning, monitor soil impacts by having a soil scientist check the soil under the piles. Where necessary and feasible, rake, till, and seed areas under burned slash piles to promote vegetative response.
- * Monitor water quality in key locations to aid in identifying and correcting any problems and to ensure that water quality will continue to meet drinking water standards (Forest Plan, page 80). Monitor sediment, turbidity and total suspended solids, as well as water chemistry parameters.

- * Monitor changes in peak flows before and after thinning, as well as subsequent changes in stream morphology, to determine whether treatments are causing any detrimental affects to the stream channel.

Riparian Ecosystems and Aquatic Habitat

- Do not pile slash within 15 feet of perennial streams (Santa Fe River) to reduce the chance of ash entering the water following slash burning.
- Avoid piling slash in or adjacent to patches of young cottonwoods in the riparian corridors to protect them from mortality during burning.
- Manage riparian areas in accordance with legal requirements regarding floodplains and wetlands; protect the productivity and diversity of riparian-dependent species, emphasizing protection of soil, water, vegetation, wildlife, and fish resources. Manage in accordance with Forest Plan guidelines regarding ground cover, shade, bank cover, streambed sedimentation, plant composition, plant structure, and crown cover (Forest Plan, pages 79-80).
- Do not conduct thinning activities within the riparian area or within 15 feet of the riparian area (riparian is defined in the section on Aquatic Habitat).
- Locate log landing areas outside sensitive areas including riparian areas, wetlands and wet meadows, and special status species habitat (Forest Plan, page 73). Once landings are no longer needed, rip and re-vegetate landing sites as needed to recover site productivity (Forest Plan, page 78).
- Directionally fell trees away from all stream channels to help reduce slash accumulations within drainage bottoms and to avoid the need to turn trees around in or near riparian corridors. (Forest Plan, page 78)
- Retain all willow, alder, and cottonwood trees in riparian areas. This is consistent with features common to all alternatives.

- * Monitor changes in fish habitat before and after implementation, including changes in aquatic insects, to ensure that thinning and burning activities do not adversely affect aquatic habitat or fish.
- * Monitor for increases in stream temperature following any thinning in the canyon bottom near the riparian area which could degrade aquatic habitat.
- * Monitor changes in the number of active beaver dams before and after treatment to ensure that treatment activities are not having adverse affects on the existing beaver population.

Terrestrial Habitat and Associated Wildlife

- If any proposed, threatened, endangered, or sensitive plant or animal species are discovered during project implementation, stop work in the immediate vicinity of the species until a Forest Service wildlife biologist or plant ecologist has investigated and recommended the appropriate protective measures. These measures may include restricted operating periods, no-activity zones, protection or creation of snags, or other measures.
- If a northern goshawk nest is found, stop work within 30 acres of the nest site. Do not conduct broadcast burning during May or June within the nest area to avoid the potential for crown fire or smoke to drive the birds off or consume the nest tree (Forest Plan, Appendix D, pg. 10).
- Apply other standards/guidelines for potential northern goshawk habitat, as detailed in Forest Plan, Appendix D, pages 6-10, including the following features common to the design of all action alternatives: retain large snags and down logs wherever possible; retain old age trees and the mature/old forest structure; sustain a mosaic of vegetation densities, age classes and species composition across the landscape; increase herbaceous vegetation to provide for goshawk prey species and to maintain satisfactory soil conditions; use R3 protocol to survey for goshawks (surveys were completed and no goshawks found); have variable canopy coverage (averaging about 40 percent) with openings up to 4 acres each while retaining at least two small groups of trees per acre with minimum 12-inch diameters.
- Avoid cutting trees containing a squirrel nest or having large piles of cones at the base of the tree, as well as any adjacent tree with a crown interlocking the nest tree and a diameter equal to or greater than the nest tree.
- Retain (do not cut) at least 15 percent of the mature and older mast-producing stands in pinyon/juniper and oak zones (Forest Plan, page 65).
- Within one-quarter mile of perennial water (Santa Fe River) do not burn two slash piles per acre so they may be used as potential nest cover for wild turkey. These piles should be at least 3-feet high by 10-feet wide (Forest Plan, page 65).
- Retain all sound snags, except within fuel breaks and 100 to 300 feet from the edge of fuel breaks if the snag may pose a hazard during broadcast burning. Retain at least 220 snags or potential snags per 100 acres where consistent with fuel management objectives. Particular attention will be given to retaining trees with dead or broken tops, heart rot, and lightning scars, in order to maintain and promote habitat for cavity nesting or roosting species (Forest Plan, page 72).
- Retain trees over 20-inch diameter within 200 feet of major ridges, cliffs, and openings (except snags that must be cut for fuel breaks), to provide perch and roost trees for raptors. This requirement is consistent with features common to all action alternatives (Forest Plan, page 66).
- Retain at least five large down logs per acre where consistent with fuel loading objectives. The desired goal is to have logs at least 11 inches in diameter and 15 feet long, in various stages of decomposition (Forest Plan, page 62).
- When cutting trees over 12-inch diameter, leave two or three of the stumps per acre at a height of 12 inches above the ground to

serve as plucking posts for raptors and feeding and "lookout stations" for small rodents.

- Wherever possible without sacrificing fuel reduction objectives, retain two thickets of small trees per acre for cover and foraging areas for flammulated owls and neotropical migratory birds.
- Expand aspen stands where possible by reducing the amount of shading and competition from conifers, and using prescribed burns to stimulate sprouting of aspen (Forest Plan, page 74). This measure is consistent with features common to all action alternatives.
- Retain (do not cut) oaks (*Quercus gameli*) and shrubs, such as wild rose (*Rosa* spp.), mountain mahogany (*Cercocarpus montanus*), Rocky mountain maple (*Acer glabrum*), currants (*Ribes* spp.), and raspberry (*Rubus* spp.).
- * Monitor the effects of treatment on wildlife habitat, recording changes in the following key habitat components: overstory tree composition, structure and density; and retention of existing large snags and hardwood trees.
- * Monitor for changes in populations of breeding birds and small mammals.
- * Monitor for increases in invasive plants where soil is disturbed by management activities. Take corrective action as indicated by monitoring results.

Heritage Resources

- Survey for and mark heritage resource sites according to specifications provided in FSM 2309.24 and FSH 2361.28.
- Avoid all known (marked) heritage resource sites during tree thinning, firewood collecting, constructing firelines, maintaining and improving roads, and other land disturbing activities associated with the project.
- Avoid burning perishable remains on heritage resource sites, and protect heritage resources having exposed burnable materials, through one or more of the following methods (determined by a Forest Service archaeologist): digging or burning firelines around the site; clearing fuels away from the

site; directing the fire away from the site; foaming and/or covering wooden structures with a fire shelter; or other protective measures. Exclude burning entirely from sites if protective measures cannot be effectively applied.

- Directionally fell trees away from known (marked) heritage resource sites.
- Do not build slash piles in or near heritage resource site boundaries.
- If previously undocumented heritage resource sites are discovered during project activities, stop all work in the immediate vicinity of the site and do not restart until authorized by a Forest Service archaeologist.
- If it is not possible to avoid or protect heritage resource sites during thinning or burning operations, or if mitigation measures prove unsuccessful, then data recovery may be conducted.
- If Native American tribes or other traditional communities express concerns about traditional use areas that may be affected by management activities, mitigation may include avoidance of those areas during operations, or other measures determined through consultation with the affected tribe or community.
- * Monitor to determine if any heritage resource sites were damaged during thinning or burning operations. If any site has been damaged, a Forest Service archaeologist will determine the appropriate corrective actions to take to minimize the risk in the future. If damage to a heritage resource site is discovered during project implementation, stop all work within the immediate vicinity of the site, evaluate the damage and determine what corrective measures are needed. Do not resume work until authorized by a Forest Service archaeologist.

Permits and Agency Approvals Required

The EIS (p. 13) lists four permits or authorizations that must be obtained prior to implementing the project. One has already been obtained—the consultation and

concurrence from U.S. Fish and Wildlife Service on the Biological Assessment. The remaining three are hereby incorporated by reference into this Record of Decision.

Findings Required By Other Laws

The planning and decision making process for this project was conducted in accordance with all applicable laws, regulations, policies and plans. This section briefly describes my findings regarding the legal requirements most relevant to this project decision.

National Environmental Policy Act (NEPA) and 40 CFR 1500 Regulations

I find that the planning and decision making process for this project was conducted in accordance with the requirements in NEPA and its implementing regulations, based on the contents of the EIS and supporting documents in the project record.

One person who commented on the Draft EIS was concerned that it did not adequately analyze the impacts of all alternatives, including the no action alternative. However, in reviewing the EIS I found nearly 100 pages that clearly describe the direct, indirect and cumulative impacts of each alternative including the no action alternative (EIS Chapter 3, including 11 separate sections devoted to cumulative effects). The interdisciplinary team analyzed two no action alternatives: one that assumes no change from status quo conditions (as a baseline) and one that assumes a high-severity wildfire would occur, based on the calculated 99 percent probability for such a fire within the next 20 years (see Appendix C, Comments 1 & 19).

National Forest Management Act (NFMA) and 36 CFR 219 Regulations

I find that the selected alternatives are consistent with the 1987 Santa Fe National Forest Plan, as amended, which sets forth programmatic direction in accordance with NFMA. This is based on the following factors:

- The descriptions in the EIS of selected alternatives and mitigation measures (pp. 15-32), as well as descriptions of environmental consequences (EIS Chapter 3) are clearly consistent with the Forest Plan goals described for wildlife and fish, cultural resources, soil and water, and riparian (Forest Plan pp. 19-20).

- The Forest Plan's forest-wide standards and guidelines were incorporated by reference on pages 5 and 10 of the EIS, and used to develop the alternatives to ensure Plan consistency (EIS p. 15).
- The mitigation measures for the selected alternatives include and reference the applicable forest-wide standards and guidelines, in order to help ensure compliance with the Forest Plan.
- The EIS describes project conformance with Forest Plan direction for management area "O", as amended in 1996, which applies to the Santa Fe Municipal Watershed (Forest Plan pages 155-156). The management area emphasis is "water quality production," and the primary purpose for this project is to "...protect the municipal water supply and restore sustainable watershed conditions" (EIS p.5). Forest Plan management area direction specifically states that prescribed fire may be used to reduce fuels. Management area direction does not prohibit thinning, nor does it address thinning specifically, which means thinning is an allowable use in this management area. Thinning is specifically allowed by forest-wide direction that states "use pre-commercial thinning to control stocking that will meet management objectives as identified in management areas and in stand specific prescriptions" (Forest Plan p. 71). The project does not involve regulated or commercial timber production and is, therefore, consistent with the management area designation of "non-suitable timber lands."
- By not building roads in this area, this project is consistent with the Forest Plan and with the agency's 2001 Roadless Area Conservation Strategy for inventoried roadless areas.
- The EIS Appendix C: Response to Comments, Comments 6-8, also discloses information regarding consistency with specific Forest Plan requirements.

I also find that the selected alternatives comply with the seven management requirements in 36 CFR 219.27(b) regarding vegetation manipulation, because the project:

1. Is best suited to the multiple-use goals established for the area considering the various

physical, biological, social, economic and other impacts as stated in the regional guide and Forest Plan. The thinning and burning features and methods have been used successfully in the past, and effects predicted in the EIS are consistent with forest plan goals, as previously described.

2. "Assures adequate restocking...". This provision is not applicable to this type of fuel reduction thinning project. Restocking requirements apply to regeneration harvest treatments.
3. Is not chosen primarily because it will give the greatest dollar return or the greatest output of timber. This project is not expected to generate revenues or timber outputs. It is expected to cost \$3-4 million to implement (EIS p. 124). This is less than the predicted cost of the no action alternative that presumes a large crown fire would very likely devastate the Watershed and result in costs exceeding \$150 million.
4. Is chosen after considering potential effects on residual trees and adjacent stands. The EIS describes the post-treatment effects on residual trees and adjacent stands as a beneficial effect because it leaves all the key components of the ecosystem, including the largest trees, snags, down logs, and shrubs, in a more variable density distribution over the landscape that mimics natural fire disturbance patterns in ponderosa pine forests.
5. Avoids permanent impairment of site productivity and ensures conservation of soil and water resources. The EIS provides ample evidence that long-term site productivity will be maintained, and soil and water resources will not be adversely impacted by the selected alternatives (pp. 73-75, 135).
6. Provides the desired effects on water quantity and quality, wildlife and fish habitat, regeneration of desired tree species, forage production, recreation uses, aesthetic values, and other resource yields. The EIS (Chapter 3) describes how the action alternatives are expected to have desired effects on all of these resources.
7. "Is practical in terms of transportation and harvesting requirements...." This is not applicable to this project, as there will be no harvesting or transportation of wood products from national forest lands in this project.

National Historic Preservation Act (NHPA) and 36 CFR 800 Regulations

I find that this project is consistent with the requirements of Section 106 of the National Historic Preservation Act, based on the following factors:

- Prior to implementation in any given portion of the project area, the forest will complete the process required by Section 106 of the National Historic Preservation Act in accordance with the Programmatic Agreement for the Santa Fe Municipal Watershed Project signed by the Advisory Council on Historic Preservation (Council, the New Mexico State Historic Preservation Officer SHPO and USDA Forest Service, Region 3, Regional Forester (36 CFR 800.14(b)(3)) (Project Record). Consultation with the Advisory Council and the SHPO for this project has been ongoing, and the Council and the SHPO have approved the survey and clearance protocols being used for this project.
- The documentation of project area surveys and Section 106 consultation procedures are tied through the agreement mentioned above to the Programmatic Agreement for Wildland Urban Interface Hazardous Fuels Reduction Projects signed by the Council, SHPO and Regional Forester on July 19, 2001.
- A heritage resource impact analysis was completed (EIS pp. 125-130), and additional details are contained in the specialist's report (Project Record). Archaeologists who prepared this analysis concluded that the selected treatments offer the best protection for heritage resources in the area compared to the no action or more limited treatment alternatives because these other alternatives leave heritage resources highly vulnerable to damage or destruction by wildfires (EIS pp. 128-130).
- Tribes have been contacted regarding identification of potentially affected historic properties as required under 36 CFR 800.4(a)(4) (Project Record). To date, tribes have not revealed any traditional cultural or other historic properties of concern in the project area.
- Mitigation measures and monitoring requirements listed in this document and in the Final EIS Appendix B help ensure compliance with these requirements. "Mitigation

and monitoring measures are expected to be effective in creating a low risk of damage to heritage resources based on past experience with similar thinning and burning projects on the Santa Fe National Forest" (EIS, p. 129).

Endangered Species Act (ESA) and 50 CFR 402 Regulations

I find that the project is consistent with this Act and it's implementing regulations, based on the following factors:

- The required biological assessment and consultation with U.S. Fish and Wildlife Service have been completed for this project, under the Regional Biological Assessment & Evaluation (BA&E) for Wildland-Urban Interface Fuels Treatment (USDA FS 2001; Project Record and www.fs.fed.us/r3/wui).
- The U.S. Fish and Wildlife issued a Biological Opinion that concurred with the Regional BA&E. The BA&E and Biological Opinion conform to Endangered Species Act regulations (available on the internet at www.fs.fed.us/r3/wui).
- The EIS shows that all ESA listed species known to occur in Santa Fe County were considered (Table 31, p. 99), and that none are known to occur or likely to occur in the project area, which contains very minor amounts of potential habitat for Mexican spotted owl and southwestern willow flycatcher (p. 99).
- Surveys were completed for spotted owl and none were found (Project Record). The project area contains no occupied habitat, critical habitat, or "protected activity centers" for any listed species. The EIS states that the action alternatives would have no adverse impacts to threatened or endangered species and would likely improve habitat diversity, prey species habitat, and mature forest characteristics (pp. 103-105).
- The EIS states that treatments would have no negative effect on potential flycatcher habitat, and treatments just outside the riparian buffer may improve potential flycatcher habitat by increasing the abundance of riparian vegetation.

Migratory Bird Treaty Act (MBTA)

I find that the project is consistent with this Act, as well as recent agency guidelines for conformance with the MBTA, based on the following factors:

- No "Important Bird Areas" as defined by Partners In Flight occur on the Santa Fe National Forest.
- The comprehensive wildlife analysis in the EIS includes consideration of the Priority Species identified by Partners In Flight that may occur in the project area. The EIS considered all birds, amphibians, reptiles and mammals that may have suitable habitat in any of the five vegetation types that occur in the project area (p. 87-89).
- The EIS disclosed effects of the project for these bird species (pp. 89-98). The analysis considered over 30 migratory bird species that use ponderosa pine stands comprised of 5 to 12-inch diameter trees with 40-100 percent canopy cover (Table 27, p. 90), that dominate the project area. The analysis considered effects to migratory birds associated with snags, down logs, riparian and other habitat types (pp. 85-98 and Tables 25-30).
- Analysis in the EIS shows that the project provides an opportunity to restore and enhance wildlife species richness for migratory birds, compared to current conditions that have low habitat diversity (pp. 90-91, 95-97).
- The monitoring plan includes surveys of migratory birds and small mammals before and after treatment to track changes in populations (Appendix B: Monitoring Plan).

Clean Water Act, 40 CFR 130 Regulations and State Water Quality Standards

I find that the project is consistent with this Act and its implementing regulations and is expected to adhere to State water quality standards, based on the following factors:

- The project area contains only one perennial stream—the Santa Fe River. Water quality for the river within the project area meets water quality standards for its designated uses, and the designated uses reflect the highest water quality classification in the state's classification system (EIS p. 60).

- The effects of the action alternatives upon surface water quality were carefully analyzed in the EIS (pp. 60, 68, 71, 72, 74), which states "The actions alternatives are not expected to adversely impact water quality and would not have an incrementally additive effect on water quality problems experienced in downtown Santa Fe and below the City limits" (p. 74). The EIS also states that if a large fire occurs under the no action alternative, that water quality standards would not be met and water quality would be seriously impaired (pp. 60, 73, 74).
- The New Mexico Environment Department Surface Water Quality Bureau was involved in the planning of this project, and continues their involvement in monitoring the effects of selected treatments. They will monitor turbidity, suspended solids and peak flows from paired (treated and untreated) subbasins established for monitoring purposes, as well as water chemistry parameters and stream geomorphology along the Santa Fe River (Appendix B: Monitoring Plan).
- Best Management Practices were used to design the mitigation measures that help avoid or minimize impacts to water quality (EIS p. 29), as listed in this document.

Floodplains and Wetlands, Executive Orders 11988 and 11990

I find that the project is consistent with the Executive Orders intended to protect floodplains and wetlands, based primarily on the following factors:

- Thinning and slash disposal activities will not occur within or impact any wetlands, riparian areas, or the riparian buffer zone (EIS pp. 84-86)
- The EIS analyzes the vegetation and peak flows in the Santa Fe River floodplain (p. 58-59, 70, 72, 79-83, Figure 45-47). Most of the project area lies below McClure Reservoir where water flows are regulated. Treatments are not expected to cause peak flows that would alter the existing floodplain (EIS p. 70, 72). However, I should note that the no action alternative with wildfire would be expected to have a 30 percent chance of creating a major flood that would impact residential, historic and commercial districts in the 100-year floodplain in Santa Fe (EIS pp. 64-67).

Clean Air Act, 40 CFR 50 Regulations and Air Quality Standards

I find that this project is consistent with Clean Air Act and Air Quality Standards, based on the following factors:

- The project area lies within an air shed that meets air quality standards.
- The planning team consulted with New Mexico Environment Department Air Quality Bureau in the planning process to ensure consistency with state standards.
- The analysis in the EIS includes models for daily burning emission estimates including carbon monoxide and particulate matter from prescribed burns. It identifies the sensitive receptors for smoke (p. 108), and considers potential short and long-term effects on: Class I wilderness, regional haze, visibility, human health, and other factors (pp. 108-112).
- The analysis in the EIS compares the effects of the action alternatives to the National Ambient Air Quality Standards (NAAQS) set by the Environmental Protection Agency to ensure compliance with the Clean Air Act (p. 106-112), and concludes that "Based on experience conducting an average of 12,000 acres of prescribed burning per year on the Santa Fe National Forest, surrounding communities are not likely to experience prolonged periods of heavy smoke, and we are not likely to exceed air quality standards or cause air quality alerts" (p. 112).

Environmental Justice, Executive Order 12898

I find that the selected alternatives would not disproportionately impact minority or low-income populations, based on the assessment regarding the effects of the alternatives on environmental justice contained in the EIS (p. 117, 121), along with the social impact analysis on pages 113-121.

Administrative Appeal Provisions

This decision is subject to appeal pursuant to 36 CFR 215.7. As stated in 36 CFR 215.11, an appeal may be filed by any person or non-Federal organization. A written appeal must be submitted within 45 days after the date that the notice of this decision is published in the Albuquerque Journal. Appeals must meet the content requirements of 36 CFR 215.14. Appeals must be submitted to:

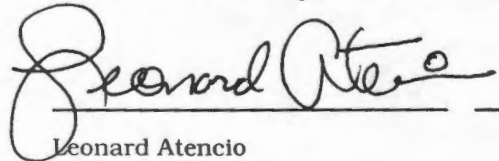
USDA Forest Service
Southwestern Regional Office
ATTN: Appeal Deciding Officer
333 Broadway Blvd., SE
Albuquerque, NM 87102

Implementation

If no appeal is received, implementation of this decision may occur after 5 business days from the close of the appeal filing period. If an appeal is received, implementation may not occur for 15 days following the date of appeal disposition.

Contact

For more information about the project, please contact John Miera, Espanola District Ranger (505-753-7331) or William Armstrong (505 438-7845).

 9/28/01
Leonard Atencio
Forest Supervisor
Date



United States
Department of
Agriculture

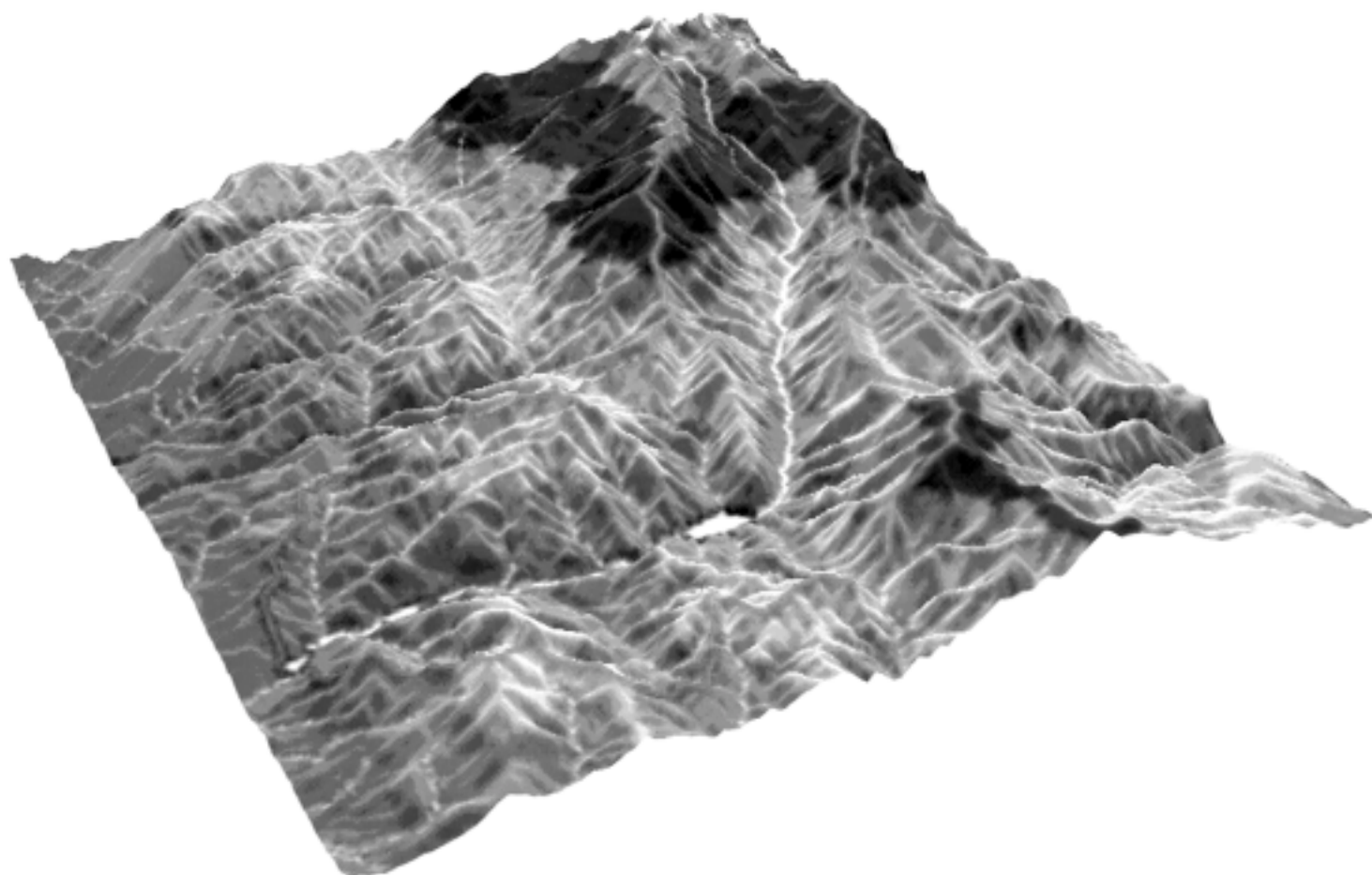
Forest
Service

Southwestern
Region



Santa Fe Municipal Watershed Project Final Environmental Impact Statement • Appendix B and Errata Sheet

Espanola Ranger District
Santa Fe National Forest
Santa Fe County, New Mexico



The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TTY).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice or TTY). USDA is an equal opportunity provider and employer.

Final Environmental Impact Statement Appendix B and Errata Sheet Santa Fe Municipal Watershed Project

Santa Fe National Forest

**Southwestern Region
USDA Forest Service**



In cooperation with:

City of Santa Fe



New Mexico



Appendix B. Project Monitoring Plan

Adaptive Management and Quality Control

Monitoring provides a quality control and adaptive management strategy. By monitoring the effects of the treatments and then evaluating the results, we are able to make appropriate modifications in management practices, assess resource trends, and apply new knowledge to similar projects in the future.

Monitoring Questions

Monitoring this project will be used to answer the following key questions:

- Have project objectives been met, or movement made toward desired resource conditions?
- Have adverse impacts been avoided or minimized to the extent predicted in the EIS?
- Were the assumptions, hypotheses or predictions made in the EIS close to the actual results?
- Were specific features of the selected alternative laid out and administered as stated in the EIS?
- Was the project implemented in compliance with laws, regulations and Forest Plan standards?
- Were there unexpected effects observed that were not included in the monitoring plan?
- How does the information from this monitoring significantly add to our scientific knowledge and inventory database?

Public Involvement

Monitoring this project is important to many people interested and involved in management of the municipal watershed. This monitoring plan was developed with the assistance of various Federal and state agencies, the scientific research community, environmental groups, and other interested groups and citizens. This plan may continue to be refined and modified as new relevant information becomes available. Interested parties will continue to have the opportunity to be

involved all aspects of the monitoring program, including:

- Assisting in the detailed design for each monitoring item.
- Collecting data and implementing the monitoring activities.
- Evaluating, interpreting and reporting results from monitoring.

Evaluation of Monitoring Results

All monitoring activities listed in this monitoring plan will be documented. If monitoring results indicate that laws, regulations, standards or objectives are not being met, or mitigations measures are not effective, the activity will be modified to remedy or ameliorate the problem. Annually, the monitoring data will be consolidated and available for review by interested parties, including technical scientist advisors from outside the agency. The Forest Service and City will evaluate the monitoring results along with the advice and comments received, to determine what changes, if any, should be made. There will be a Forest Service project monitoring coordinator, as well as a coordinator from Santa Fe Watershed Association, working in partnership under an agreement to complete the monitoring and evaluation described in this adaptive management strategy. The Forest Service will periodically evaluate and update the monitoring plan. This monitoring plan, like the EIS, is based on the best available scientific information at this time, some of which is referenced in the EIS. It is important that as new relevant research results become available, that they be integrated into this adaptive monitoring strategy.

Project monitoring will include periodic reviews of the Final EIS and Record of Decision, in order to evaluate whether or not new information has a bearing on the NEPA analysis or decision made, and to ensure that mitigation measures are being properly applied.

Monitoring Plan

The proposed monitoring activities are summarized in the following table.

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change	Funding Source	Annual Cost Est.	Baseline Data
WATER								
Question/Issue: Are treatments adversely affecting water quality such that we are not in compliance with Federal/state and Forest Plan standards, and Clean Water Act regulations? Are treatments resulting in beneficial increases in water yield or unacceptable peak flow events that may alter the stream channel morphology?								
Water Quality	Sediment (turbidity) and total suspended solids in water. Water Chemistry: ph, temp., turbidity, conductance, dissolved oxygen; + metals, ammonia, nitrate, nitrite, nitrogen, phosphorus, suspended & dissolved solids, major cations and anion, organic compounds, fecal coliform bacteria, radionuclides, and cyanide.	Measure turbidity and suspended solids at two streamflow gauging stations set up on paired ephemeral subdrainages (treated & untreated). Sampling of water at 3 sites on SF River, per approved Quality Assurance Project Plan.	At 5-min intervals during storm events (see Clausen & Spooner, 1993 study design). 3x annually, spring, summer & fall.	City A.Lewis NMED-A.Franklin	Turbidity 2x or more in treated vs untreated drainage. State standards.	City Match to 319 grant NMED	Part of 40K 1st yr then 20K/yr after. 50% for equip & install. \$8,529	City, Nov 2000 NMED
Peak Stream Flows in Side Drainages	Streamflow water volume (ac-ft) during rain events in ephemeral subdrainages.	Use Parshall flume and flow gauge to measure and record peak flows in paired subdrainages (treated & untreated). Rain gauge between drainages to normalize results w/ ppt data.	In 15-min intervals during storm flow events	City A.Lewis	No indicators. Record data for inventory and knowledge.	City	Part of grant for 40K/yr 1 st yr then 20K /yr thereafter.	Install fall 2000, to get 1 yr. data
SF River Geomorphology	Stream width, depths, cross-sec area, entrenchment, channel bottom particle size distr., bank erodibility hazard index; + relative elevations of thalweg, water's edge & bankfull at each habitat unit (pools, riffles, runs, glides), + cross sec area of pools.	Use Rosgen method (Harrelson, et al. 1994). Record measurements at two cross sections (a riffle+ a pool) and along one stream reach.	Annually each summer	NMED A.Franklin	Particle size decrease, or increased with depth ratio outside range of natural variability (Rosgen)	NMED	\$1,323	Blue Earth Ecological 2000

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change	Funding Source	Annual Cost Est.	Baseline Data
SOIL								
Question/Issue: Are treatments adversely affecting the soil such that we are not in compliance with Forest Plan standards for acceptable soil loss and maintenance of long-term soil productivity?								
Soil Erosion, Loss	Erosion rate (tons/acre/yr)	Measure change in rate of soil erosion in demo sites and within paired subdrainages (treated & untreated)	Annually	USFS	Erosion exceeding standards, per Terrestrial Ecosystem Survey "tolerance" rates (RUSLE)	USFS	\$2,500	Data collection began fall 1999; need more data.
GROUND VEGETATION								
Question/Issue: Are treatments meeting the objective of increasing vegetative ground cover, in order to stabilize the soil, filter sediment runoff, improve nutrient cycling, increase biological diversity, and carry future surface fires?								
Understory Vegetative Ground Cover	Ground cover: grasses, forbs, shrubs, etc.	Sample using transects or plots. Measure % vegetative ground cover and abundance by species. May be part of habitat or fuels survey protocols.	2x annually for 3 yrs	SFWA P. Grant	Ground cover less than 25% after 2 growing seasons following thin & burn treatment	319 grant: part of 11,000 per yr.	\$2,500	Data collected in May 2000. Need More Data
FIRE								
Question/Issue: Are prescribed burns resulting in escape crown fires (outside firelines)? Are they staying within burn prescriptions and behaving as predicted in the EIS (without becoming independent crown fires)? Are mitigations being followed?								
Escape Crown Fires resulting from prescribed burns; unexpected fire behavior.	Crown fires (acreage) resulting from Rx burn. Energy Release Component (ERC), fuel moistures, Palmer Drought Index (PDI)	Recorded observations of fire behavior by burn boss & patrols. Record 3-5 day ERC, fuel moistures and PDI; other weather.	During and after burn, until fire is declared out. Just prior to ignitions.	USFS K. Joseph USFS K. Joseph	Crown fires >10 acres or threatening life or property ERC >65, PDI <mod., Live fuel moisture <100%.	USFS USFS	\$4,000 \$2,000	N/A N/A

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change ¹	Funding Source	Annual Cost Est.	Baseline Data
AIR								
Question/Issue: Are burning treatments adversely affecting air quality such that we are not in compliance with Federal/state and Forest Plan standards and Air regulations? Is smoke from prescribed burning resulting in adverse impacts to public health or visibility?								
Smoke From Burning	Particulate matter (PM-10 or PM-2.5), TEOM, and smoke (visual).	Record data from PM-10 or PM-2.5 monitors located along/near Upper Canyon Road and visually monitor smoke plume.	Daily during burns, until smoke subsides.	USFS G. Barkmann	Exceeding National Ambient Air Quality Standards (NAAQS).	USFS	\$8,200 (incl. rent equip. & supplies)	NEED DATA
Smoke From Burning; Health & Safety	Air quality warnings, alerts or travel way visibility impacts.	Record air quality warnings, alerts or travel way visibility impacts from smoke.	During burns until smoke has subsided.	USFS G. Barkmann	Warnings, alerts or traffic accidents caused by smoke.	USFS	\$2,000	Assessment report & EIS data
FUELS & FOREST VEGETATION								
Question/Issue: Are treatments effective in meeting the fuel reduction objectives by breaking up fuel continuity in the overstory and reducing the density of understory ladder fuels?								
Fuel Hazard: Dense Understory Ladder Fuels and Overstory Canopy Cover	Basal area, trees/acre, diameter class distribution canopy cover percent.	Stand exam plots, stratified random sample. May use USFS-R3 protocol.	1x per year after thinning & burning, for 2 years.	USFS Armstrong & SWWA P. Grant	If dominant diameter class (VSS) does not increase after treatment; If canopy cover is >40% in thinned areas, or >30% in fuelbreaks.	USFS & SFWA (Pt. of 319 grant).	\$12,000 for all stand exams	USFS 1998 stand exam data
	Forest tree density changes and distribution over the landscape.	Photos taken at selected points for visual comparisons of paired photos		USFS K. Joseph	Increase in fuel hazard above thresholds listed in EIS			,

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change ¹	Funding Source	Annual Cost Est.	Baseline Data
FOREST & RIPARIAN VEGETATION								
Questions/Issues: Are invasive non-native plants increasing in abundance where treatments caused soil disturbance? Are bark beetles infesting the cut trees on the forest floor and thus posing a threat to live trees in the area?								
Invasive Plants	Siberian elm, Russian olive and other non-native plants in Santa Fe River canyon bottom and other areas where ground is disturbed by management activities.	Sample survey treated areas in the canyon bottom between the two reservoirs and in roadside removal areas, thinning machine tracks, south side fuel break and any known (illegal) ORV use areas.	2nd or 3rd year after ground disturbance	USFS M.Orr	Increase in invasive plant occurrence	USFS	\$2,000	Tolisano's 1998 riparian survey data
Insect Infestations	Ips beetles in cut down logs.	Observation by a qualified specialist.	In May or June after thinning.	USFS Armstrong	High levels of Ips in felled logs.	USFS	\$1,000	N/A
WILDLIFE HABITAT & DIVERSITY								
Question/Issue: Are treatments resulting in a loss of key habitat features such as large snags, down logs or riparian hardwood species, or reducing vegetative cover too much in the drainage bottoms/riparian corridors? Are treatments resulting in an increase or decrease of existing aquatic insects, fish, beavers, birds or small mammals, which may indicate an improvement or decline in biological diversity?								
Key Wildlife Habitat Features	Large snags, down logs & hardwoods. Canopy cover in drainage bottoms (riparian areas & mixed conifer patches).	Stand exam plots, stratified random sample; include MSO restricted habitat.	1x/year after thinning & burning each area for 2 years	USFS M.Orr	#12+D Snags #10+D Logs #10+ Riparian hardwoods Below 30%	USFS	No added cost; part of stand exams	USFS 1998 stand exam data
Overstory and Understory Trees and Plants	Abundance by species.	Stand exam plots, stratified random sampling; and ground vegetation transects	1x/year after thinning & burning for 2 years	USFS Armstrong & SFWA P. Grant	No increase in understory plant species diversity.	USFS	No added cost; part of stand exams & ground vegetation transects.	Stand exams for OS done; Need data for ground vegetation.

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change ¹	Funding Source	Annual Cost Est.	Baseline Data
Aquatic Insects Macro-invertebrates and Fish Populations	Species richness, composition (% Ephemopteral), tolerance/intolerance, feeding (percent filterers), and habitat (percent clingers).	Multi-habitat approach and EPA Rapid Bioassessment Protocols (Barbour et al 1999) to sample at 3 sites on upper Santa Fe River.	Annually each summer	NMED A.Franklin	Change in macroinvertebrates as aquatic habitat & water quality indicators.	NMED	Insects: \$850	Tolisano's 1998 data + NMED Oct 2000 + SFHS 1996-2000 + Blue Earth Ecol, 2000
	Trout species numbers, size and condition (by species).	EPA Rapid Bioassessment Protocols to capture. Record no., weight & size by species, on 3 sites on upper Santa Fe River.	Annually each summer	NMED A.Franklin	No indicators. Document change in treated and untreated areas, for database info.	NMED	Fish: \$1,400	
Wildlife Populations; Biological Diversity	Abundance and species richness of breeding birds & small mammals.	Standardized methods to detect changes in populations of birds and small mammals in treated vs. untreated areas.	Spring/ Summer after treatments	USFS M.Orr	No indicators. Document change in wildlife in treated and untreated areas for database & knowledge.	USFS	\$80,000	Data collection started Fall 2001 by Rocky Mountain Research Station
	Abundance of active beaver colonies	Count number of active beaver dams.						
HERITAGE RESOURCES								
Question/Issue: Are treatments adversely affecting heritage resources such that we are not in compliance with Forest Plan standards and National Historic Preservation Act regulations?								
Site Protection	Heritage resource sites.	Sampling 20% of known sites, identified during pre-treatment surveys; Observations made by archaeologists.	Annually, after thin & burn treatment	USFS A.Baldwin	Evidence of damage from thinning & burning.	USFS	\$3,000	Archaeological survey & report.

Resource or Issue	Parameters to Measure	Method and Sampling Techniques	Timing & Frequency	Responsible Group	Indicates Possible Need to Change ¹	Funding Source	Annual Cost Est.	Baseline Data
SOCIAL Does not apply if Option A (No Wood Removal) is selected.								
Questions/Issues: Are haul trucks causing traffic-related problems along Upper Canyon Road or other roads on the haul route?								
Upper Canyon Road	Accidents, speeding citations, or major traffic delays; road or home damage from trucks.	Report number of reported accidents, citations and traffic delays; Inspect reports of damage.	Annually, if hauling products.	City of Santa Fe	Evaluation of reported traffic problems or damage.	City of Santa Fe	\$3,000	Need data on historic levels.



United States
Department of
Agriculture

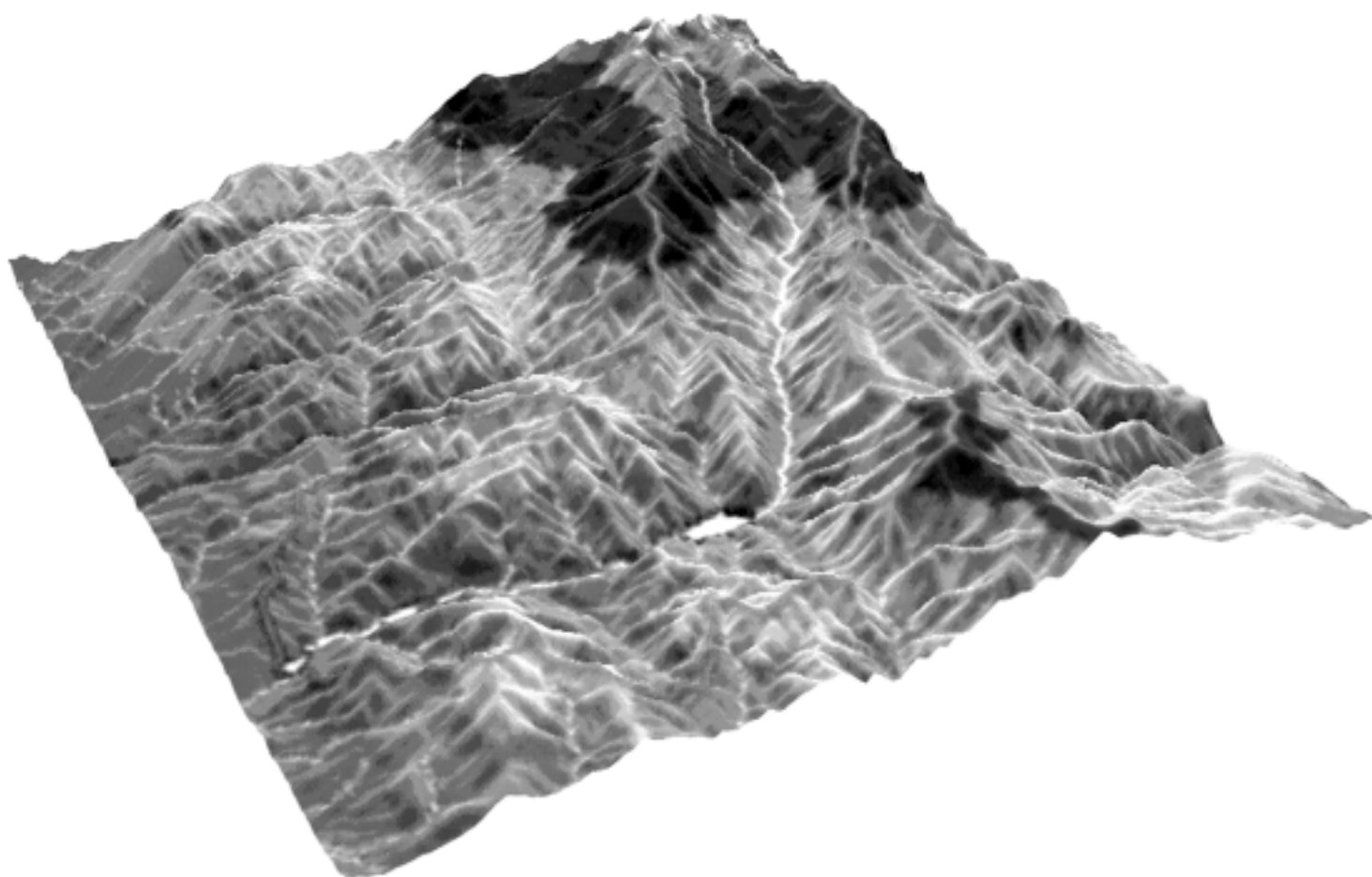
Forest
Service

Southwestern
Region



Santa Fe Municipal Watershed Project Final Environmental Impact Statement • Appendix C

Espanola Ranger District
Santa Fe National Forest
Santa Fe County, New Mexico



The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TTY).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice or TTY). USDA is an equal opportunity provider and employer.

Final Environmental Impact Statement Appendix C Santa Fe Municipal Watershed Project

Santa Fe National Forest

**Southwestern Region
USDA Forest Service**



In cooperation with:

City of Santa Fe



New Mexico



Prepared By

William Armstrong (Forest Vegetation, Fuels), Gretchen Barkman (Air, Smoke, Pollution), John Bruin (Recreation, Wilderness, Lands), Susan Bruin (Planning, Editing), Regis Cassidy (Forest Vegetation, Fuels), Jim McCord (Soil, Water, Noxious Weeds), Mary Orr (Riparian, Aquatic, Terrestrial Wildlife), David Seesholtz (Social, Economic)

Table of Contents

Content Analysis Process and Comments	1
Laws, Regulations, Policies and Plans	3
National Environmental Policy Act: Analysis	3
Open to Recreation Use	3
Keep Closed to Recreation Use	4
Wilderness Designation (For)	4
Wilderness Designation (Against)	5
National Forest Management Act: Species Viability	5
Forest Plan: Vegetation Treatment	6
Forest Plan: Wildlife	6
Fire Management Policy and Plans	7
Public Involvement	8
Alternatives Considered and Eliminated	9
Horses, Mules	9
Wood Chipping	9
Road Building (For)	9
Road Building (Against)	10
Goats	10
Suggested Alternatives	11
Citizen's Protection Plan	11
Forest Conservation Council Alternative	12
Another Alternative	13
Alternative A: No Action	15
No Action Alternative: Analysis	15
No Action Alternative (For)	16
Preferred Alternative(s)	17
Preferred Alternatives (For)	17
Limit Preferred Treatments	17
Expand Preferred Treatments	18
Alternative D1: Machine Thinning	19
Machine Thinning (For)	19
Machine Thinning (Against)	19
Machines: Non-local Labor	21
Machine vs Manual: Monitor	22
Machines: Steep Slopes	22
Machines: Worker Safety	23
Option A: No Wood Removal	24
Wood Trucking: Need	24
Wood Trucking: Quality of Life	24

Wood Trucking: Safety	25
Wood Trucking: Tourists	26
Wood Trucking: Pollution	26
Wood Trucking: Historic Structures/Roads	26
Wood Trucking: Monitoring	27
Wood Trucking: Mitigations	28
Wood Trucking: Cumulative Effects	28
Wood Removal: Environmental Impacts	29
Wood Removal: Utilization	30
Wood Removal: Limit Amount.....	30
Wood Removal: Profits	31
Wood Removal: Cost vs Value	31
Option B: Thin Larger Trees, 100 Acres	33
Option B (For)	33
Option B (Against)	33
Thinning	35
Thinning: Immediate Need	35
Thinning Prescriptions/Patchiness	35
Thinning: Long-Term Effects	36
Thinning: Historic Conditions	36
Thinning: Contour Felling.....	36
Thinning: Solar Chain Saws	37
Thinning: Avoid Raspberry Bushes.....	37
Fuel Breaks	38
Fuel Break: Need	38
Fuel Break: Size, Tree Density	38
Fuel Breaks: Location.....	39
Fuelbreaks (Against).....	39
Fuelbreaks: Visual Quality	41
Fuelbreaks: ORV's/Weeds	41
Fuelbreaks: Herbicides	41
Fuelbreaks: Monitoring	42
Prescribed Burning	43
Burning (For).....	43
Burning (Against)	43
Burning: Smoke	43
Burning: Timing and Personnel	44
Slash Burning: Scatter vs Pile	44
Slash Burning: Soils.....	45
Slash Burning: Monitoring	45
Burning: Maintenance	46
Burning: Fire Regimes	46
Fire Suppression	47

Soil and Water	48
Water: Tree Numbers	48
Soil Types: Water	48
Invasive Plants/Soil: Firewood Gathering	49
Invasive Plants: Seeding	49
Monitoring: Soils/Ground Vegetation	50
Monitoring: Water	50
Monitoring: Water, Paired Subbasins	51
Riparian and Aquatic	53
Riparian Buffers: Need	53
Riparian Buffers: Location	53
Riparian Buffers: Size	53
Riparian/Aquatic: Monitoring	53
Wildlife	55
Nesting: Treatment Timing	55
Wildlife: Cumulative Impacts	55
Snags	55
Wildlife Mitigation: Personnel	56
Wildlife: Mitigations	56
Birds, Small Mammals: Monitoring	56
Species Surveys	57
Goshawk Standards	58
Social and Economic	59
Volunteers	59
Cost/Benefit Analysis	59
Funding Implementation	61
Fund With Recreation Fees	61
Monitoring - Other	62
Monitor Compliance: Mitigations	62
Monitoring: Personnel	62
Monitoring: Technical Assistance	62
Monitoring: Funding	63
Monitoring: Scheduling	63
Monitoring: Stand Data	64
Monitoring: Variability	65
Monitoring: Vegetation Parameters	65
Monitoring: Treatment Effects	66
Names of Commenters and Letter Numbers	67

Content Analysis Process and Comments

Process

Public comments were solicited on the Draft Environmental Impact Statement (DEIS) for the Santa Fe Municipal Watershed Project over the course of a 45-day period between April 13 and May 29, 2001. The comments received were compiled and categorized in a systematic “content analysis” process by a Forest Service Content Analysis Team. Each comment was entered into a database, along with the name, address, organization or agency affiliation, and type of comment (eg. letter, fax, e-mail, petition, form letter, telephone transcript). An analyst reviewed the comment letters, and identified and labeled each distinct comment within each letter with topic and sub-topic codes. A second analyst reviewed and sorted the specific comments to ensure accuracy and consistency, then entered them verbatim into another database.

Each set of sorted comments in the database was used to develop the comment statements listed in this document. Each comment statement in this document is followed by sample verbatim quotes from the comment letters. The sample quotes allow the reader to gain a deeper and more complete understanding of the comment. The quotes included in this document are those that provide distinct details about the comment statement, variations on the comment statement, or are representative of other similar quotes associated with that comment statement. The sample quotes do not include quotes from all comment letters, and some sample quotes were condensed from lengthy commentaries. *The names of those who commented and their corresponding letter numbers are listed at the end of this document.*

The deciding officer reviewed the comment statements and quotes prior to making a decision about which alternatives and options to select for the project. Once the decision was made, the planning team wrote responses to each comment. The content analysis and decision making process did not count the number of comments by topic or consider the comments as votes, but focused instead on the substance of the comments.

Comments

This section summarizes the pervasive topics found in the comments received on the DEIS. We received 61 comment letters (including faxes, e-mails and phone transcripts), including two from the Wild Watershed Alliance that discussed a “citizen’s protection plan” for the Watershed. In addition, we received 575 copies of a form letter and 1 petition by (449 signatures) that summarized and supported the citizen’s protection

plan. The citizen’s protection plan supported the selected treatments to reduce hazardous fuels by thinning the smallest trees and using prescribed burns, to adopt Option A: No Wood Removal, and not select Option B, cutting larger trees in the canyon bottom. The citizen’s protection plan had other recommendations, and opposition to some specific features of the selected treatments. We also received 31 copies of another form letter supporting the plan to reduce hazardous fuels and urging adoption of Option A: No Wood Removal.

Some of the comments in the citizen’s protection plan were outside the scope of the DEIS and fuel reduction project, but are responded to in this document, such as: designation of additional wilderness, opening the watershed to recreational uses, reintroduction of native wildlife species, and fire suppression strategies.

Generally the public comments expressed a clear understanding and support for the purpose and need for the project, which was to reduce hazardous forest fuels in an effort to decrease the risk of a catastrophic fire in the Santa Fe Municipal Watershed (hereafter referred to as Watershed). Most people agreed with the selected treatment that involves thinning the smallest trees and burning the resulting slash and other hazardous fuels as needed. Only a couple people favored the no action alternative that would “let nature take its course.” A few people wanted the treatments to be more limited in extent or in the number of trees cut, while a few wanted more extensive and intensive thinning to be done along with road building and wood harvesting. Most people made suggestions about specific methods and environmental protection measures to use. The vast majority of these suggestions were found to be consistent with the selected alternatives, such as: do not build roads; retain the largest trees as well as snags, down logs and unthinned patches; thin to variable densities leaving a mosaic pattern on the landscape; restore historic low-intensity fire regimes; ensure that adequate mitigation and monitoring measures are employed to avoid escaped prescribed fires; stay out of the riparian zone; use contour felling to limit erosion and runoff; implement in stages over time; and monitor and evaluate treatments in an adaptive management strategy.

There were two main focal points of concern, disagreement or questions about specific methods associated with the preferred/selected treatment alternatives. One concerned the use of feller-buncher thinning machines (Alternative D1) and how this would affect the ability to use local laborers and contractors who do not have this equipment, and how the machines might impact soil and water conditions. The other concerns were related to the fuel breaks, in terms of the width and extent, size of openings, and effects on soil, wildlife

habitat and firefighter safety. There were also a few comments about slash burning methods and use of prescribed fire. A large number of comments from the project monitoring committee and their technical advisory group consisted of recommendations regarding the details of the monitoring plan, including data collection, personnel, scheduling, equipment and funding.

Most of the people who wrote letters expressed strong concern and opposition to allowing wood removal and haul truck traffic through the residential neighborhoods and the historic district on the east side of Santa Fe. These letters voiced concerns about traffic safety hazards to pedestrians, bicyclists, school children and motorists along these narrow roads; impacts to the ambiance and quality of life for residents and tourists who use these roads (including noise and traffic delays);

vibration damage to historic homes and cultural properties along the route; damage to the roads and bridges; and cumulative effects of adding more truck traffic to roads considered to already be over-used. This document responds to those comments as well as the others comments received.

Numbers of Comments by Type

Written Comments	56
Oral Comments	5
Form Letter #1: Copies	575
Form Letter #2: Copies	31
Petitions (450 signatures)	1

Laws, Regulations, Policies and Plans

National Environmental Policy Act: Analysis

1. Comment: The DEIS should address direct, indirect, and cumulative impacts of each alternative, to ensure compliance with the National Environmental Policy Act (NEPA).

- “The DEIS on which this project is based fails to take a ‘hard look’ at the direct, indirect, and cumulative impacts—both positive and negative—of the alternatives, including no action. Coupled with a persistent bias against the ‘no action’ alternative, these omissions render the DEIS useless as a source of information on which to base an informed, objective opinion.” (Letter 230)

Response: *The DEIS contains nearly 100 pages that discuss and disclose the direct, indirect, and cumulative impacts of each alternative including the no action alternative, accordance with NEPA regulations (DEIS, pp. 41-136). Additional effects analysis in the project record further supports the “hard look” taken by those who prepared the DEIS so that an informed decision could be rendered. An interdisciplinary team of professional natural resource specialists prepared the DEIS (pp. 137-138) and described the predicted impacts that would result from each alternative, including cumulative effects. In addition, the DEIS was reviewed by qualified scientists from universities and research stations outside the National Forest System, who supported the project and agreed with the scientific basis for the predicted effects (see Project Record). While cumulative effects are described throughout the “Affected Environment and Environmental Consequences” chapter of the DEIS, cumulative effects are also specifically described on pages 41-42, 56-58, 73-75, 98, 105, 112-113, 121-122, 125, 130, 132, 134-135.*

Open to Recreation Use

2. Comment: Consider opening the watershed to limited recreational use.

- “The question of opening the upper watershed to the public was dismissed out of hand given current fire danger. Once the fire danger is reduced through the proposed treatments, why could this option not be reevaluated? Many municipal watersheds throughout North America are open to recreational use: given modern water quality

treatment techniques, the water quality rationale for closure of the upper watershed no longer applies. We understand that this may not be an issue to raise, let alone discuss at length, in this particular DEIS; but it would seem that the response should be responsive to the consistent interest on the part of the public in opening this discussion. While I think this issue should be addressed in the DEIS, it should be couched in terms of being a separate action that in and of itself would require a DEIS.” (Letters 640 and 647)

- “I support the citizen’s watershed protection plan, including: Allow hiking, cross-country skiing, birdwatching and other low-impact uses in the watershed to citizens who volunteer or contribute to river restoration projects.” (Letter 34)
- “When conditions permit, these citizens support opening the watershed for limited day hiking, cross-country skiing and wildlife viewing privileges to members of the public who have demonstrated responsibility by volunteering for river restoration projects.” (Letters 223 and 654)
- “We call for granting limited day hiking, cross-country skiing and wildlife viewing privileges to citizens who have demonstrated responsibility by volunteering for river restoration projects in the Watershed and/or downstream. The watershed would be opened to this type of responsible use only after hazardous fuels are reduced. No motorized or animal transportation would be permitted. The watershed was closed to public use and enjoyment in 1932 because centuries of commercial logging, personal wood use, livestock grazing and unregulated recreational use had caused significant harm. We are not proposing to return to such irresponsible use. Instead, we are proposing an innovative system of responsible use that would give citizens the opportunity of experiencing the exceptional beauty of this area less than ten miles from Santa Fe’s Plaza and, at the same time, help restore the Santa Fe River downstream. Regulated recreational use of municipal watersheds is common throughout the nation. In fact, the majority of municipal watersheds managed by the Forest Service are open for recreational use. The Forest

Service argues that the watershed should remain closed because of fire risk, conflict with tree felling and burning activities and impacts to riparian areas and water quality. The Citizen's Protection Plan would not open the watershed for recreational use until fire risk is reduced and after tree felling and burning are completed. Conflict with any future management actions would be avoided by allowing the Forest Service to close the watershed when needed. Use of riparian areas and the reservoirs is restricted under the Citizen's Protection Plan." (Letter 643)

- [Similar comments from Letter 18]

Response: *We agree that once the hazardous fuels are reduced within the watershed, the prohibitions on recreational use could be re-evaluated. A decision regarding public access in the Watershed does not have a bearing on this current fuel reduction project decision. The DEIS describes several issues (concerns) that were raised when we first considered this option, before eliminating it from detailed analysis (see DEIS p. 162). The issues regarding public access would be most appropriately evaluated in a separate environmental analysis (EA or EIS) and public involvement process, as suggested by a few commenters. Opening the Watershed to recreational use will require a change in the Forest Plan as well as change in the Secretary of Agriculture's closure order, and that type of analysis and decision making will be considered during the Forest Plan revision process. The 1932 Closure Order by the Secretary of Agriculture and subsequent Forest Service Closure Orders allow for cutting and removing timber as needed for the proper care and protection of the Watershed, while prohibiting bathing, camping, picnicking, fishing and other public uses in the Watershed (Project Record #1).*

Keep Closed to Recreation Use

3. Comment: Keep the Santa Fe Watershed closed to recreation activities.

- "We oppose opening the watershed to hiking, skiing and wildlife viewing. It sounds good, but it would be a giant enforcement headache and would inevitably degrade the watershed. The watershed has been closed all these years for a very good reason—to protect the water supply. The water is the issue. We can't have our cake and eat it." (Letter 3)

- "I am opposed to granting special privileges to persons or groups to use the watershed for recreation. I believe that the Santa Fe Watershed should remain closed to all human use to permanently protect our water supply." (Letter 655)

Response: *See response to Comments 33, 49, and 151 (JB).*

Wilderness Designation (For)

4. Comment: Recommend that the roadless areas within and surrounding the Watershed be designated as wilderness.

- "The entire watershed and Santa Fe National Forest lands to the north and south are inventoried roadless areas. These lands should be recommended for wilderness designation because of their proximity to Santa Fe and the important wildlife values that only roadless lands provide. While these lands are waiting protection as wilderness, the roadless portion of the watershed should be fully protected under the Roadless Area Conservation regulations (36 CFR Part 294)." (Letter 643)
- "There is strong citizen support for new wilderness designation in the watershed..." (Letter 223)

Response: *The designation of wilderness is not within the scope or connected to the decision to be made for this fuel reduction project. In addition, none of the alternatives propose road building. Implementation of the project does not foreclose any future options to designate portions of the Watershed or surrounding area as wilderness, and the project is consistent with the Roadless Area Conservation Regulations (currently undergoing legal challenge; see July 10, 2001 Federal Register Notice). The Forest Service makes determinations regarding wilderness suitability and recommendations for wilderness designation only during the Forest Plan revision process, unless Congress directs the study of specific areas for potential wilderness designation (36 CFR 219, FSM 1923).*

It should also be noted that the statute that added part of the Watershed to the Pecos Wilderness states "nothing in this Act shall interfere with the management of, or rules, regulations and law applying to the Santa Fe Municipal Watershed," and "Unless expressly autho-

ized by Congress, the Secretary shall not conduct any further statewide roadless area review and evaluation of National Forest System lands in the State of New Mexico for the purpose of determining their suitability for inclusion in the National Wilderness Preservation System” [Public Law 96-550 Sec. 102(9) and 104(3)© respectively; Dec. 19, 1980; 16 USC 1132].

Wilderness Designation (Against)

5. Comment: Withdraw wilderness designation from lands in the Santa Fe Watershed area.

- “I sincerely believe that the Santa Fe Watershed area that falls under the jurisdiction of the Forest Service should be de-commissioned as far as it being a designated wilderness area. I am decidedly not suggesting that the area become a roaded one, only that the public finally have the opportunity to enjoy and revere an exceptionally beautiful forest. People have a definite tendency to tattle on others who are doing something wrong or if they see smoke, so I believe that the risk of fire would actually be lessened.” (Letter 17)

Response: See preceding response to Comment 152 regarding wilderness designation. Also, see response to Comments 33, 49, and 151 regarding opening the Watershed to limited recreational use.

National Forest Management Act: Species Viability

6. Comment: Use current survey data and analysis to address the impacts to species viability, to ensure compliance with the National Forest Management Act (NFMA).

- “Given that many of the native vertebrate and invertebrate species inhabiting the Watershed are sensitive to the proposed management activities, and given the nearly complete lack of analysis of impacts to these species, this project clearly runs afoul of the National Forest Management Act’s viability and diversity requirements found at CFR [sec] 219.19, [sec] 219.26, and [sec] 219.27”. “For each of the species potentially harmed by the Santa Fe Municipal

Watershed Project, the Forest Service must have up to date survey data indicating the abundance and distribution of these species throughout the project area, population trend data, survey data indicating the abundance, distribution, and quality of habitat, and data on habitat trends. This information [survey data] should form the basis of a viability analysis that predicts the direct, indirect, and cumulative impacts on individuals occupying the project area, habitat quantity and quality for these species, and overall population viability across Santa Fe National Forest.” (Letter 230)

- “Population survey data is needed to determine the maintenance of minimum viable populations of wildlife. The Forest Service is required by 36 C.F.R. Sections 219.19 and 219.26 of the 1982 regulations implementing the National Forest Management Act to collect population data for Management Indicator Species (MIS) (as required by section 219.19) and for all affected species (as required by section 219.26). The DEIS-SFW fails to state whether quantitative data has been obtained and, if so, what are the trends for MIS species based on empirical survey data. We suggest that this data (or lack of data) be disclosed to the public and decisionmakers.” (Letter 643)
- “I support the Citizen’s Watershed Protection Plan, including: Conduct a scientifically credible inventory of all species and monitor ecological change.” (Letter 34)

Response: The treatments prescribed for this project adhere to the Forest Plan standards and guidelines developed to maintain viability of species (Forest Plan pp. 61-66, 72-78, and Appendix D). These standards and guidelines are used and referenced in the DEIS pp. 5, 29-31). The DEIS identifies the sensitive species and management indicator species that could potentially be affected by the project, and describes the estimated effects to these (and other) potentially affected species (DEIS pp. 77-105). The DEIS (pp. 78, 86, 87, 96 and 98) discusses effects regarding viability of Management Indicator Species (MIS) and finds that species viability would not be compromised by this project. The DEIS states, “Habitat for Merriam’s wild turkey, elk, hairy woodpecker, and pinyon jay would likely improve or remain unchanged due to increased understory vegetation, maintenance of large ponderosa pine, selective removal of smaller conifers, and maintenance of snags”

(p. 98). *The analysis indicates that wildlife habitat diversity would improve, and that most species would benefit from the prescribed treatments (DEIS pp. 5, 30, 54, 95, 96, 97).*

Collecting quantitative population survey data of all potentially affected species for each site-specific project is not economically feasible and is not required by law or regulation. In conducting the analysis for this project, professional wildlife biologists considered the available scientific information on habitat and population trends of management indicator species, and utilized empirical data from applicable scientific research, as cited throughout the terrestrial wildlife analysis chapter of the DEIS (p. 87-98). The wildlife effects analysis documented in the DEIS is based on vegetation habitat types that occur within and surrounding the project area, from which inferences can be made about the associated wildlife species (DEIS p. 87-95). A list of species associated with each vegetation type was compiled using the Biota Information System of New Mexico database (BISONM). We believe the amount and quality of scientific information used in the analysis is commensurate with the project activities proposed, and the anticipated low potential for adverse impacts to management indicator species.

In addition, wildlife biologists will conduct pre- and post-treatment inventories and monitoring of small mammals and birds (DEIS p. 168). Additional surveys will be conducted for changes in the number of active beaver dams before and after treatments to monitor fluctuations in the resident beaver population. Treatments will be implemented in stages over time, and monitoring results will be evaluated to determine if modifications in treatment prescriptions are indicated.

Forest Plan: Vegetation Treatment

7. Comment: Ensure that the vegetation treatment for the project is consistent with the Forest Plan.

- “Specific goals, objectives, standards and guidelines relevant to the Santa Fe Watershed are found on pages 155 and 156 of the Santa Fe National Forest Land and Resource Management Plan (‘Plan’). By law, the Watershed Project must be consistent with this Plan. Despite the DEIS’s contention that ‘trees from the area may be harvested to reduce fuel loads and maintain watershed values,’ there is no such authorization contained in the Plan. The Plan only authorizes research, fire suppression, and prescribed fire. The Plan explicitly states that ‘[t]here

are no vegetation modification practices proposed in this management area.’ Forest Plan at 155. Therefore, before the Santa Fe Municipal Watershed Project can be approved, the Santa Fe National Forest must first amend its Land and Resource Management Plan.” (Letter 230)

Response: *The vegetation treatment prescribed for this project is fully consistent with the Forest Plan. The 1996 amendment and correction to the Forest Plan removed the statement that “there are no vegetation modification practices proposed in this management area” (“Record of Decision for Amendment of Forest Plans in Arizona and New Mexico,” p. 85). This change in the Forest Plan was made for the Watershed along with all other management areas that do not contain suitable timberlands, in order to clarify the agency’s intent that vegetation modification practices may be used on these non-suitable timberlands to meet non-timber management objectives such as hazardous fuel reduction and watershed improvement (as described in DEIS p. 10). The Forest Plan allows for uses that are not specifically prohibited, and it does not prohibit vegetation modification practices or firewood harvest to reduce fuel loads.*

Forest Plan: Wildlife

8. Comment: Ensure that wildlife habitat management for the project is consistent with the Forest Plan.

- “The Santa Fe Municipal Watershed Project is also inconsistent the 1996 Forest Plan amendments addressing management of the northern goshawk, Mexican spotted owl, and old growth forests. The DEIS provides no evidence that the Forest Service followed the protocols established by these amendments as well as subsequent regional guidance for surveys and, if appropriate, establishment of management areas for both the goshawk and the owl. The DEIS fails to analyze changes in structural stage and canopy closure by habitat type specifically required by the plan amendments. The DEIS also fails to allocate at least 20% of the Watershed to management for existing and future old growth forest.” (Letter 230)

Response: *The selected alternatives were compared to the amended Forest Plan and found to be fully consistent with the Plan. The wildlife protection measures included as part of the selected alternatives were specifically designed to conform to the Forest Plan. The DEIS de-*

scribes habitat characteristics for threatened, endangered and sensitive species that could be potentially affected by this project (DEIS, pp. 99-103). The DEIS analyzed the potential changes or impacts to spotted owl, goshawk and mature forest habitats (DEIS, pp. 103-105). A professional wildlife biologist conducted surveys for spotted owl and goshawk in accordance with Forest Plan protocols and other Forest Service requirements, and no spotted owls or goshawks were found (see Project Record). Thus, it is unlikely that there are any spotted owls or goshawk nest sites in or adjacent to the project area. A management area for these species would be defined if a nest were discovered during implementation. The treatment areas do not contain critical habitat or "restricted" (suitable) spotted owl habitat as defined in the Recovery Plan for the Mexican spotted owl.

In addition, the DEIS (p. 30) includes mitigation measures that help ensure consistency with the Forest Plan regarding management for these species, and specifically incorporates Forest Plan standards/guidelines for goshawks and spotted owls. It includes Forest Plan standards to maintain existing mature or older forest structure in potential northern goshawk habitat, and other direction from Forest Plan, Appendix D, pages 6-10: retain large snags and down logs wherever possible; retain old age trees and mature/old forest structure; sustain a mosaic of vegetation densities, age classes and species composition across the landscape; increase herbaceous vegetation to provide for goshawk prey species and to maintain satisfactory soil conditions; use R3 protocol to survey for goshawks; have variable canopy coverage (averaging 40 percent) with openings up to 4 acres each while retaining at least two small groups of trees per acre with minimum 12-inch diameters. The DEIS also includes specific requirements for retention of snags and down logs, retention of mature piñon, juniper and oak, and other habitat conservation measures.

The DEIS analyzed changes in structural stage and canopy cover (DEIS, 87-105). The Forest Plan requirement for old growth allocation is not applicable to project areas, but is appropriately applied on an ecosystem management area basis. The forest is currently defining probable old growth and old growth management areas as part of a watershed assessment process, while maintaining existing mature and old growth forest. There is no existing old growth forest within the project area, and the DEIS describes how the treatments would enhance the development of mature/old growth forest. Treatments would not in any way reduce the ability of these forest stands to become old growth. "All the large, mature trees on the landscape would be maintained,

and their growth enhanced... Forest structure would shift from that resembling a young forest to that of a more mature forest...." (DEIS p. 104)

Fire Management Policy and Plans

9. Comment: Address how this project relates to the Federal Wildland Fire Management Policy, and approve fire management plans to comply with this policy.

- "The DEIS SFW does not mention the relationship of this project to the Federal Wildland Fire Management Policy and Program Review, its Implementation Action Plan or the recent revision of the Forest Service Manual that incorporated the federal Wildland Fire Management Policy. According to the Federal Wildland Fire Management Policy, fire management plans are mandated for all areas subject to wildland fires. These plans should address all potential wildland fire occurrences and include a full range of fire management actions. Moreover, plans should facilitate the implementation of landscape-scale prescribed burning with the goal of restoring fire to fire-dependent ecosystems." "The second most important issue of the Fire Policy is the need to develop and approve new fire management plans. Indeed, in the 1996 Implementation Action Plan Report for the Fire Policy, fire management planning is presented as an 'Action Item to be Implemented Immediately'. The Fire Policy lists fire management planning second only to firefighter safety in order of priority." (Letter 640)
- "The Federal Wildland Fire Management Policy and Program Review require disclosure of how fire processes will be restored across the landscape..." (Letter 643)

Response: The Santa Fe Municipal Watershed project is consistent with fire management policies described in the "1995 Federal Wildland Fire Management Policy" and "1996 Federal Wildland Fire Management Policy and Program Review and Action Plan" referenced by the commenter. In accordance with these 1995/1996 policies, the Santa Fe National Forest completed a Fire Management Plan and updates that Plan annually. The Fire Management Plan is a forest-wide programmatic

plan that provides guidance regarding a full range of fire management actions that occur on the national forest, including fire prevention, suppression, firefighter qualifications and preparedness, use of prescribed fire and prescribed natural fire, interagency cooperation, and other topics. The Watershed project is consistent with guidance contained in the Fire Management Plan, and similar direction in the Forest Plan, which encourages the use of prescribed burning and restoring fire to fire-dependent ecosystems.

We also consistently follow the more recent and relevant direction from the 1999 GAO Report: “Western National Forests—A Cohesive Strategy Is Needed to Address Catastrophic Wildfire Threats,” the September 2000 “National Fire Plan” and October 2000 “Protecting People and Sustaining Resources: A Cohesive Strategy” (agency response to the GAO report). These reports are available from the Forest Service website www.fs.fed.us. The National Fire Plan and Cohesive Strategy emphasize hazardous fuel reduction, and were used for Congressional appropriations that will be used to fund this project. This project adheres to the National Fire Plan recommendation to “reduce small diameter trees and other woody forest materials that contribute to fire hazard...” and “assure that hazardous material is being removed in a timely and environmentally sound manner.”

Public Involvement

10. Comment: Develop an outreach program to solicit suggestions from residents in affected neighborhoods.

- “It would be valuable in the planning process to solicit suggestions from residents of the affected neighborhoods in an effective outreach program. The Forest Service has facilitated an open process with environmental and community groups, but door to door outreach to affected neighborhoods, strongly urged in the partners meetings, has not yet taken place.” (Letters 645 and 649)

Response: We agree that it is extremely valuable to get suggestions from residents near the project area, and disagree that it has not yet taken place. We fulfilled the NEPA planning process requirements for public involvement, and beyond that we developed a continuous collaboration and dialogue with the local community. We felt it was imperative to meet with nearby neighborhoods and hear their honest opinions, and hired a private consultant to help reach and meet with interested citizens in the most affected neighborhoods on the east side of Santa Fe. The contractor contacted nearly all the residents closest to the Watershed and invited them to small informal “kitchen table visits” about the project. We solicited and received many suggestions from residents during the project planning process. Homeowner and neighborhood associations were contacted and asked if they would provide a list of members and names of people interested or concerned about fire danger in the area. Representatives of these associations were contacted by telephone and invited to attend meetings held at the Audubon Center. Six meetings with residents from affected neighborhoods were held on August 10, 20, 24, and September 5, 6, and 12, 2000. The meetings culminated in two larger scale meetings held at the main branch of the Santa Fe Library on October 3 and 5, 2000. Notice of the latter meetings was sent to a list of all east-side city residents provided by the City of Santa Fe Water Department. Copies of the comments received from these meetings can be found in the Project File (Project Record 140) as well as a summary of the meetings (Project Record 141). Monthly field trips were also publicized and conducted during the spring, summer and fall of 1999 and 2000 (DEIS, page 10). An informative brochure was distributed to city residents in their monthly water bills (DEIS, page 11). Presentations were made at over 17 public meetings with Santa Fe residents, including the Network Neighborhood Association meeting on August 28th, 2000. This meeting was well attended by residents from east-side neighborhoods.

Alternatives Considered and Eliminated

Horses, Mules

11. Comment: Consider using horses and mules to remove wood products.

- “At some point in time, the old process of using horses and mules to remove wood products should be resumed. It seems it was rather quickly disposed of as an option. This could well be a long-term sustainable activity—kept to a very small scale—that would help re-introduce this nearly lost art. It would also help as a management option in maintaining forest health.” (Letter 227)

Response: *Though it may appear in the DEIS that horse logging was dismissed rather quickly, the truth is that the we spent a considerable amount of time looking at this possibility. The biggest limitation to using draft animals is the steepness of the terrain over a very large acreage that needs to be treated. According to the studies of horse logging (McNamara, D, 1984; Fieber, W. 1985), maximum skidding distance uphill is less than 100 feet. Horses cannot sustain skidding uphill for an entire day. Maximum skidding distance downhill is 800 feet. Maximum slope for horse skidding is 30 percent downhill and 10 percent uphill; otherwise slopes are too hazardous for a horse and operator. One California study showed that at an average skid distance of 400 feet and average tree diameter of 10 inches, production rates for horse skidding was 77 logs per day per horse.*

There is a very limited number of horse or mule teams available and production is generally slow. A horse logging study noted that all aspects of the falling and skidding have to be built around the horses abilities and inabilities. Trees need to be felled in the direction of the intended skid and cannot be felled across one another (Koroleff, A. 1942). In the Pacific Southwest study, delays accounted for 63 percent of the total production time.

Draft animals may appear to be “light on the land” but they produce more pounds per square inch (psi) than mechanical equipment, which means more soil disturbance and compaction. The soils in the Watershed consist of decomposed granite. These soils are very loose, making slopes over 10 percent dangerous for the draft animals. There is also a concern over the introduction of noxious weed species in the Watershed from horse waste and from the bales of hay that would be most likely stored at various places on site.

Wood Chipping

12. Comment: Consider chipping wood.

- “Small spindly trees should be chipped and sold in volume to businesses, landscapers local landfills for cover.” (Letter 2)

Response: *We agree and did consider chipping the wood (DEIS pp. 160-161). Chipping the smaller woody material has the advantage of taking care of the slash immediately after cutting and was proposed in the few roadside areas where a chipper can be feasibly placed. Most of the gentle-sloping roadside acres are on City-owned lands, and the City hired a contractor to conduct thinning and to chip the slash where feasible. However, the DEIS describes the reasons why this method was determined to not be feasible or practical in most of the remaining area that needs to be thinned (pp. 160-161). The main problem with widespread chipping in this particular area is due to the steep, rocky and inaccessible slopes that will be thinned. Slash would need to be dragged to a chipper, the chipper would need to be moved frequently. Thus, without adequate road access, this is not an economically feasible or practical option.*

Road Building (For)

13. Comment: Consider building new roads, for fire safety, water and reservoir management, and wood removal.

- “New roads should be built to accommodate Forest Service Advance teams for safety precautions staging areas.” (Letter 2)
- “Please plan on building roads for heavy equipment so that regeneration water catchments and check flow dams can be constructed.” (Letter 3)
- “Please reconsider building new roads to increase road access and remove more wood. What will it matter if the area is pristine but charred by a devastating fire?” (Letter 18)
- “Is there any possibility of a new road or roads being built to connect to other egresses from the area under study? I know new roads are a difficulty, but I suspect that one or two might be the easiest answer to the problem. The difficulties are many, not the least the impact of traffic upon the roads leading out of the watershed”. (Letter 658)

Response: We agree with the expressed benefits that roads could provide, including additional safety for firefighters and thinning crews, and greater ability to utilize the small diameter wood that needs to be disposed of. The DEIS describes these benefits along with the many reasons why it is not a reasonable or economically practical alternative to build new roads in this particular Watershed (pp. 155-157). It also describes predicted negative consequences and high costs associated with building roads through this steep, erosive and essentially roadless Watershed. Roads are not necessary in order to meet the project's purpose and reduce hazardous fuels, which are mostly the 3-6 inch diameter stems that have a low economic value. Some of the other considerations were: inconsistencies with the Forest Service's Roadless Area Conservation Plan and controversies regarding roadless area values, expected increases in traffic impacts in Santa Fe, increases in uncontrolled public access in an area that prohibits public use, increases in invasive weed species, increases in soil erosion and stream sedimentation, and other unavoidable adverse effects that seem inconsistent with the mandates to protect the natural resources and water quality in this municipal watershed.

Road Building (Against)

14. Comment: Do not build roads or increase road density in roadless areas to minimize impacts on wildlife.

- "Minimize disturbance to wildlife by reducing road densities in project areas, build no new roads, and proscribe (no) activities in roadless areas." (Letter 22)
- [Similar comments from Letter 643]

Response: No new roads will be built, and there are no road densities to reduce in this area. There is only one administrative service road in the Watershed that is closed to public access. Noise disturbance is expected to temporarily affect wildlife habitation of affected areas during thinning and burning activities. Wildlife would move back into treated areas following cessation of noise disturbance. Mortality of relatively immobile species is not expected to be substantial or diminish the persistence of affected populations (DEIS p. 96).

Goats

15. Comment: Consider using goats or other grazing animals for clearing vegetation.

- "What about grazing animals (controlled), goats would be a good way of clearing the overgrowth? Why not consider this?" (Letter 35)

Response: This alternative was considered but dismissed primarily because goats cannot eat woody conifer trees (other than seedlings). The objective of this project is to reduce hazardous fuels consisting of dense conifer tree cover (DEIS p162). Most other grazing animals, such as sheep or cows, eat herbaceous vegetation, not woody vegetation. In addition, grazing animals in the river corridor or ephemeral stream drainages could pose water quality problems and accelerated erosion of streambanks.

Suggested Alternatives

Citizen's Protection Plan

16. Comment: Consider the "Citizens Protection Plan" to reduce hazardous fuels in the Santa Fe Watershed.

- "The Citizen's Protection Plan reduces hazardous fuels in the Watershed without heavy machinery, construction of new roads or commercial logging. It calls for pruning the lower limbs of overstory trees to raise crown height, removing brush and small-diameter understory trees and retaining most of the overstory tree canopy to shade the ground and prevent surface fuels from drying out. Labor intensive manual thinning would provide jobs and income for local workers and businesses." (Letter 223)
- "The National Environmental Policy Act and Forest Service regulations require that the Forest Service analyze and evaluate reasonable non-commercial alternatives. The National Environmental Policy Act requires the agency to 'rigorously explore and objectively evaluate all reasonable alternatives.' 40 C.F.R. [section] 1502.14(a). In addition, the agency is required to analyze a non-commercial restoration alternative FSM 2432.22c. The Wild Watershed Alliance's Citizen's Protection Plan reduces hazardous fuels without harming the long-term productivity of the forests and wildlife of the Santa Fe Watershed and surrounding area. The Plan is a reasonable and multi-faceted approach to ecological restoration that does not include commercial extraction. The Forest Service is therefore obligated to analyze and evaluate the Citizen's Protection Plan... The Plan calls for retaining the following elements of thinned stands: 1) all living or standing dead trees (snags) older than 100 years or with a d.b.h. of 12 inches or greater; 2) all dominant and co-dominant trees of both early and late successional species; 3) at least 40% of a younger stand's basal area and 60% of an older stands basal area; 4) course woody debris at or above levels recommended by Graham et al. (1994); and 5) at least 30% or more of the treatment area in an unthinned condition... The Plan calls for no thinning in slopes greater than 30 percent, sensitive areas... In addition, the Plan calls for manual thinning treatments to be staggered over time and intensively

monitored for water quality and impacts to soils. ...We call for the reintroduction of native trout, peregrine falcons and other native species to suitable habitat in the Watershed and adjacent areas of the Santa Fe National Forest. The reintroduction of extirpated terrestrial and aquatic species is feasible in the watershed and surrounding roadless lands because of the large expanse of unfragmented habitat and excellent condition of the Santa Fe River above the reservoirs. Santa Fe Lake has a population of pure Rio Grande cutthroat trout that could be reintroduced into the Santa Fe River. There may also be suitable habitat for peregrine falcon reintroduction. Reintroduction of native wildlife is supported by the public and vital to multi-faceted restoration." (Letter 643)

Response: *The National Environmental Policy Act (NEPA) and Forest Service regulations do not require analysis and evaluation of "non-commercial" alternatives. However, the treatment alternatives analyzed in the DEIS are considered non-commercial alternatives designed to restore sustainable Watershed conditions (DEIS, p.5). The treatment alternatives described in the DEIS reflect substantial citizen input and received substantial citizen support.*

With minor exceptions, the thinning and burning alternatives described in the DEIS are consistent with the thinning and burning recommendations outlined in the Citizen's Protection Plan. Like the Citizen's Plan, treatments described in the DEIS reduce hazardous fuels in the Watershed without constructing new roads. There will also be no use of commercial logging equipment. As suggested in the Citizen's Plan, the alternatives in the DEIS are expected to help restore sustainable ecological conditions without harming long-term productivity of forests and wildlife (DEIS, pp.41-105). As suggested, they retain the important structural and functional elements of the ecosystem within the thinned stands, including the older living or standing dead trees (snags), the largest (dominant and co-dominant) trees of early and late successional species, course down woody debris, and patches of unthinned stands. As suggested, they also involve staggering the treatments over time and intensively monitoring their effects (DEIS pp. 3, 18, 19).

The thinning and burning treatments described in the DEIS differ from the Citizen's Plan in the following ways: 1) treatments are not limited to slopes less than 30 percent, because such a limitation in this area domi-

nated by slopes over 30 percent would not allow us to treat sufficient acreage to meet fuel reduction objectives (DEIS, p. 55,56); 2) treatments do not include pruning the lower branches of trees because we believe we can meet fuel reduction objectives without such a high-cost activity, based on past success with similar projects (DEIS pp. 52, 55,56); 3) treatments reduce the basal area and canopy cover to a slightly lower amount than suggested, in order to meet fuel reduction objectives based on the latest scientific research and analysis (DEIS pp.50-56 and 141-153); 4) treatments may utilize a feller-buncher machine to cut the trees, although no logs would be dragged by these specialized thinning machines (see response to Comments 24-29 regarding feller-bunchers); and 5) there are some differences regarding the use of fuel breaks, which is discussed in the response to Comments 54-60.

The DEIS states that after treatment, “Watershed conditions would support small-scale, low-intensity surface fires rather than large, uncontrollable crown fires, thereby promoting ecological sustainability” (DEIS p. 5); “Burning the slash would release nutrients into the soil and promote regeneration of grasses and other plants, restoring ecological processes for fire-adapted organisms” (DEIS p. 16); and “... long-term productivity would be enhanced by the treatments, through creating openings in the closed-canopy forest areas and reintroducing low-intensity surface fires, which together should improve productivity” (DEIS p. 135).

The Citizen’s Plan recommends a few other actions that are considered outside the scope of this project-level analysis and decision-making process: Opening the Watershed to recreational activities; designating the non-wilderness portion of the Watershed as a wilderness area; and reintroducing native species. The first two recommendations have previously been addressed (see responses to Comments 2 and 4). Regarding reintroduction of native species, we generally support this idea and it is our policy to encourage the New Mexico Department of Game and Fish to reintroduce native species where national forest lands have habitat to support their reintroduction. However, species reintroduction is not within the jurisdictional authority of the Forest Service to implement, and is not relevant to this fuel reduction project decision.

For those interested in pursuing this idea further, we would like to pass on some information. Most species native to the Watershed area are already present in the Watershed, with the exception of species such as wolf, grizzly bear, Rio Grande cutthroat trout, peregrine falcon and osprey. The extirpated species of wolf and grizzly bear could not be reintroduced because not enough habitat exists to support them and due to the proximity of

human development and habitation. The Rio Grande cutthroat trout cannot be reintroduced without the total elimination of the rainbow trout presently in the Santa Fe River and reservoirs, because the two species readily hybridize. This would be a major undertaking by the city and state, involving killing (with chemicals) all the rainbow trout prior to reintroducing the Rio Grande cutthroat. The state has a policy to not reintroduce American peregrine falcon in New Mexico because an indigenous population exists and the introduction of birds obtained from falconry stock is not favored. The peregrine falcon is slowly re-occupying suitable nest sites in New Mexico without human intervention. During the past year a nest pole was erected to attract osprey. They are seen around the reservoirs in the spring but they have not attempted to nest as they have at other reservoirs in the state.

Forest Conservation Council Alternative

17. Comment: Reconsider the Forest Conservation Council’s alternative, involving low-impact thinning, no timber harvest, more prescribed and natural fire, and financial assistance to landowners to help fireproof their property.

- “The DEIS fails to consider an adequate range of alternatives. In FCC’s 2/18/2000 comments, we specifically requested analysis of a no harvest alternative based on recommendations contained in Forest Service literature and regulations. The alternative included three major components: (1) prescribed burning; (2) lop and scatter thinning of small-diameter thickets; (3) assistance to private landowners to help fire proof private property and structures. The DEIS failed to analyze the alternative. Instead, the DEIS separated components 1 and 2, then provided reasons why these components could not be implemented by themselves. DEIS at 161 and 162. Despite the clear intent of our alternative-to pursue thinning and burning together- the DEIS erroneously separates the two and discredits them as stand-alone options. The DEIS fails to address the third component, assistance to private landowners, altogether. The alternative package we developed was based on clear requirements of Forest Service regulations. In all projects involving ‘stewardship’ goals, the Forest Service Handbook and

Manual explicitly required consideration of non-harvest alternatives . . . Clearly, the alternative ‘package’ we proposed is a reasonable alternative justified by the literature capable of meeting all project goals and objectives in an efficient manner, and explicitly required by Forest Service Manual and Handbook guidance. The Forest Service’s rejection of this alternative without consideration is arbitrary and capricious. We hope that you will . . . consider another alternative which is based upon selective, low-impact thinning with no timber harvest, greater reliance on prescribed and natural fire, and financial assistance to nearby landowners to give them the resources they need to reduce fire risk on their properties.” (Letter 230)

Response: *The Forest Service did consider a no-harvest alternative, referred to in the DEIS (p. 26) as “Option A”. Option A was analyzed in combination with low impact thinning, followed by prescribed burning. The suggested lop-and-scatter slash disposal method is also included as an option for all treatment alternatives (DEIS, p. 16). None of the alternatives involve commercial timber harvesting (ie. removal of saw timber products or use of log-skidders, loaders or log trucks). Alternative B1 with Option A is virtually identical to the FCC suggested alternative. It involves a limited amount of low impact thinning-from-below, followed by slash burning, no wood removal, and a much larger acreage of prescribed burning alone.*

In addition, the planning team considered a no-harvest alternative that called for using prescribed burning alone to reduce hazardous fuels without mechanical thinning (DEIS p. 162). This alternative was later eliminated from detailed study because it clearly would not meet the primary fuel reduction objective (purpose and need) based on current fuel loadings. It was determined that a relatively “hot” fire would be needed to adequately reduce the numbers of live pine trees over 6 inches in diameter, in order to meet fuel management objectives. The analysis in the DEIS found that a controllable low intensity burn would not reduce crown bulk densities below the desired threshold, so those areas would remain vulnerable to sustaining crown fire spread (DEIS p.54). A higher intensity prescribed burn would be too risky due to existing abundance of ladder fuels, overstory canopy fuels, topography and proximity to residential areas and the municipal water supply. The planning team also considered another no-harvest alternative that involved thinning only the trees 6 inches in diameter or less (DEIS, p. 162). However, it too was determined to not meet the purpose and need for this

project. This alternative would not create openings in the overstory canopy sufficient to reduce crown fire risk. It would also not encourage growth of ground vegetation, or provide a safe space for burning the slash.

If these two alternatives of no harvest and burn only were combined into a single alternative as FCC suggests, the combined alternative would still not meet the purpose and need, and would create less acceptable conditions than either of the alternatives considered individually. Thinning only trees 6 inches or less and then trying to control a prescribed fire would be extremely difficult if not impossible without losing the entire stand to fire. The residual stands would still be too thick (crowns too close to one another) to reduce the chance of crown fire (DEIS pp.54, 161).

Regarding the suggestion to provide assistance to private landowners, the Santa Fe National Forest is already actively involved in a cooperative, interagency “Firewise” program that is doing just that. It is a separate action and program of work outside the scope of this fuel reduction project. However, agency personnel have been consistently working with local landowners to find ways to reduce the fire risk on their properties. Many “firewise” methods require little or no cost, yet the Firewise program has provided some financial assistance to homeowners for fire protection (such as those in the Hyde Park Estates located on the north west edge of the Watershed). In addition, our forest recently awarded \$670,000 in grants for community planning for fire protection, including Rio Arriba County, Eight Northern Indian Pueblos, San Miguel County, Truchas Land Grant, Hondo Fire District and Mora County (more information about fire protection activities can be found at www.fs.fed.us/r3).

Another Alternative

18: Comment: Consider dry wood gathering, dozer roads, water pumping vehicles and fire towers, as an alternative for the Watershed.

- “What is the first step? How about cleaning up the forest of all dry wood... get hold of a large “cat” and cut six meter wide roads, so that trucks with water can get to a fire. Get a large and one small truck to haul water and each has a good pump... Build one or two high-up watch-towers, for a constant watch-man during the dry season or all the time. He too should have a small jeep with water – trailer and machetes.” (Letter 20)

Response: *The hazardous fuels that must be reduced in the Watershed in order to minimize the risk of catastrophic crown fire are the living conifer trees that average 600-1000 trees per acre in an ecosystem that historically supported an average of well less than 50 trees per acre. Thus, gathering dry wood from the forest floor would not meet the purpose and need for this project. Likewise,*

building dozer roads and fire towers, and having water pumping trucks, would not meet the primary objective of this project that is to reduce hazardous fuels. We agree that during fire suppression, or to prepare for broadcast burning, water pumping trucks may be required. It was determined that building new roads was not appropriate for this area (see response to Comments 13 and 14).

There are numerous examples of catastrophic fires occurring in similar stand conditions throughout the interior West, including last summer's Viveash Fire that occurred near the Watershed. The author of this concern places a lot of confidence in the Forest Service's ability to continue to suppress fires. It is common knowledge that suppressing wildfires is becoming more difficult and dangerous even with advances in fire suppression techniques. This is due to ever-increasing fuel loading in forest types that experienced frequent, low intensity fire occurrences prior to fire suppression and people's continued desire to live in a forested setting. The large wildfires that occurred in New Mexico over the past 5 years burned uncontrolled for over 2 days before suppression efforts could begin to become effective.

The other No Action alternative analyzed, without a high-severity crown fire, "assumes little or no change from current conditions, and provides a baseline for comparing the effects of action alternatives" (DEIS, p. 15). This No Action alternative is required in order to meet National Environmental Policy Act regulations at 40 CFR 1502.14(d) and FSH 1909.15 sec 14.1. We agree with the author of this concern that insect activity, wind, and natural succession would continue under this No Action scenario, and the DEIS describes these kinds of ongoing natural disturbance and vegetative succession events that would continue to occur in the Watershed (pp. 44-48). Currently, natural succession is allowing more fir trees to become established in the understories of stands historically dominated by ponderosa pine, thereby increasing the abundance of ladder fuels and fire-susceptible species. Tree mortality caused by insects, and trees blown down by high winds, are also causing increased fuel accumulations, making a high-severity wildfire even more likely.

If forest stands within the Watershed were within their historic range of variability, the processes described by this author, along with periodic low-intensity burns, would help maintain the Watershed in a more diverse

and healthy condition. However, existing conditions within the Watershed are so far outside that range of variability that relying on natural fire ignitions to return the ecosystem to this favorable condition would be very risky and highly unlikely. Allowing a fire to go unsuppressed under current conditions in the Watershed would be extremely dangerous, not only due to the dense fuel loadings but also due to the close proximity to homes, historic structures, popular recreation sites, and the municipal water supply.

No Action Alternative (For)

20. Comment: Do not implement any fuel reduction treatments.

- "Let nature take its course. Your good intention of protecting the watershed could and - given history - very likely will lead to unforeseen consequences. Please leave the forest alone before much of local life has to suffer the consequences of your shortsightedness." (Letter 5)
- "Per your report on the Santa Fe Watershed project please note I vote for Alternative A [no action]. No trucks and fuel should be allowed [sic] in this delicate area." (Letter 220)

Response: *If we selected Alternative A, the no action alternative, we would very likely experience highly damaging impacts to all the precious natural resources in the Watershed as well as to the citizens who live and recreate next to the Watershed. These negative impacts are clearly spelled out in Chapter 3 of the DEIS. The likelihood of a severe wildfire is also discussed in response to Comment 19, and we address the concerns about haul trucks in response to Comments 30-38.*

Preferred Alternative(s)

Preferred Alternatives (For)

21. Comment: Implement the preferred alternative.

- “The Department (Game and Fish) supports the implementation of the Forest Service’s preferred action, a combination of manual and machine thinning, and slash pile and broadcast burning. According to the DEIS, in general, no trees over 16-inch DBH will be felled, and treatment areas will ultimately contain an average of 50 to 100 trees per acre, in a highly variable, clumpy pattern that mimics natural disturbance patterns.” (Letter 21)
- “We support the Alternative suggested in the cover letter for the DEIS which combined Alternatives C1 and D1 and use of the adaptive management strategy.” (Letter 224)
- “We can not eliminate the possibility of a catastrophic fire occurring in the watershed, but we can reduce both the probability and the size of such an occurrence. Treating the watershed with any of the proposed fuel reduction alternatives will reduce the size and intensity of a wildfire. Of the proposed Alternatives, C1 and D1 offer the most protection. However, combining Alternatives C1 and D1 using the adaptive management strategy will provide a much more flexible alternative.” (Letter 228)
- “I support options C1 and D1. I think that radical steps are needed to get the watershed into a condition where it will not be wiped out of wildfire similar to the Cerro Grande fire. The area needs to be restored to healthy forest and this can only be done by removing a large number of smaller trees and then using prescribed fire to prevent clogged understory growth. Between C1 and D1, I prefer whichever approach has less impact on the forest understory and leaves the area in a natural state.” (Letter 660)
- “I support alternative D1, machine thin/burn slash/broadcast burn. To some extent, manual thinning will also be required. Further, the overall rate at which the project can proceed will be enhanced by a combination of manual and machine thinning.” (Letter 227)

- “It is my desire to see alternative C1 applied to the watershed area (as well as almost all of the intermountain non-wilderness west from the Klamath to Elk mountain).” (Letter 27)

Response: *We greatly appreciate the many supportive comments we received regarding our preferred alternatives. The analysis in the DEIS indicates that Alternatives C1 and D1 would be the most effective means of reducing hazardous fuels to protect the Watershed, while minimizing adverse consequences as much as possible.*

Limit Preferred Treatments

22. Comment: Limit treatments to those that are necessary, cost effective, based on a proven track record, and protect ecological integrity.

- “While FCC wholeheartedly agrees that some form of vegetation treatment may be necessary to reduce the potential for catastrophic fire, we believe that such treatments should be limited to those which are truly necessary, those which are based upon a proven track record, those which are cost effective, and those which protect the ecological integrity of the Watershed... We believe the preferred alternative you have selected misses this mark [some vegetation treatment] by a wide margin. The alternative represents a ‘sledgehammer’ approach to forest management in a situation that calls for precision and care. The extensive amount of logging you propose has the potential to exacerbate, rather than reduce fire danger, extirpate wildlife, increase sedimentation and flooding, and force taxpayers to foot the bill for an enormously expensive project whose benefits are highly uncertain.” (Letter 230)

Response: *The resource specialists and scientist consultants involved in planning this project determined that the fuel reduction treatments prescribed for this area are necessary, based on a proven track record, and designed to protect the ecological integrity of the Watershed. They have compared what would happen with different levels and types of treatment (DEIS pp. 33-40). The analysis in the DEIS indicates that the selected treatments are expected to reduce the risk of fire and flood impacts to Santa Fe, while improving wildlife habitat and long-term soil stability (DEIS pp. 18, 33, 51-56, 60-72, 96-98).*

Scientific research has consistently validated what the Forest Service has observed for decades; that the thinning-from-below combined with prescribed burning is the most effective way to reduce fuels loads and the risk of severe wildfire impacts (see the relevant scientific literature in the DEIS pp. 4, 52 and 141-153). The selected alternatives were determined to be the most effective for meeting fuel reduction objectives while restoring sustainable watershed conditions (DEIS p. 55-56).

We should probably note that this is not considered a logging project, because the objective of logging is generally to remove the most merchantable trees from the forest while this project involves cutting the smallest and least merchantable trees in the area in order to meet non-timber objectives (DEIS, pp. 1, 16). The DEIS provides ample evidence that the selected fuel reduction methods are scientifically sound and environmentally sensitive, considering the existing condition in this Watershed. Most environmental groups support this plan because it: leaves all the largest, most mature trees as well as most snags and down logs; creates a highly variable mosaic of tree densities and sizes that mimics natural disturbance patterns; and reintroduces the important ecological role of fire. Implementing in stages over many years allows us the opportunity to monitor and evaluate the effects of treatments, and make adjustments as needed (DEIS, pp. 19, 27, 164-169).

There are no guidelines on what percent of an area must be treated to reduce the risk of crown fire. Research indicates that the more acreage treated to reduce fuel loading, the greater the chance at reducing the severity and extent of a crown fire. Our experience with the Cerro Grande Fire showed that the larger areas that had been thinned before the fire experienced significantly less damage compared to smaller areas that had not been thinned. Stands in the Garcia area of the Cerro Grande Fire where fuels had been adequately reduced over a large area resulted in the active crown fire dropping to the ground and becoming a surface fire resembling a broadcast burn, even under the extreme fire weather conditions present during the early days of the Cerro Grande Fire.

Regarding cost effectiveness, the Forest Service realizes that the cost of proposed treatments will be high, especially with the lack of road access. The analysis team developed and analyzed the effects of alternatives independent of cost criteria. The cost for treatments were estimated to be \$3-4 million, while the cost of allowing a catastrophic fire to occur in the Watershed was estimated at over \$150 million (DEIS pp. 123-124).

Expand Preferred Treatments

23. Comment: Expand treatments in order to ensure adequate protection of the Watershed from catastrophic fire.

- “Alternatives C1 and D1 are acceptable as far as they go, but I don’t believe they go far enough. The climate is warming; we have had two drought years with terrible fires in the last seven years. So your proposals do not take enough action and are oversensitive to maintaining the area just as it is. If there is a major fire, the area will be totally changed...” (Letter 18)

Response: We recognize the need to continue to expand fuel reduction treatments beyond the project area (DEIS pp.18,19), and to use adaptive management practices to evaluate the effectiveness of treatments and make modifications as needed (DEIS pp. 19, 27, 163). In designing this project, in collaboration with interested citizens and other scientists, we had to find a way to achieve an effective fuel reduction treatment while protecting the soil, water, habitats and other valuable resources in the Watershed. The analysis in the DEIS indicates that the selected alternatives should both ensure adequate fire risk reduction without incurring significant adverse environmental impacts (DEIS pp. 33-40, 52-56, 135).

Alternative D1: Machine Thinning

Machine Thinning (For)

24. Comment: Use machines to thin trees to reduce the impacts to lands.

- “With much certainty I support mechanical logging, motorized feller-bunchers, select cutting, thinning in both the City of Santa Fe area and USDA Forest Service Lands within the Santa Fe watershed. Proper modern technology applied to this project allows safe logging, thinning and fuel reduction with minimal impact to the area.” (Letter 2)
- “I support alternative D1, machine thin/burn slash/broadcast burn. This addresses the problem in as quick a fashion as possible”. I recommend that to the extent conditions allow, the project be pursued in as aggressive a manner as possible.” (Letter 227)
- “Of the proposed Alternatives, C1 and D1 offer the most protection. However, combining Alternatives C1 and D1 using the adaptive management strategy will provide a much more flexible alternative”. (Letter 228)
- “As to the appropriate Alternative, I would suggest a combination of two. I support the 36% thinning as in B, but I also support the use of mechanical thinning as in D1. I believe this would be the most expeditious method. The sooner the project is completed, the better.” (Letter 27)
- “We’d select Alternative B-1 except for wood removal and the diameter limit. But we have no objection to use of your impressive-sounding thinning machine.” (Letter 42)

Response: Thank you for taking the time to write a letter supporting the selected alternative. Alternative B1 was the original proposed action for this project, in part because it is the most expeditious method of treating a large acreage. Alternatives C1 and D1 were developed and later preferred over B1 because they will be the most effective fuel reduction treatments for this project area. Using machines to do at least some of the thinning will provide us with the flexibility to more efficiently and safely reduce fuel loads in the Watershed, with minimal environmental impact.

Machine Thinning (Against)

25. Comment: Do not use machines to thin trees because their use may adversely impact soils and wildlife, and increase fire hazards.

- “Alternative D1 alternately simply bothers me or gets my dander up to stratospheric heights. Here’s why... A good thinner inevitably considers every tree individually. A machine is only as good as its operator. I’m sure every contract inspector you care to ask has one or more horror stories of some darn yahoo who thinks they’re god when they climb in their cab. The separation from surroundings too easily creates a “Nintendo” attitude that often leads to destructive behavior. Machines do not run faster than a good crew. Crack thinners already exist in New Mexico, machines aforementioned don’t, there are a few harvesters around but these are not the low impact variety. Further, most of the operators of harvesters in this state operate in an almost clearcut conscience. Machines require a given width of travel that does not allow for proper clump-spacing, even with an articulating arm the option does not exist to light thin within the interiors of clumps. Although the new machines have impressive statistics as far as weight distribution, etc., the numbers become meaningless after days and weeks of going up and down slopes in the morning and day’s end. An operator is more likely to gun it and spin up rough slopes rather than take the time to ease their way around when pay is by the acre. Hand crews have the option of ‘popping over’ from Camp Stoney or Hyde Park Roads and making narrow runs down to the Santa Fe River, thereby eliminating a great deal of fatigue. Never underestimate the will and drive of a New Mexico thinner.” (Letter 23)
- “...if you do not choose option B1, please choose C1, so as to minimize impact on the forest floor, wildlife, vegetation, soil, etc. by not introducing machinery into the forest. As you say in your DEIS, economics are not an issue for this project, so hopefully you will not be persuaded to opt for machinery in order to save money, and shorten the job.” (Letter 13)

- “We oppose the use of a feller-buncher in the Watershed. The primary reasons for this position are ecological. A machine of this size will undoubtedly cause erosion. On steep slopes, the machine will be placing logs on the slopes, rather than driving over them. We disagree with the assertion in the DEIS that the rows and piles of whole trees would not significantly alter expected fire behavior and ecological effects. The machine would leave a track of whole trees through the forest.” “Given the topography of the Watershed, it may not be feasible to thin, either manually or with a machine, in some of the proposed treated areas where slopes are greater than 40%. Slopes greater than 40% should not be mechanically thinned with a feller-buncher. . .” (Letter 229)
- “Citizens expressed strong opposition to the use of feller-bunchers. Feller-bunchers can significantly increase fire danger.” (Letter 223)
- “We strongly oppose . . . the use of feller-bunchers. Clearcutting ridgetops will reduce shade creating even more of a fire hazard.” (Letter 217)
- “The Forest Service failed to disclose the environmental consequences of feller-bunchers as required by the National Environmental Policy Act. Feller-bunchers that must travel across soil to reach each tree may be doing long-lasting damage to soils and watersheds through soil compaction and soil churning. The first pass of the vehicle causes the most damage which might well be hidden under a layer of undisturbed duff . . . The public has not been presented with any information concerning soil water infiltration rates and soil bulk densities in the watershed so it is impossible to quantify the impacts of feller-bunchers to soils. But clearly the balance between organic matter accumulation and decay will be altered, perhaps to a significant degree, by the widespread use of feller-bunchers.” (Letter 643)

Response: *We would like to begin this project with the flexibility to use both manual and machine thinning, in different parts of the project area. We did not want to exclude the option of using a tool like the feller-buncher machine to accomplish our fuel reduction objectives, based on the information we have gathered and observed regarding feller-buncher use in the western US.*

We understand the concerns expressed, and in order to avoid those potential pitfalls, contracts for both manual and machine thinning will have strict provisions governing conduct, specifications and penalties for non-performance. Bidders on any thinning contract will have to submit a lengthy proposal detailing past experience, include references, and they will need to demonstrate their ability to perform the job to specifications. Forest Service personnel will visit the job site on a regular basis to monitor the contractor’s work. By allowing for both manual and machine thinning to be done in the beginning, we can monitor and compare each method, and determine which one may be the preferred method to use in this area in subsequent years.

We believe that feller-bunchers can be used in the Watershed without significant adverse impacts to soils. The machines will create soil disturbance, but this does not necessarily result in reduced site productivity or other impacts (see Abeels, P.F.J. 1995). Soil compaction is also a function of soil type and moisture content. The coarse, stoney, dry soils in the Watershed are not very susceptible to compaction, and compaction seldom occurs when soils are frozen.

Studies that have quantified changes in soils due to mechanized harvesting included impacts from skidding or forwarding the trunks out of the woods, which will not be done in the Watershed. Therefore, the impacts described in the studies should be viewed as far greater than what would occur in the project area. The number of passes a machine makes over an area is also important—the fewer passes the less soil disturbance or compaction. One study of machine thinning in Oregon showed soil bulk density (a measure of compaction) in the machine trails increased only 12 percent compared to undisturbed areas (Allen and Taratoot. 1999), which is at the low end of the levels that can produce discernible effects on tree growth (Froelich and McNabb 1984). The study concluded that the machine’s movement over the terrain probably contributed most to the soil disturbance and compaction. Areas of exposed soil were small and discontinuous, which alleviates concerns about potential erosion problems (Williams, J. 1988). A similar study in Oregon documented a minimal amount of exposed mineral soil from machine thinning—0.6 to 3.2 percent of the area thinned with a machine harvester/forwarder system (Youngblood, A. 2000). Soil disturbance occurs where the harvester makes a sharp turn. Another study in Vermont also found that soil bulk density increased but not to a level detrimental to root penetration or seedling establishment. These increases were temporary and 2 years later the soil bulk density was at pre-harvest level (Donnelly and Shane 1991). This study included the effects from mechanized log skidding, which will not occur in the Watershed.

Thus, scientific research results combined with our onsite observations of feller-buncher thinning operations, minimizes our concerns about environmental effects of thinning with these machines. These machines have been used extensively and successfully in the Intermountain West for the past 20 years. Feller-bunchers are specifically designed to work on steep slopes with minimum impact. These tracked machines exert only 3 to 7 pounds per square inch (psi) of static ground pressure depending on the make and model. An elk would typically exert on the order of 15 psi. The machine is able to reach out with a long grapple arm and thin 22 feet on each side rather than having to drive up to each tree. This permits the machine to thin a 50-60 foot swath from a single machine path, thereby confining soil disturbance to two 1-foot wide tracks with a nominal 8-foot wide wheel base. It can thin 1/20th of an acre while remaining stationary. Thus, the number of passes over the ground is quite limited. The machine can cut and hold several small trees vertically in the air, then place them down gently into a pile. Thus, by not falling, dragging or skidding the trees and branches, impacts to residual trees and the soil is substantially reduced (see DEIS p.25 for more information and photographs).

Piling and burning the bundles of whole trees in this manner results in the fuels less than 3 inches in diameter being consumed and the larger diameter wood remaining charred but not consumed (DEIS p. 53). The fuels less than 3 inches in diameter are of the most concern, according to fire behavior specialists. The larger diameter stems that don't burn in the prescribed slash burning would not increase the intensity or spread of a wildfire that might occur in the area after treatment.

The use of feller-bunchers will create noise disturbance equal to or less than disturbance from manual work crews with chain saws. The analysis documented in the DEIS indicates that there will be no other adverse effects to wildlife associated with the use of feller-bunchers (DEIS pp. 98-99). The DEIS describes effects regarding use of feller-bunchers on each affected resource, under Alternatives D1 and D2.

Machines: Non-local Labor

26. Comment: Hire people from within New Mexico to conduct thinning, rather than using machines from out-of-state.

- “A reason we oppose the use of a feller-buncher is that this project should support the local economy by creating jobs for local workers. There are no local contractors with

feller-bunchers. This project is an opportunity to engage local people in fuel-reduction work and can be [a] model for future projects in the Southwest.” (Letter 229)

- “C1 treated the largest area while maximizing economic benefits to the regions. D1 would depend on a contractor with the appropriate equipment, which eliminates all potential candidates in New Mexico and the region. While we appreciate the reduced risk to workers under the D1 alternative, our sense is that local/regional forest industries would appreciate the opportunity for employment and training of forest workers. One possibility may be to begin with the labor-intensive approach, and hold out the possibility of contracting with a feller buncher to ‘mop-up’ the remaining areas to be treated if progress is too slow or there are other factors that favor mechanized thinning.” (Letter 640)
- “Given the lack of in-state machines, it would alienate and anger the local communities to bring them in. New Mexico is at the top of the poverty list, manual thinning has the potential of creating many good jobs. As the bid-per-acre will no doubt increase, so should the minimum tech wage be raised from its current (\$8?) rate, as long as the individual thinner can afford good chaps, hats, boots, etc., the more safe he or she will be able to operate. Further, it should be an imperative of the contracting officers to make sure that the contractor in name is not hiring out a bunch of low paid hacks in order to only enrich himself over the needs of the forest. Machines almost always necessitate this dreadful possibility. It is easier and more efficient to train a sawyer than an operator. This allows more concentration on training for good clump-space thinning practices. ... Machines can't drop and lop like a hand crew can. I've seen both and I am assured that a good hand crew can out perform any machine, without any John Henry outcome, better, faster and cheaper. As there really are not any machines in New Mexico it must be considered that anyone with the capitol to invest in them in New Mexico more than likely has little or no thinning experience. As a thinner I have come to believe that it is easier to train a monkey to thin over a someone who has only logged or cut firewood, forget about

some bubble-butted equipment operator. Any one with the capital to invest in a machine will have the obligation to pay for it over the need to execute a good and safe operation. I believe that a minimum bid of somewhere around \$400 an acre is what should be appropriate.” (Letter 23)

- “I believe local labor should be used because I think the project should be kept as local as possible for economic reasons and community sentiment towards the project.” “I believe that . . . manual labor (local people) should be used instead of the people from Montana.” (Letter 36)
- [Similar comments from Letters 18, 223, 647, and 654]

Response: *We understand the concerns expressed about providing local jobs, and the DEIS discusses the employment situation in New Mexico as it relates to this project (DEIS, pp.122-124). It is our policy and goal to provide employment opportunities to New Mexico residents, particularly when we implement the National Fire Policy aimed at reducing fire risk in our forests. We anticipate that we will provide numerous opportunities for manual thinning contracts in New Mexico, including contracts to manually thin trees in the Watershed. We also provided major financial grants this year for enterprises aimed at utilizing small trees and wood residue from forest fuel reduction (thinning) projects. While it is true that forestry companies in New Mexico currently do not have feller-bunchers, this situation may change in the near future, as it has in other western states. More and more contracts for thinning with machines are being awarded in New Mexico, including a current operation in Angel Fire. Even if we limited our contracts to manual thinning methods, we cannot guarantee that they will be awarded to a New Mexico resident. When a Forest Service thinning contract goes through the Federal procurement process, we cannot guarantee the locality of qualified bidders. Bids must be evaluated as to how well the bidder can meet the objective and at what price.*

The selected alternative allows for the use of both manual and machine thinning contracts, in order to provide the necessary flexibility in order to meet project objectives. We plan to issue short-term contracts in the beginning, in order to use an adaptive management strategy and maintain future options. Through annual monitoring of manual and machine thinning contracts, we will be able to better determine whether one method should be used exclusively or not.

Machine vs Manual: Monitor

27. Comment: Monitor manual and mechanical thinning to determine the best method.

- “An experimental approach to using manual and mechanical thinning would be best. If such an approach is not feasible, a more qualitative approach might serve; however, this is a question the Technical Advisory Group should comment on.” (Letter 642)
- “Manual vs. machine thinning. There appear to be a variety of advantages and disadvantages to both manual and mechanical thinning techniques, involving issues of safety, efficiency, and cost. Since there is not yet a clear understanding of the consequences of machine vs. manual thinning, we propose that both methods be used for a period of time. The effects of the two methods can be monitored and evaluated, and a decision to go ahead with one method for all of the project can be made based on which method results in the least soil structure impact and erosion, and on the best safety and economics record.” (Letter 645)

Response: *We agree. Selecting the combination of manual and machine methods of thinning (Alternatives C1 and D1) provides the flexibility to use either or both of these methods based on results of monitoring and evaluation.*

Machines: Steep Slopes

28. Comment: Address how to navigate machines around slash on steep slopes.

- “While I like the idea of scattering branches for broadcast burning and better distribution of nutrients, what about the problem with navigating the feller/buncher around the slash piles as it operates on steeper slopes?” (Letter 647)

Response: *The feller-buncher operator will not likely have much difficulty navigating around numerous piles of slash. In the machine thinning operation, the branches and tops are not cut off and piled, but remain on the tree stem. On the more gentle terrain, the feller-buncher machine will place bundles of cut trees in front of the machine and drive over those small stems as it moves up*

slope. On steeper slopes (over approximately 30 percent), the feller-buncher will generally place the cut trees in bundles off to either side of the machine (DEIS p. 25).

The least amount of soil disturbance tends to occur when slash is placed in front of the machine and the machine walks over the slash. The next amount of disturbance occurs where the slash is placed in small stacks to either side of the machine. The greatest chance of soil disturbance occurs when the machines need to maneuver over more ground in order to scatter the slash.

Machines: Worker Safety

29. Comment: Quantify or document the relative risk to worker safety from thinning with feller-bunchers compared to manual thinning.

- “The DEIS-SFW justifies feller-bunchers based upon worker safety. However, the relative risk of personal injury in manual

and mechanical work is not quantified or documented.” (Letter 643)

Response: *Feller-bunchers are being used on similar fuels projects throughout the West, including New Mexico, with good results and safety records. The feller-buncher in this project will be used to cut trees and place the trees in piles for later burning. A feller-buncher can generally cut 800 to 1,000 trees per day on slopes up to 50 percent, including bundling small trees as they are cut and placing the bundles into piles. A person with a chain saw can cut and pile approximately 50-100 trees in a day. With a feller-buncher, the operator is seated in an enclosed and protected cab. On the other hand, the chain saw operator is constantly walking on difficult terrain and exposed to the weather elements and rigors of working under extreme physical conditions. A feller-buncher operator can do as much work in a day as 8 chain saw operators. Our research and observations indicate that the probability is much greater of having a chain saw operator injured than a feller buncher operator (DEIS p. 120).*

Option A: No Wood Removal

Wood Trucking: Need

30. Comment: Allow wood to be trucked through east-side neighborhoods if necessary to reduce fire risk.

- “More traffic is a necessary pain to get the cut wood out. The residents of the area are better off with more truck traffic than having the nearby mountains, and perhaps their houses, burned.” (Letter 18)
- “Santa Feans are familiar with large delivery trucks going up and down the east side roads in order to build multi-million dollar homes and a few thousand logging trucks going by would be welcomed. Knowing that this fuel reduction and timber producing project will preserve this area for generations to come.” (Letter 2)

Response: *The alternatives in the DEIS considered removal of wood on up to 560 acres, but that original acreage estimate has been substantially reduced upon additional field reconnaissance. Some wood will be removed from this project area from the City-owned lands. The selected alternative does not allow additional wood hauling from national forest lands in the Watershed, since very little accessible firewood will remain once the wood has been hauled from City lands in the Watershed (see Record of Decision). The analysis in the DEIS indicates that leaving this small amount of wood to be burned as slash or left on site will not measurably affect our ability to meet fuel reduction objectives in this area. The impacts associated with wood hauling on local neighborhoods are described in the DEIS, pages 119-122.*

Wood Trucking: Quality of Life

31. Comment: Do not allow wood to be trucked through east-side neighborhoods because of impacts to safety and quality of life.

- “Eastside streets are notoriously narrow, and maneuvering huge lumber trucks through them, though feasible, would—by their noise, their bulk, their holding up of traffic to make the difficult turns—make life miserable for years to come for both residents and the many tourists on which Santa Fe’s economy depends.” “Trucking thousands of loads of wood would have a hugely nega-

tive impact on life on the east-side neighborhood of Santa Fe and on the city of Santa Fe generally. Recently (the work is still ongoing) the city redid the sewer line running down the middle of the road, causing huge disruption to the lives of locals and to many others. That disruption would be only a mild foretaste of the disruption caused by the truck trips back and forth down the road necessary to take the timber out.” (Letter 41)

- “Anyone who uses this road could tell you that it’s already ill-equipped to handle the traffic. There are times when it seems impossible to get in or out of the neighborhood. My concern is that dozens of logging semis every day on an on-going basis for the next few years will make it totally impossible for people who live here to function. How can we get to work, or get our kids to school if we can’t get out of the canyon? It’s already a struggle; ask anyone who’s been around for the recent sewer line repairs. When traffic increases on Cerro Gordo because Canyon is impassible, the amount of dust that’s kicked up on the road is hazardous. It truly affects the quality of life . . .” (Letter 218)
- “Obviously the quality of life along the road would dramatically suffer given the noise and pollution.” (Letter 44)
- “... Stick with Option A and avoid the 40 to 50 logging trucks driving through my neighborhood. I understand that this option doesn’t reduce the effectiveness of the thinning program.” (Letter 6)
- “...Leaving the felled wood in place seems far preferable to sending numerous logging trucks thru Santa Fe’s streets.” (Letter 7)
- “The road, the neighborhood, the houses, the animals, the people, the market values, the community would all suffer greatly if removal were to proceed on such a large scale and for so long a period of time. Please no large trucks or high traffic volumes.” (Letter 27)
- “The introduction of a steady stream of wood-hauling trucks would destroy the ambience of this historic district, which includes some of the oldest homes in the city. A group of several dozen of us have been working with the city for more than a year on plans to

reduce truck traffic in the area. The sudden introduction of logging trucks would undermine all that we have tried to accomplish.” (Letter 26)

- “I urge you to choose Option A, which leaves the felled wood in place, rather than sending as many as fifty logging trucks per day along our narrow roads. I urge it as someone who would not enjoy the noise of those trucks, nor wrestling with them on our narrow roads...” (Letter 8)
- [Similar comments from Letters 1, 4, 9, 14, 18, 25, 29, 35, 42, 217, 219, 224, 642, 643, 645, and 656.]

Response: *The impact of increased traffic associated with wood hauling upon the quality of life and ambiance along the travel route was identified as a key issue in the DEIS (pp. 12 and 113). Option A was developed to reduce these impacts by not allowing large trucks to haul wood through east-side neighborhoods. The City’s thinning contractor will be using small pickup trucks, typical of the size and weight of current vehicle traffic on the haul route. Once that contractor removes the wood that is accessible to the service road, there would not likely be more than approximately 50-120 acres remaining on national forest lands where wood could be feasibly removed from using manual labor and pickup trucks. The selected alternative decided against allowing additional wood removal from the Watershed, with a provision to reassess this decision based on monitoring results from the City’s thinning and hauling contract (see Record of Decision).*

Wood Trucking: Safety

32. Comment: Do not allow wood to be trucked through east-side residential neighborhoods because of safety hazards.

- “Upper Canyon Road in particular is narrow and winding, with no turnouts, no shoulders, numerous blind spots, continuous local traffic, pedestrians, bicycles and children. It is especially hazardous in winter. We have driven it to school and work for many years and can tell you that using it as a logging road would be a formula for disaster.” (Letter 659)
- “We have an even greater concern for the safety of pedestrians, bicyclists, and day to day local traffic. Additionally, Upper Can-

yon Road is a very popular place for many Santa Feans and tourists to visit. There are numerous points in the road where it is so narrow that a large truck and another vehicle (let alone another truck) cannot easily pass. These safety concerns would also extend to Camino Cabra, which is not built for heavy truck traffic.” (Letter 44)

- “Canyon Road is much too narrow to accommodate the added traffic... Logging would inflict months of misery and danger on these citizens. More crucially logging trucks threaten the lives of citizens, especially children. Logging loads are notoriously subject to tips and wrecks. Presently Canyon Road is a haven for mothers walking carriages, bikers, hikers, folks walking their dogs. All that neighborhood ambiance would be destroyed.” (Letter 221)
- “I support Option A of the DEIS to reduce logging traffic on dangerously narrow Upper Canyon Rd, Camino Cabra, Camino Cruz Blanca, Camino del Monte Sol and Old Santa Fe Trail. These roads run past 5 schools and thousands of homes on extremely narrow streets—in some cases they are 1 lane only with sharp curves and with walls and buildings right up against the street with no buffer zone like a sidewalk.” (Letter 654)
- “It should be pointed out that there is a day school (the Gentle Nudge) on Upper Canyon Road and three schools and a college along Camino Cabra and Camino Cruz Blanca, which I understand are on the route. I feel the potential effect on the health and safety of these children and young adults should be considered.” (Letter 40)
- “This route, and streets further along your proposed route, include five schools in the first two miles. Several of these are elementary schools to which children walk, without sidewalks or crosswalks or crossing guards.” (Letter 659)
- “The plan admittedly carries the potential for serious property damage and unspoken dangers to the many motorists, hikers and bicycle riders along this scenic and fragile country road.” (Letter 15)
- “The road is not designed or engineered to handle that type of traffic. Upper Canyon

Road is not wide enough for both a semi and a car to pass each other safely without one having to pull off the side and stop. ...Cerro Gordo Road is (also) an unpaved road barely wide enough for 2 cars to pass, with steep inclines, hairpin turns and blind corners.” (Letter 25)

- “...All the alternatives already call for debris to be left in place on most of the several thousand acres to be thinned. It seems only sensible that this same practice be followed on the small proportion of lands, 560 acres, along the watershed access roads, eliminating the need for hauling.” (Letter 26)
- [Similar comments from Letters 3, 4, 16, 36, 42, 217, 223, 228, 645, 657 and others.]

Response: We understand these concerns and the selected alternative avoids these potential impacts by selecting Option A: No Wood Removal. We agree that Upper Canyon Road is narrow and a popular place to partake in leisure activities (DEIS, Figure 49 & page 115), and there are several schools along potential access routes. Option A was developed to reduce possible safety hazards within these areas. Several mitigation measures (DEIS p. 32) were developed to help regulate activities within these areas for the purpose of reducing safety hazards. This safety concern was recognized in the monitoring plan to monitor the effects of haul trucks (DEIS p. 169). See similar response to Comments 30 and 33-38.

Wood Trucking: Tourists

33. Comment: Do not allow wood to be trucked through the neighborhoods, to protect tourist interests.

- “I totally oppose logging out timber cut in the Santa Fe watershed. Along East Alameda the logging trucks would destroy life in the park and along the river. Tourists would shun areas along the dangerous route of the trucks—which would mean the central area they currently flock to enjoy.” (Letter 221)

Response: We understand that tourists use the roads that were considered for a possible haul route, and the impacts that additional haul trucks could cause. We selected Option A: No Wood Removal. See response to Comments 30-38 regarding wood hauling.

Wood Trucking: Pollution

34. Comment: Do not allow wood to be trucked through the neighborhoods because it adds to pollution.

- “I urge you to choose Option A...because it seems an unnecessary expenditure of petroleum, with concomitant pollution, which will have an effect in a much greater area than just our nearby roads.” (Letter 8)
- “...there will be less pollution in Santa Fe without this extra truck traffic.” (Letter 7)

Response: For a number of reasons, we selected Option A: No Wood Removal (see Record of Decision). Unfortunately, to reduce hazardous fuels in the watershed, it appears that we must use some petroleum products and generate some pollution. We know that smoke emissions from prescribed burning (or natural fires) generates air pollution. And vehicles, chain saws and feller-bunchers needed for the thinning operation will use petroleum products and create some pollution, whether or not products are hauled from the Watershed (DEIS p. 135). We will apply appropriate and proven mitigation measures to minimize pollution, and based on similar projects implemented on our national forest over the past several decades, we do not anticipate any measurable adverse impacts regarding pollution from use of petroleum products. See responses to Comments 30-38.

Wood Trucking: Historic Structures/Roads

35. Comment: Do not allow wood to be trucked through east-side neighborhoods because of the potential to inflict structural, vibration damage to homes, roads and historic cultural properties.

- “The route is lined with old historic adobe buildings right up next to the street, as well as spectacular old CCC stone arroyo crossing tunnels; these will be destroyed by the vibration caused by this kind of heavy truck traffic. This is a grotesque violation of the maintenance provisions of the historic ordinance, upon which the Federal Historic District designation relies.” (Letter 659)

- “The adobe walls of our home and many others are built on foundations of rubble. This type of traditional structure was not designed and constructed to withstand heavy truck traffic. In addition, our house, as well as many others, is built right to the road which further heightens the structural impact.” (Letter 44)
- “The DEIS indicates correctly that Upper Canyon Road is a substandard roadway, with dimensions and conditions far below those required for new roads These specifications are somewhat below those required by the State Highway Department for a ‘lane,’ which would be rated for maximum 250 passenger vehicles per day. Other roads leading to the project area are similarly substandard, and may be vulnerable to the same impacts from this project.” (Letter 649)
- “The . . . option . . . would be damaging and disruptive to the Santa Fe eastside community. I feel that ‘14 to 80 truck passes per day along Upper Canyon Road and the rest of the haul route’ would cause permanent damages to the streets along the route and to several residential structures that nearly abut on Canyon Road. The front of my home is about 10 feet from the northern edge of Canyon Road. It is approximately 120 years old, an adobe structure with a stone rubble foundation. It has withstood the effects of time and weather for more than a century but I have serious misgivings whether it can withstand the effects of mega-ton truck traffic.” (Letter 40)
- “Another concern is the destruction caused by heavy equipment. Do not forget that this is a historical zone and many of the building[s] or homes were constructed over 100 years ago. They cannot withstand the constant ‘rumble’ and foundations, wall[s] and ceiling[s] could be damaged. What about gas, water and sewage lines and pipes?” (Letter 35)
- “While in support of the Project’s overall goals, the Foundation feels that the DEIS is deficient in the assessment of the impacts of . . . the proposal to remove wood products from the Canyon for use as building material and firewood. Although the DEIS mentions the threat of damage to historic

earthen structures by heavy truck traffic, it does not adequately address this issue—which is of particular concern to the Foundation. The undertaking . . . has the potential to adversely effect historic properties and cultural resources that are listed on the National State Registers of historic properties. Along the only feasible truck route leaving the Canyon are two structures on the National and State Registers—the Randall Davey House at 1800 Canyon Road and the Crista Rey Church, which is a Contributing structure within a National Historic District. Furthermore, depending on the truck route chosen, trucks will travel either directly adjacent to this District (south along Camino Cabra) or through this District (west along East Alameda). In addition to these properties, there are two others on the State Register within the Canyon that are potentially subject to adverse impact. The truck route along Canyon Road also passes through the City’s Eastside Historic District. Along this route in the upper Canyon are eleven properties designated ‘Significant’ by the City and 28 properties designated ‘Contributing.’ Almost all of these structures are historic adobes.” (Letter 225)

- [Similar comments from Letters 15, 25, 39, 645 and others.]

Response: We understand these concerns and identified these concerns during the planning process. The selected alternative avoids these potential impacts by selecting Option A: No Wood Removal. The impact associated with heavy wood hauling trucks upon historic structures, homes and roads along the travel route was analyzed in the DEIS, pages 119-120, and recognized in the special monitoring requirements for haul trucks listed on page 169. Option A was developed to reduce the impacts of hauling wood through the eastside neighborhoods. See responses to Comments 30-38.

Wood Trucking: Monitoring

36. Comment: Establish a standard by which to monitor and assess haul truck impacts to historic properties.

- “There seems to be no scientifically established standard by which to judge adverse impact except on a case-by-case basis. The

potential adverse effect would have to be established on site by qualified third parties before implementing. Properties would have to be assessed individually as to their structural design, their condition prior to proposed action, and potential for adverse effect. Analysis of structural design would entail the following criteria (see letter 225) . . . An analysis of . . . (see letter 225) . . . it is almost impossible to implement a reliable program of assessment and monitoring. Clearly, the DEIS has not adequately addressed this issue is sufficient detail . . . The DEIS should resolve these potential adverse effects either by mitigation, by avoidance or by minimizing the effect . . . The Santa Fe Historic Foundation recommends the choice of Option A (no wood removal) . . .” (Letter 225)

Response: *Option A: No Wood Removal was developed and also selected in part because of this concern (DEIS p. 26, and Record of Decision). The DEIS recognized this potential impact (pp. 119-120). The Area of Potential Affect for this project (36 CFR 800) includes the haul route, since there are known historic properties along that route. We could have tried to mitigate impacts by reducing the frequency, size and weight of truckloads. We also could have monitored vibration intensities using vibrometers or some other tool, as required in the DEIS (p.32). Nonetheless, there would still be a real chance of impacting historic structures due to the cumulative (additive) effect of increasing heavy pickup truck traffic on this route. We agree that the roads involved were not designed for repeated traffic by pickup trucks fully loaded with “green” logs or firewood. Also, see responses to Comments 30-36 for other information about wood hauling.*

Wood Trucking: Mitigations

37. Comment: Include specific measures to mitigate impacts from truck traffic through east-side residential neighborhoods.

- “In the event that wood products are removed from the area, the additional hauling traffic should be restrained to hours from 9:30 am to 3:30 pm, escorted, monitored for speed and routed to reduce the risk of collision with other vehicles, pedestrians and bicycles, all of which must occupy the same narrow road surface. The road should be resurfaced prior to beginning the thinning project, or as soon as feasible, with heavy truck traffic not to begin until the resurfacing is completed.

The additional traffic generated by the proposed project (all Action Alternatives B through D) will create hazards to public safety, and threaten the many structures that are directly adjacent to the roadway... Some measures are summarized in the DEIS . . . but other recommended actions range from road surfacing, maintenance and speed monitoring to establishing a one way loop over Canyon and Cerro Gordo Roads. . . Since the City of Santa Fe has failed to address the inadequacies of these roads, it is insufficient to call upon the City to take measures to mitigate traffic impact. Rather, the final EIS should analyze the hazards and recommend specific measures to be taken prior to implementation of the project. These measures should be taken regardless of which Alternative is selected, since all alternatives will substantially increase traffic hazards.” (Letters 649 and 645)

- [Similar comments from Letter 4.]

Response: *The potential for adverse impacts associated with increased haul truck traffic through east-side neighborhoods was a key issue in this analysis. As stated in the DEIS (page 114), the lower section of Upper Canyon Road experiences an estimated 2,000 vehicles per day, of which 6 percent were larger commercial vehicles. A variety of possible mitigation measures were identified in neighborhood meetings (see Project Records 140 & 141) as well as by the interdisciplinary team and the Santa Fe Watershed Partnership group. The DEIS (page 32) identifies various mitigation measures designed to reduce the impact of large trucks hauling wood materials through the east-side neighborhoods. Included in this list are time and speed restrictions. The selected alternative avoids these potential impacts by not allowing additional haul truck traffic from the Watershed, other than that associated with wood removal from City lands.*

Wood Trucking: Cumulative Effects

38. Comment: Analyze cumulative effects of traffic from the proposed project and other anticipated projects in the area.

- “Projects currently anticipated in the area, including trailhead parking and expansion of activities at the City, Audubon and Nature Conservancy open space properties should be reconsidered in the context of project impacts.” (Letter 649)

- “Upper Canyon Road is already under heavy assault from an ever-increasing load of construction trucks and other traffic. The introduction of a steady stream of wood-hauling trucks would destroy the ambience of this historic district, which includes some of the oldest homes in the city. A group of several dozen of us have been working with the city for more than a year on plans to reduce truck traffic in the area.” (Letter 26)
- “...the following residents...petitioned the city last month to take measures to reduce the noise and volume of the already bad traffic situation here. A traffic-calming study is expected to begin soon. In our meeting with the city, residents were especially concerned about the impact from trucking traffic...” (Letter 226)

Response: Recent additions to the Randall Davey Audubon Center and additional trailhead parking for The Nature Conservancy and City of Santa Fe open space properties are expected to result in a slight increase in vehicle traffic along Upper Canyon Road. The majority of traffic for the trailheads will likely come from east-side residents, whereas the traffic associated with the Audubon Center will depend upon the specific functions being held at the center. The DEIS addresses past, present and foreseeable future actions in the cumulative effects analysis regarding impacts from haul truck traffic (DEIS pp. 121-122). This new information provided in this comment letter can add to that cumulative effects information regarding current and future activities contributing to the traffic situation. The selected alternative, Option A: No Wood Removal, avoids the potential cumulative impacts associated with additional haul traffic described in the DEIS and in the comment letters.

Wood Removal: Environmental Impacts

39. Comment: Implement Option A (No Wood Removal) to aid in nutrient cycling, reduce soil erosion, and promote wildlife diversity.

- “We favor Option A, that is, the treatment that removes no wood from the 560-acre roadside thinning treatment area. We see no substantial advantage to removal of this wood, and substantial disadvantages. A

disadvantage for the forest itself is the removal of material that would contribute to nutrient cycling if burned or left in situ.” (Letter 645)

- “We realize tree thinning may be necessary but to whatever degree the downed wood could be left on the ground, that would be preferable. My understanding from reading the available documents is that this technique reduces erosion and promotes wildlife diversity anyway.” (Letter 218)
- “Avoidance of soil disturbance while getting rid of many smaller trees should be the focus. In my opinion that requires emphasis on burning slash in place rather than removing it.” (Letter 42)
- “I strongly support Option A (the ‘Citizen’s Protection Plan’) in the Santa Fe Watershed. The Watershed has been protected for many years and as a result has become a unique wildlife area. Option A would preserve the area while dealing effectively with concerns about forest fire. The Forest Service’s preferred option, on the other hand, would destroy this unique area by introducing heavy machinery, building roads and cutting vast firebreaks which fragment wildlife habitat. Sensitive streamside areas would also be subject to harm.” (Letter 657)

Response: We concur that leaving the thinned material in place will contribute to nutrient cycling while minimizing soil disturbance and erosion (DEIS pp. 69-72). Option A was ultimately selected (see Record of Decision). As described in the DEIS, only a small area near the single service road is feasible for wood removal, and most of the accessible land is owned by the City. Wood removal by the City’s contractor will be monitored to determine the effects. No road building was proposed for this project, and no clearcuts were proposed. Habitat fragmentation would not occur.

Even if the wood was to be removed from this small roadside acreage, it would not have a measurable impact on soil nutrient status in the Watershed. Removal of the larger material (leaving the slash in place) would not cause substantially different runoff nor erosion effects.

Wood Removal: Utilization

40. Comment: Allow individuals to use cut wood, in order to support the local community.

- “Santa Fe is a rapidly growing area and a multiple purpose permit should be issued for latillas, vigas and fuel wood.” (Letter 2)
- “Have you considered allowing removal by individuals for a small fee? Would it be feasible to bring the larger logs to an area near the entrance to the watershed, where for a fee and on certain days of the week, individual could cut and remove them with regular sized pickups? I’m sure this would not handle the whole volume of timber to be removed but, it would support the local community in the eyes of the public and create a small revenue source.” (Letter 25)
- “This organization has also been consistently in favor of the use of small post/pole, viga, and firewood sales to meet forest management objectives and to provide resources for local residents either for their own use or for sale.” (Letter 22)
- “Restricting wood removal under Option A also appears wasteful to many members of the community to burn off fuels that could be useful as firewood or building/fencing products to the local community.” (Letter 640)
- [Similar comments from Letters 222, 227, 229, and 658.]

Response: *The Santa Fe National Forest typically allows the public to cut wood on national forest lands, and strongly supports the local community by frequently providing public wood cutting areas on each district. For the last 3 years, approximately 10,000 cords of firewood and other miscellaneous small products have been provided to local communities from the Santa Fe National Forest (Project Record). With the 2000 National Fire Policy and critical need for fuel reduction across the forest, we expect to yield at least 10,000-15,000 cords of firewood and 0.5-1.0 million board feet of other small products annually over the next several years. This is in addition to the 10,000-15,000 cords of firewood and other small products coming annually off the Carson National Forest, along with additional quantities from the Cibola and other national forests nearby.*

The Santa Fe Watershed presents unique challenges that make it extremely difficult to use as a public wood

cutting or gathering area compared to other areas of the forest. Most areas being thinning on the forest have ample road access. The Watershed on the other hand is an inventoried roadless area without an adequate road system to facilitate wood removal. Second, most of the slopes are too steep and the soil too loose for much wood to be feasibly removed. Third, the wood that needs to be cut to meet fuel reduction objectives in the Watershed is mainly the 2 to 6 inch diameter fir and ponderosa pine, which is not the best for firewood. Forth, the acreage and amount of wood that is accessible for removal in this area is relatively insignificant, and that excess wood could be burned in slash piles within 1-2 days with minimal impact. One of the major issues regarding wood removal from the Watershed is related to the fact that the only entrance/exit road is at the end of Upper Canyon Road, which is a very narrow road with old adobe and stucco homes up against it, and valuable historic structures along the haul route. It would create considerable public safety concerns if we were to add numerous large, heavy haul trucks to the existing traffic problems that residents currently experience on that road and the connecting residential and historic roads in that area. It was in considering these facts that we decided to adopt Option A: No Wood Removal for the Santa Fe Watershed.

Wood Removal: Limit Amount

41. Comment: Limit wood removal amount and quality while providing firewood to those in need.

- “. . . the amount of wood removed should be severely reduced to that which can be comfortably handled by the existing firewood program (approximately 250 to 300 cords per year). This wood should consist of the highest quality suitable for firewood. The social benefits . . . are described in the Draft EIS as the potential for jobs in handling the wood products . . . and the availability of firewood to elderly families...” (Letter 28)

Response: *Currently, the Espanola and Pecos/Las Vegas Ranger Districts, containing national forests closest to the Santa Fe area, sell approximately 5,000 to 6,000 cords of firewood annually (DEIS, p. 125). Over the past 3 years, over 10,000 cords of firewood have been removed annually from the Santa Fe National Forest. Commercial firewood sellers in Santa Fe also sell firewood from non-Forest Service lands. Over the next 5-10 years, the amount of firewood coming from national forests in northern New Mexico is expected to substantially increase, even if no wood was removed from the Watershed. Much of that wood will go to elderly families*

and others in need of firewood. The social benefits of the firewood program do extend well beyond the number of jobs generated. Approximately 9 percent of the Santa Fe area uses firewood as its primary source of heating (Census Bureau, Department of Housing, 1999). In the rural areas of the county, firewood is used for cooking and often is the only source of heating. Often firewood gathered through personal firewood permits helps supplement incomes of elderly and others throughout the county and northern New Mexico as it helps reduce costs for other sources of heat and cooking.

The amount and quality of firewood that could potentially come from accessible national forest lands in the Watershed is relatively low (approximately 1,000 cords of firewood is the most current estimate). The City's contract will remove wood products from about 50 acres. The wood that comes out may not consist of the highest quality firewood because ponderosa pine and white fir are not as desirable for firewood as piñon and juniper. We selected Option A: No Wood Removal for the remaining "roadside" national forest lands in the Watershed (approximately 50-120 acres; see Record of Decision). This decision not to remove additional wood from the Watershed should not affect our ability to contribute to the community's need for firewood from national forest lands, or our ability to reduce hazardous fuel loads in the Watershed. See response to Comment 40.

Wood Removal: Profits

42. Comment: Clarify who would receive potential profits from commercial logging in the Santa Fe Watershed.

- "I totally oppose logging out timber cut in the Santa Fe watershed." "On another issue, who gets the profits—given what's happened in the past, the commercial company in charge would take all the wood and leave nothing for the poor it supposedly was to benefit?" (Letter 221)

Response: None of the alternatives allow for timber harvesting in the conventional sense involving skidders, loaders, and log trucks or through the use of a timber sale contract. The objectives and prescriptions for this project are quite different from the timber sales of the 1980's. The alternatives displayed in the DEIS were developed with the thought of thinning occurring through a service contract rather than a timber sale contract, and the purpose is for fuel reduction. Under this scenario the contractor would remove mostly small diameter ponderosa pine and white fir products estimated to have a

fairly low merchantable value. However, current (revised) estimates of accessible roadside acreage for wood removal is less than 2 percent of the project area. In light of this limited amount of accessible acreage, the low value of the wood, and the potential social impacts of hauling additional wood from the Watershed, we selected Option A: No Wood Removal (see Record of Decision, and response to Comments 30-39).

Wood Removal: Cost vs Value

43. Comment: Consider the high cost of wood removal, processing and distribution compared to the low value of the wood and high public costs.

- "I do not know if the Draft EIS takes into consideration the additional costs involved in making these products [vigas and latillas] suitable for installation once they are transported from the canyon... These costs include: Site storage of the material while it is prepared for use and while it is awaiting sale or collection. . . . Handling and sorting before preparation for use. . . . Preparation for use. . . Costs involved in re-sale and/or re-delivery of the product, including marketing and sales costs. . . Given all of these factors, the low quality of the products compared to their actual costs, it seems to me unlikely that there would be much commercial demand for these products for use as prepared vigas or latillas. As a byproduct of a fire abatement program, they are unlikely to compete with what is already available in the area, which is a far superior product, and likely to bring a price that is at least competitive, if not less expensive than wood products resulting from the Project... In my experience, Ponderosa pine vigas are not the vigas of choice in the Santa Fe area ('dead standing' Engelmann Spruce being the most widely sought after species)... These same limitations apply to the White Fir species, which may qualify for removal from the upper portion of the Project area. Just as small diameter Ponderosa or White Fir are not the species of choice for vigas, the local demand for latillas prefers 'dead-standing' Spruce. . . As firewood, Ponderosa Pine is the species that local woodsellers will hide underneath their pieces of pinon, hoping that potential customers will not spot an inferior species. Almost every local species,

pinon, juniper, gambrel oak, Douglas Fir, even aspen is preferred to Ponderosa, which has a reputation for being 'punky,' hard to burn and a wood that will not produce much heat. Its chief use would be in wood stoves, and would probably be accepted if it were cut to length, split and given away free. As commercial firewood, small diameter Ponderosa would have negligible value...Just as the excess firewood is likely to create a disposal problem, so too with chipped material. If the wood transported from the site were to be processed by chipping, the volume of chipped material is obviously far greater than the demand in the Santa Fe area. In addition to this excess and a potential disposal problem, the chips are likely to contain insect life (bark boring beetles and spruce beetles) that may be harmful to the trees, gardens and architectural woodwork where the mulch is used. ..A realistic assessment of the economic and social benefits of wood removal as part of the Watershed Project would conclude that the benefits may result in the production of a few usable small diameter vigas, and some usable firewood of questionable quality. The economic benefits may be figured in the thousands of dollars at best while the economic costs of wood removal and handling may well exceed the \$600,000 mentioned in Table 40 of the Draft EIS, page 124." (Letter 28)

- "Given the low economic value of these wood products compared to the cost to the public of transporting them from the canyon, and taking into account the negative impacts on the social and natural environment of wood removal, I would urge the approval of 'Option A' (No Wood Removal) as part of the preferred alternative for the Santa Fe Watershed Project." (Letter 227)

- Being regular visitors to the forest above Santa Fe, I understood immediately the folly of this plan to remove vast quantities of questionable forest products. It is far more important that Forest Service's limited funds and resources are totally focused on reducing the fire danger in the watershed. We strongly urge the approval of 'Option A' (No Wood Removal) (Letter 44)

- [Similar comments from Letter 39.]

Response: *After considering many different factors, we selected Option A: No Wood Removal, for this project (see response to Comment 35 and Record of Decision). We agree with the comments expressed about the many high costs involved in the wood removal option, including: transporting, sorting, loading/unloading, cutting to proper lengths, temporarily storing, marketing, selling, distributing, and managing these processes. And we agree that the commercial value of the wood that needs to be removed to reduce hazardous fuels is low. Currently, the Espanola District sells pine firewood permits for \$7.50 per cord. Thus there is some level of public demand for small-diameter white fir, Douglas-fir and ponderosa pine (including an increasing demand for wood chips of any species) and some people told us they would prefer to have that wood put to a beneficial public use rather than left to decay or be burned onsite in the Watershed.*

We also agree that the cost of chipping slash and hauling chips would exceed any economic return from the sale of chips. The objective in removing chips was not to turn a profit but to get the slash out of the woods, put it to beneficial public use, and avoid having to burn it (smoke issue). Regarding the concern about insects, the chance of transporting insects with chips removed from the Watershed is unlikely because the chipping and drying processes generally kills insects and insect larvae in the wood. Also, the DEIS discusses why chips cannot be left in the Watershed, due to several environmental concerns (pp. 160-161).

Option B: Thin Larger Trees, 100 Acres

Option B (For)

44. Comment: Implement Option B, which allows for cutting larger (over 16-inch diameter) trees near the riparian zone.

- “The main goal of the project is to reduce catastrophic fire risk. To this end, removing some of the larger conifers (up to 24 inch) in the 100 acres of bottomland is a reasonable activity to undertake.” (Letter 227)
- “I agree with the intent of Option B and actually consider it a very important part of the health of the riparian watershed area. I had an opportunity to tour the watershed site a while back ... It was obvious that the conifers had taken over and were starving off the harder wood species.” (Letter 27)

Response: This option was analyzed for the reasons mentioned in the comments. Thinning out the conifers up to 24 inches in diameter in the canyon bottom would be expected to reduce the risk of severe crown fire impacts near the water supply. This was noticed in the Viveash Fire area near the Santa Fe Watershed, where the dense conifer patches in the riparian zone burned at much higher severity levels than patches of deciduous vegetation or conifer areas with meadows and other openings. Opening the conifer-dominated patches in the canyon bottom would cause an increase in grasses and riparian vegetation that would improve soil stabilization and filtration of sediments. However, this option was not selected for the following reasons: the differing opinions expressed by forest ecologists consulted, the magnitude of public concerns expressed, the lack of large tree habitat in the project area, and the minor acreage affected by this option (100 acres within the 7,280-acre treatment area). If we treat sufficient acreage on the adjacent upper slopes, then trees in the canyon bottom will be at a lower risk of mortality during crown fire events.

Option B (Against)

45. Comment: Do not implement Option B, which allows for cutting larger (over 16-inch diameter) trees near the riparian zone.

- “We are opposed to Option B, the plan to thin approximately 100 acres of forest patches of conifers growing in flatter, more mesic conditions in and near riparian zones. This plan involves thinning of trees up to

24” in riparian areas. We do not believe that making an exception to the 16” cutting cap in these areas will make any difference to the reduction of risk of crown fires. A first entry thinning of trees up to 16” can open up the canopy and allow recovery of riparian-adapted plant species. In the future it may be desirable to remove trees up to 24” but they do not present the most critical risk, and we believe it is inappropriate and ecologically unwarranted at this time.” (Letter 645)

- “The Department [Game and Fish] also concurs with the Forest Service’s preference for not thinning approximately 100 acres of larger conifers in the canyon bottom . . . These trees are important wildlife habitat for migratory birds and bats, and are critical components for future snags and downed logs.” (Letter 21)
- “Option B: I don’t like it because the large trees should be left and the understory over-growth controlled.” (Letter 660)
- “We are opposed to Option B, the plan to thin trees up to 24” in approximately 100 acres of dense conifer patches growing in the canyon bottom. Currently these conifer patches provide much needed stream bank stability. The preferred alternatives, thinning trees up to 16” in this area, will open the canopy enough for riparian zone. The lack of consensus regarding treatment in the riparian area suggest[s] that more information is needed to guide treatments.” (Letter 229)
- “I doubt that trees larger than 16” dbh need be cut. A forest of trees over 16” is not very susceptible to crown fire. I do not understand the motive for proposing removal of trees to 24”. There is no excess of big trees according to Table 13.” (Letter 42)
- “Cutting large trees within the riparian area (Option B) will raise concerns about the project overall. The trade-off between what might be gained by removing large conifers in the riparian zone, and what can be lost in community support for the overall project as well as in riparian health, argues for dropping this option from consideration.” (Letter 640)

- “What about removing all of the small conifers—especially junipers and pine that are encroaching on the riparian area? If these can be removed the water table will then come up and the larger conifer trees eventually die off because of waterlogged soils. They then become valuable as snag trees and nesting habitat. (Letter 647)
- [Similar comments from Letters 1, 6, 7, 9, 15, 29, 223, 224, 228, 642, 643, 654, 660, and others.]

Response: *Although portions of the canyon bottom will remain at risk of experiencing high severity fire impacts, we decided not to select Option B (see Record of Decision). Option B was not selected due to the opinions expressed by forest ecologists consulted, lack of community support, scarcity of large trees in the project area, and the very minor acreage that this option applies to.*

We agree that larger trees are not as susceptible to crown fire and are relatively rare within the Watershed. Also, the crowns of conifer trees do provide some soil protection by decreasing the velocity of high intensity rains, allow-

ing more water to be absorbed into the soil. But Option B was considered in the DEIS because on the more productive soil in the canyon bottom, there are dense patches of larger trees quite susceptible to mortality from a crown fire due to their interlocking crowns, understory ladder fuels, and topographic location. Many trees over 16 inches in diameter have died in recent crown fire events, including the Cerro Grande and Viveash Fires. Also, the roots of conifer trees are not as effective as the long fibrous roots of riparian vegetation in providing streambank and soil stability, withstanding flood events, and filtering sediment. Regardless of these pros and cons, this option would have only affected 10-12 small patches totaling 100 acres, which is relatively insignificant in the scope of the large landscape that needs thinning.

We plan to remove small conifers throughout the project area (other than in the riparian buffer zone). The water table is primarily limited by the controlled flows from McClure and Nichols Reservoirs. Regardless of how many conifers could be removed from the riparian zone, waterlogged soils would not be expected due to the regulated stream flows.

Thinning

Thinning: Immediate Need

46. Comment: Move forward with thinning the Santa Fe Watershed as quickly as possible to prevent a catastrophic fire and flood.

- “I live in Santa Fe and am in favor of thinning (cutting trees) as quickly as possible to prevent a catastrophic fire in our watershed.” (Letter 655)
- “We are Santa Fe residents who live in our own home located a half mile west and below the watershed. We have attended a number of meetings regarding the DEIS and we are in firm agreement on the need for immediate thinning of the watershed, both for fire risk and intensity reduction and for the environmental health of the watershed.” (Letter 659)
- “No question that thinning is needed. The watershed is a powder keg waiting to go off.” (Letter 39)
- • “Talk more tomorrow and DO something in the meantime.” (Letter 20)
- “The more time that passes while this thinning has not occurred, the greater the likelihood that a major catastrophic fire might occur...The very threat of major flooding that would occur through downtown Santa Fe as a result of a major fire in the watershed is sufficient reason to aggressively pursue a tree thinning project in the watershed. The risk this puts on us economically is very high.” (Letter 227)

Response: We appreciate the community understanding and support for the importance of thinning in the Watershed to prevent a catastrophic fire. Completing the project in a timely manner is in everyone’s best interest. The DEIS (Figure 36 p. 65) illustrates the 100 and 500-year flood zones within the City of Santa Fe that would probably be impacted by such a fire and flood event. A large part of the commercial downtown area is within the 100-year floodplain (DEIS, pp.67 & 119).

It will, however, take considerable time to complete this project. The slash (cut branches and tops) from thinning creates a fuel hazard that must be left to dry so it can be

burned, since there is insufficient road access for slash removal. It will take considerable time to work through such a large landscape: first thinning a subdrainage, then allowing the slash to dry in that subdrainage, then burning the slash in that subdrainage before thinning and creating additional slash in the adjacent subdrainage. Thinning cannot proceed any faster than our ability to burn the created slash. In addition, burning conditions (temperature, humidity, wind, fuel moisture, etc.) must be just right to minimize the chance of escape fire and smoke accumulations.

Thinning Prescriptions/Patchiness

47. Comment: Describe the specific thinning prescriptions, and consider the matrix of openings and dense patches.

- “We would like to see more information on the specific prescriptions in the final EIS. In addition, a description of the range of sizes and shapes of openings and dense patches is needed.” (Letter 229)
- “Natural fires in the past were patchy, and forest structure was patchy. I believe it would be perfectly OK to leave patches of dense forest and to have patches within the watershed that were missed by the fire”. (Letter 648)

Response: For additional information about the trees to be cut or retained, you can obtain a copy of “Methodology Used in Developing the Number of Trees to be Retained in the Santa Fe Watershed” (Project Record). The trees retained will depend upon the site and the size of the trees present, the desire for a minimum 20-foot crown spacing between trees or clumps of trees, and other factors. Thus, the sizes and shapes of openings and dense patches will be highly variable. After thinning, patches of dense trees will likely range from clumps of 3 to 5 trees to patches several acres in size. Openings created by thinning will likely range from the size of 3 to 5 trees to a maximum of about 1 acre. Numerous inclusions of steep slopes will not be treated within larger treatment areas. Burning will be expected to create additional small openings, as areas of heavy ground fuels, severe mistletoe, or dense thickets of dead fir are likely to torch during the burns. Thus, overall, we expect the project area to be very patchy and variable in terms of tree density.

Thinning: Long-Term Effects

48. Comment: Consider the long-term implications of thinning and burning, including target number of trees after additional mortality.

- “I would like to ask if you have seriously considered the impact on the forests 50-100 years from now—if you remove most of the trees that are 16” in diameter and smaller—does this not mean that you will be removing the future tall trees of the forest? What will the forest look like 50-100 years from now?” (Letter 13)
- “In deciding a target number of trees per acre, the Forest Service should also consider the inevitable mortality that will occur due to slash and broadcast burning, which will reduce the number of residual trees.” (Letter 229)

Response: In response to the first comment, yes, we have seriously considered what the forest in the Watershed will be like 50-100 years from now, both with and without the proposed treatments. First of all, many of the 12 to 16-inch diameter trees will be retained, along with many smaller size trees. The thinning will create small openings that allow for the establishment of new pine regeneration, because pine trees need adequate sunlight in which to grow. In fact, the more open growing conditions will enhance the growth of all remaining trees in the thinned forest. It is predicted that after treatment and in the long-term, the project area will be more diverse in terms of tree species mix (eg. more aspen), structural composition (eg. dense and open patches), and ground cover species mix. This would support a more diverse wildlife community than exists in the Watershed today.

In response to the second comment, yes, we considered the inevitable mortality that will occur during prescribed burning, which will reduce the number of residual trees. However, the expected tree mortality from slash pile burning will be minimal. Slash piles will normally be burned when conditions are wet and/or the ground is covered by snow. Trees will be dormant when burning on snow occurs, greatly reducing their susceptibility to fire damage. Also, Forest Service thinning contracts will have specifications that require specific minimum distances from residual trees.

The greatest mortality of live trees will occur in stands broadcast burned without prior thinning, although the cool conditions that will be required for broadcast burning unthinned stands in the Watershed will greatly limit

the number of trees that will be killed by the fire. In this situation, clumps of small fir trees will be expected to burn while the large fir trees and most pine trees over 5-inch diameter will generally survive.

Thinning: Historic Conditions

49. Comment: Conduct thinning to reestablish historic ecosystem functions, structures and species composition, including tree size classes.

- “Restore ecosystem functions, structures, and species composition, including reducing species populations; specifically: reestablish historical tree size-class inventories by preserving all trees which are over 16 inches in diameter at breast height or were established prior to 1900.” (Letter 22)

Response: Yes, we agree, and the preferred alternatives are aimed at the desired condition the commenter describes, including retaining all trees larger than 16-inch diameter. However, some smaller trees established prior to 1900 may need to be thinned out to protect the stand’s larger trees from crown fire.

The historic tree size class structure and composition in the Watershed is one with relatively smaller size mature trees compared to areas dominated by basalt and limestone soils. On these decomposed granite soils, a 20 to 24-inch tree is considered a very large tree. Field examination of historic trees in the Watershed indicated that the pine stands had a basal area less than 50, compared to a current basal area exceeding 100. The thinning is designed to reduce tree stocking to within more historical stocking levels and species mix. Stands treated by thinning will generally be reduced from 600-1000+ stems per acre to 50 to 100 of the largest trees per acre.

Thinning: Contour Felling

50. Comment: Properly implement contour felling on steep slopes to reduce soil erosion.

- “To hold soil from washing off steep slopes in the Watershed, we call for the use of contour felling . . . Contour felling is a labor intensive process that requires limbed trees be placed perpendicular to the slope, set into the soil, staked on the downhill side and arranged on a shingle pattern. The Forest Service demonstration plot in the watershed showed how

not to do contour felling. Stumps were left on the logs from limbing and they were not dug into the soil or staked. As a result, water ran underneath the suspended log. When done properly, contour felling helps reduce impacts of soil disturbance, protects water quality, captures soil nutrients, increase soil organic matter content and improves site productivity. The Citizens Protection Plan calls for small trees that may become ladder fuels during prescribed fires to be felled and placed every ten to twenty feet on sloping terrain. Logs less than 6 inches dbh are bundled to increase their size and effectiveness. Decaying logs break down relatively quickly in the southwest, contributing both organic matter and nutrients to the soil . . . Thus contour felling is also a soil building strategy.” (Letter 643)

Response: Yes, we generally agree with the comments and desire for contour felling. Contour felling is part of the selected treatment plan for the Watershed (DEIS pp. 1, 18, 29). It is possible that some water ran underneath some of the logs in the demonstration plot, but this is not a major concern. There is no evidence of excessive soil erosion off the demonstration areas where contour felling was done. Our research combined with observations by soil scientists and hydrologists indicate that contour felling does not have to be done as precisely as the commenter suggests for it to be effective. The contour felling methods we propose using in the Watershed have been proven effective for decades, including recent examples in the Cerro Grande and Viveash burn areas. Our plan calls for 200 logs per acre arranged roughly along the contour, which will provide an effective matrix against any soil erosion. Digging trenches to anchor logs into the soil on thousands of acres would be cost prohibitive and increase soil disturbance. We are not sure how bundling of small logs would be done safely on the rugged steep terrain in the Watershed, and have no evidence to believe it would be necessary. Logs, even small ones less than 6 inches in diameter, are very heavy and cumbersome for a worker to move.

Thinning: Solar Chain Saws

51. Comment: Use solar-powered chain saws to thin the forest in order to minimize petrochemical pollution.

- “We call for the use of solar energy powered chainsaws to reduce noise and pollution by petrochemicals in the watershed. The chains of these electric saws would be lubricated with vegetable oil. Up to a third of the oil and gas used by two-stroke chainsaw engines is expelled into the air and on the soil. In addition, a gallon of bar oil is used per acre in a typical logging operation. Solar powered chainsaws have been effectively used in northern New Mexico for tree clearing projects.” (Letter 643)

Response: We are amenable to considering the use of alternative pollution-reducing technologies such as solar-powered chain saws, if such use is economically and technically feasible. When we investigated this idea, we were unable to find that such a tool exists.

Thinning: Avoid Raspberry Bushes

52. Comment: Avoid impacting raspberry bushes when thinning areas near McClure Reservoir.

- “Leave shrubs alone to the extent possible. In particular near McClure Reservoir steer clear of small raspberry bushes; some of them are *Rubus Aliceae*, which is known only right there; however the species may mostly be on city-owned land. I do not understand why it is not on the state list of protected plants.” (Letter 42)

Response: The DEIS includes a mitigation measure to avoid cutting any shrubs, including the common raspberry (*Rubus*) species (p. 31), and this will be included as a restriction in the thinning contract(s). However, the rare *Rubus alicae* species of raspberry is not known to currently occur in the project area. There is one historical record of this species from the early part of the 20th century, however, a botanical researcher from the University of New Mexico conducted a survey in the mid 1990’s to find a *Rubus alicae* and it was not found. It is believed that the reported *Rubus alicae* site is now occupied by McClure Reservoir.

Fuel Breaks

Fuel Break: Need

53. Comment: Create the wide fuel break proposed on the southern border of the Santa Fe watershed.

- “The wide fuel break along the southern ridge of the watershed seems like a good idea to me. Since the prevailing winds are from the southwest and a significant amount of development has occurred southwest of the watershed near the forest boundary, the wide fuel break should be retained.” (Letter 228)
- “I favor the fuel breaks as a first priority.” (Letter 18)

Response: Thank you for your comment in support of the preferred alternative and plan for an effective fuel break on the southern border of the Watershed. See responses to Comments 54-60 regarding the fuel breaks.

Fuel Break: Size, Tree Density

54. Comment: Consider fuel breaks that are narrower and have higher tree densities.

- “We know that fuel breaks are a necessary part of the fire protection consideration for the Watershed Project. But the question remains, how large must they be and where should they go? We have concerns about allowing fuel breaks as large as 0.5 miles in width along the southern boundary. Fuel breaks should create conditions that allow firefighters to build a defensible area against fire. They cannot be ‘fire proofed.’ We would also like you to consider allowing a greater density of trees in the fuel breaks, and feel that 20 to 30 trees left per acre may be unnecessarily low.” (Letter 645)
- “We share this concern with the fire breaks being too wide (0.5 miles). We support Bill Romme’s comments on this issue, with the understanding that fire does need to be kept out of the watershed until crown densities are reduced.” (Letter 642)
- “I share the concern expressed by the Watershed Association about creating fuel breaks up to one-half mile wide. This is probably much wider than is really necessary, and

could have undesirable effects on other aspects of ecosystem structure. I do think it is appropriate to reduce tree density to as low as 20-30 stems/acre in small areas along some key ridgetops, to create areas where fire spread could be effectively contained or where crown fires would be likely to drop to the ground. However, on a windy ridgetop, such a wide spacing of trees could result in substantial loss of residual trees to windthrow. Some of these areas could essentially lose the tree component and be converted into shrublands or meadows. I think this would be OK in limited areas, but to allow such a conversion to take place across half a mile of a prominent ridgetop would be a greater vegetation change than probably is desirable.” (Letter 648)

Response: We agree that the fuel breaks are necessary and create conditions that give firefighters a defensible area for suppression efforts. We understand the comments about fuel break width and have modified our original estimate regarding the width of the southern ridge fuel break (see Errata sheet). Generally, the southern fuel break will range from several hundred feet up to 1/4 mile wide, and will be variable based on topography and forest conditions.

Until a substantial amount of the project area has been treated to reduce fuels, the need for an effective fuel break along the Watershed’s southern perimeter is critical. The most likely chance of a wildfire moving into the Watershed will be from the southwest boundary of the project area. During the fire season, prevailing winds blow from the southwest and would push a wildfire in a northeasterly direction. For this reason, the fuel break area along the southern ridge must have sufficient openings in the canopy and be wide enough to slow down a crown fire and make fire suppression efforts possible and safe. Fuel breaks along the Watershed’s north ridge and interior ridges will be much narrower, since they primarily function as control lines for prescribed broadcast (surface) burns in the Watershed.

Regarding tree density, the 20 to 30 trees per acre may seem low to some people, however, keep in mind that these are 20 to 30 of the largest trees in the area; mostly 12-inch diameter or larger. Based on examining the number of historic stumps in the area, the proposed number of residual trees per acre is within the natural range of variability for these soil types. If we leave additional trees in the fuel breaks they will likely be ineffective, based on the fire simulation models and wildfire occurrences that we have observed in the western U.S.

Windthrow is not believed to be a concern. Fuel breaks will consist of the tallest and largest trees, which tend to be windfirm since they have been exposed to wind events most of their life. Ponderosa pine will be the primary species retained, and this species has a well-developed taproot that helps it withstand wind events.

Fuel Breaks: Location

55. Comment: Construct fuel breaks at the tops of slopes that run parallel to the Santa Fe River.

- “The DEIS describes the spatial and temporal plan for treatments in the Watershed by saying that work will begin on the south side of the Santa Fe River, including the wide fuel break proposed for the southern ridgetop. Given that fire tends to burn up a slope, we recommend that treatments begin at the top of the watershed and work down the slope towards the canyon bottom over time. It is also surprising that the fuelbreaks within the watershed (i.e. not the ridgetop fuelbreaks) run from the canyon bottom up the ridgetop, but do not run parallel to the Santa Fe River. These fuelbreaks would function to slow a fire burning up the slope or to slow a fire entering the Watershed. We encourage you to consider these suggestions.” (Letter 229)

Response: *Thank you for the suggestions and your concurrence with the plan to begin at the top of the Watershed on the south perimeter fuel break. The topography of the watershed dictates where fuel breaks will be placed (DEIS p. 17). The fuel breaks run from the canyon bottom up to the ridge line because they are following the ridges of side drainages. If fuel breaks were constructed parallel to the Santa Fe River, they would have to be located on the sides of steep slopes as mid-slope fuel breaks. Mid-slope fuel breaks have not been demonstrated to be as effective as ridge line fuel breaks. Also see response to Comments 54 and 56-60 regarding fuel breaks.*

Fuel Breaks (Against)

56. Comment: Do not create cleared fuelbreaks that may have adverse impacts to soil or wildlife, or may create dangerous conditions for firefighters.

- “These citizens expressed strong opposition to fuel breaks... Fuel breaks, some up to a half-mile wide, would virtually clearcut every ridgetop in the watershed and surrounding areas of the Santa Fe national forest, creating dangerous conditions for firefighters.” (Letter 233)
- “Less than three paragraphs are devoted to fuels breaks in the 170 page DEIS-SFW. The number of miles of fuel breaks to be constructed is not disclosed. Despite being common to all alternatives, there is no mention of any adverse environmental consequences. These virtual clearcuts would remove 98 percent of the existing trees along ridgetops and around the perimeter of the watershed. In some cases, the fuel breaks will be half a mile wide. Most snags will be felled within and surrounding fuel breaks. There is no discussion of how fuel breaks will be kept clear of vegetation in the future when grasses, shrubs and invasive species dominate these sites. Fuel breaks must be cleared of flammable grass, shrubs and weeds to be effective in stopping the spread of wildfires into the watershed or contain prescribed burns. If clearing is not done, fuel breaks will increase the rate of flame spread and fire line intensity and endanger firefighters. The DEIS-SFW failed to cite the numerous scientific papers and government studies warning that without long-term maintenance fuelbreaks would revert to a more hazardous vegetation type (van Wagtendonk, 1996; Weatherspoon, 1996; Weatherspoon and Skinner, 1996; Sessions, Johnson, Sapsis, Bahro, and Gabriel, 1996)... Massive ground disturbing activities associated with the creation and maintenance of fuelbreaks will encourage colonization by invasive species. These impacts are ignored in the DEIS-SFW. Fuelbreaks fragment wildlife habitat, interfere with wildlife travel and dispersion and harm species dependent on closed canopies and dense forests. Bats, in particular, could be adversely affected since ridge tops are important for bat dispersal and roosting (U.S. Fish and Wildlife Service, 2001). Felling a large number of snags in and around fuelbreaks will adversely affect over 150 species which utilize snags. The Forest Service must disclose these impacts and analyze their effect on species viability...” (Letter 643)

- “Fuel breaks are proposed to be one half-mile wide. Will there be ensuing erosional damage as caused from these fuel breaks? How will these fuel breaks be maintained and what sort of maintenance practices on these fuel breaks are anticipated for the long term? ... What sorts of plant species might be impacted by these fuel breaks?” (Letter 647)
- “I would also ask the Forest Service not to heavily cut fuel breaks - this will cause substantial erosion and scarring.” (Letter 13)
- “I also want to express my opposition to ridgetop clearcutting for fuel breaks which would cause serious erosion.” (Letter 219)
- “I am also concerned about the creation of fuel breaks which fragment wildlife habitats.” (Letter 15)
- [Similar comments from Letters 29 and 223.]

Response: The comments quoted raise several distinct issues that we will respond to. The size of fuel breaks has previously been discussed (see response to Comment 54). First, we would also like to dispel the mis-perception that “fuel breaks would virtually clearcut every ridgetop in the watershed and surrounding areas of the forest.” It is more accurate to characterize the creation of fuel breaks as thinning rather than clearcutting, or that “fuel breaks cause massive erosion,” or that they “create dangerous conditions for firefighters.” These are all myths. It is well known among soil scientists that shaded fuel breaks such as those proposed for the Watershed will not cause massive erosion. Fire behavior scientists also strongly agree that fuel breaks do not create dangerous conditions for firefighters. In fact the opposite has been demonstrated in numerous fires, including Cerro Grande and Viveash; fuel breaks provide safety areas for firefighters.

The DEIS did not disclose the miles of fuel breaks because this number cannot be accurately predicted at this time. In addition, the size and layout of the burn blocks and surrounding fuel breaks or control lines will vary from the estimates on maps in the DEIS, and will be refined in a site-specific manner on the ground. In the spirit of adaptive management (DEIS p. 19), monitoring and evaluation will give us a more accurate estimate of how large a block we can burn at one time before we impact nearby neighborhoods with smoke, which will help determine the length, width and location of fuel breaks or control lines around the burn blocks.

Will fuel breaks create adverse impacts? The specialists that completed the DEIS do not believe there would be adverse consequences associated with the fuel breaks. While some people envision a fuel break as a clearcut with trees and ground vegetation removed, shaded fuel breaks planned for the Watershed will not be virtual clearcuts. They will contain 20 to 30 of the largest trees per acre while enhancing productivity of ground vegetation (and soil stabilization) in areas where the smaller trees are removed and the tree canopy is opened up. The increase in ground vegetation will stabilize the soils and reduce erosion. Thus, this degree of thinning, combined with the mitigation measures listed in the DEIS, will not lead to significant increases in runoff and erosion.

It is true that existing snags within the fuel breaks will be felled in order to have an effective fuel break. This is necessary because snags are frequently sources of wild-fire ignitions during lightning storms or act as a torch that carries a surface fire up into the nearby tree canopy (DEIS, p. 17). In the majority of the project area, existing snags will be retained.

Decades of experience with wildfire and prescribed burns has taught us that ground vegetation does not need to be cleared from fuel breaks in order for them to be effective. Based on the existing plants, soil type and terrestrial ecosystem survey data, the ground vegetation most likely to develop in these shaded fuel breaks are bunch-grasses, oak, kinnikinnic, locust and various forbs. By maintaining and enhancing this ground vegetation, we help protect the soil, improve habitat diversity, and provide fuel for low-intensity maintenance burns. We certainly agree with the comment that “without long-term maintenance, fuel breaks would revert to a more hazardous vegetation type.” The DEIS describes how maintenance burns would likely be used in the future to maintain the desired conditions (pp. 16, 42, 72, 135), and the DEIS cites several of the scientific research papers referenced in the comment letter (Literature Cited pp. 141-153).

The shaded fuel breaks planned for this area will not fragment wildlife habitat or harm wildlife species in any way. The more open habitat condition in these small acreages will mimic natural fire regimes on ridge lines in dry ponderosa pine forests, within the historic range of variability. Closed-canopy corridors will remain within the moist drainage bottoms and in other untreated patches. Fuel breaks will contain numerous logs and woody debris, along with herbaceous plants and shrubs that are currently lacking under the heavy shading of dense stands. These shaded fuel breaks will not interfere with wildlife travel. Also see response to other Comments 54-60 regarding fuel breaks.

Fuel Breaks: Visual Quality

57. Comment: Consider the impact of fuel breaks on the visual quality of the Santa Fe Watershed.

- “Most fire breaks are scheduled for ridgelines that will be visible from Santa Fe and other areas around town, and wide fuel breaks could very well become a visual concern.” (Letter 645)
- “Fuel breaks are proposed to be up to one half-mile wide. How will these fuel breaks impact the viewscape?” (Letter 647)
- “We oppose fuel breaks which would permanently scar the landscape.” (Letter 643)

Response: The visual analysis described in the DEIS (p. 132) indicates that the area is not visible from key viewing locations. However, the Atalaya and Arroyo Hondo trails lie just outside the southwest boundary of the watershed, and there are two points along these trails—at Glorieta Baldy and Thompson Peak—which offer limited views into the western portion of the Watershed. Due to the distance and angle of these views, there should not be a noticeable difference in these views after the Watershed has been treated. The southern fuel break will vary in size and shape, retain clumps and individual large trees, and have more ground vegetation that exists today. Thus, even the south fuel break will not appear as a scar on the landscape, but will look like a typical open ponderosa pine savannah created by frequent, low intensity surface fires. Also see response to other Comments 54-60 regarding fuel breaks.

Fuel Breaks: ORV's/Weeds

58. Comment: Analyze potential impacts from increased off-road vehicle use in proposed fuel break areas.

- “Already, ORV users are illegally using the watershed. We have documented largescale trespass at the headwaters of Aqua Sacra Creek, which is also the site of the largest proposed fuelbreak. . . . ORV use will likely expand when miles of fuelbreaks are created since these remote areas are not being patrolled. Off-road vehicles also carry the seeds of invasive species on their tires and

fuelbreaks are favored by ORV users... Fuel breaks are proposed to be up to one half-mile wide. Will these breaks become favored by ORV and ATV users and thus become little better than recreational open roads?” (Letter 643)

Response: It is true that some illegal ORV use and other recreation uses are known to occasionally occur in the Watershed, particularly near the headwaters of Aqua Sacra Creek (DEIS pp. 41-42). It is possible that despite the security patrols and increased presence of government employees in the Watershed, illegal recreational activity may continue to occur. However, we would not anticipate a significant increase in illegal ORV use as a result of creating fuel breaks. First of all, most of the fuel breaks will be less than 250 yards wide and virtually unnoticeable by trespassing ORV users. The south boundary fuel break may have short sections that extend up to 1/4 mile wide (revised from original estimate; see Errata Sheet), but it will not look like a clearcut, road or trail. While the shaded fuel break will have a more open stand of trees, it will also contain an abundance of new down logs that would tend to discourage ORV use in the area, especially when more suitable terrain is available nearby. Even if that particular fuel break did increase ORV use, it is considered to be the most critical feature of the selected alternatives in order to reduce the risk of catastrophic fire in the Watershed.

Fuel Breaks: Herbicides

59. Comment: Ban the use of herbicides for maintaining fuel breaks.

- “Biological poisons such as herbicides are often used to clear flammable vegetation in fuelbreaks because other maintenance tools are either ineffective or cost-prohibitive. We strongly oppose herbicides, especially in the watershed, as they kill native plants, insect pollinators, mycorrhizal fungi and may contaminate drinking water and threaten human health. The DEIS-SFW must disclose how fuel breaks will be maintained and analyze the environmental consequences of proposed maintenance treatments. Any future use of herbicides to maintain fuelbreaks is a connected action as this concept is understood by the National Environmental Policy Act and cannot be analyzed separately.” (Letter 643)

Response: *Herbicide use was not mentioned in the DEIS and is not a method being considered for killing vegetation to maintain fuel breaks. The DEIS discloses how periodic, low intensity prescribed burns are expected to be used in the future to maintain desired conditions in the fuel breaks. Desired conditions allow for an abundance of grasses and other ground vegetation along with many large, fire-resistant pine trees, while keeping down the number of seedlings, saplings and other ladder fuels.*

Fuel Breaks: Monitoring

60. Comment: Monitor the effects of creating fuel breaks.

- “Include the widest firebreaks (greatest reduction in tree density) as one type of treatment to be monitored. (Letter 640)

Response: *The monitoring plan described in the DEIS includes monitoring the effects of all treatments, including treatments in the fuel breaks (DEIS pp. 163-169).*

Prescribed Burning

Burning (For)

61. Comment: Use broadcast burning to achieve fuel reduction and other objectives, while minimizing the risks.

- “I also would not object to the broadcast burning of the remaining acres if it truly does reduce the fire danger. I have confidence that all necessary precautions would be taken to prevent escaped fires. The smoke we will have to learn to live with.” (Letter 27)
- “Broadcast burning is a necessary component of this treatment. As indicated on the maps in the DEIS, it is imperative to surround the broadcast burn units with thinned areas where the slash has been treated.” (Letter 229)
- “I am also in favor of controlled burns when conditions are acceptable.” (Letter 655)
- “Sangre de Cristo Audubon Society is interested in a number of activities on the Santa Fe National Forest, and the protection of watersheds and the creation and preservation of wildlife habitat are among our highest priorities. One management strategy which we have consistently advocated is the use of an aggressive prescribed burning program as a significant part of the Forest Service's vegetation management activities. Prescribed burning serves not only to reduce fuel build-up, it also maintains wildlife habitat and species diversity in a manner more consistent with historical patterns, particularly in ponderosa pine.” “We strongly support the goals of the project as described in the DEIS.” (Letter 22)

Response: We agree. Broadcast burning is an essential tool for meeting fuel reduction objectives in this area, as the analysis and research cited in the DEIS clearly indicates.

Burning (Against)

62. Comment: Thin but don't burn, to avoid smoke and escape fires that can impact Santa Fe residents.

- “Thinning is okay... cut and remove fuels, but don't burn. Fire is too unpredictable and dangerous” (Letter 19)

Response: We agree that prescribed burns cannot be completely predictable or without risk. However, the mitigation and monitoring measures described in the DEIS will minimize the risk of escape fire and smoke impacts (DEIS pp. 27, 28, 31). Mitigation measures include a requirement to surround the burn units with thinned areas where slash has been treated in order to minimize the risk of escape fire (pp. 27, 54, 56). Due to the lack of roads, steep terrain and other conditions specific to this Watershed, we believe that burning is absolutely essential for meeting our fuel reduction objectives. Without burning to reduce the slash and other fuels, there would be a high risk of experiencing an uncontrollable wildfire event that would seriously impact the City's residents. We also know that low-intensity fires have numerous beneficial effects on the environment, including effects on soil nutrients and productivity, and wildlife habitat diversity.

Burning: Smoke

63. Comment: Avoid burning to reduce smoke impacts, or consider using air incinerators.

- “Watershed does need to be thinned but please don't burn - respiratory problems.” (Letter 222)
- “No On Option A. Restricting wood removal under Option A would necessitate additional burning with related smoke impacts to downstream neighborhoods.” (Letter 640)
- “Some time ago, for a project in Michigan, I reviewed data on controlled air [starved air] incinerators. They burn quite completely with no smoke. If such an incinerator were set up in the watershed and the heat created used to generate electricity, which could be sent via a buried cable to PNM's distribution system, the project could be completed without trucking cordwood down Canyon Road and without the nuisance of smoke from open burning [to say nothing of the risk of a prescribed burn getting out of control].” (Letter 43)
- “We believe that the Watershed Project should employ cutting edge technologies for burning slash and woody debris that have been developed in recent years through research on restoration of southwestern forests. The final EIS should present alternative, technological approaches to burning

debris in situ which result in low impact on soils and understories. For example, controlled air incinerators can consume debris and reduce the risk from prescribed fires, without producing smoke.” (Letter 645)

Response: We should first point out that the entire project area acreage will not be thinned, due to areas where the terrain is too steep or already sufficiently open. Some areas that are too steep to mechanically thin may need to be burned to reduce fuel loads, and areas that are thinned need to have the woody material under 4-inch diameter burned in order to eliminate the fuel hazard created by the thinning “slash.” Our analysis and past experience with fires tells us that burning is a tool that must be used in order to reduce the hazardous fuels in this area, in order to minimize the risk of a much more serious wildfire event.

We understand the concerns regarding smoke, and will ensure that the appropriate mitigation and monitoring measures will be taken to reduce smoke impacts to the extent possible (see DEIS p. 31). These include burning on days when atmospheric conditions are most conducive to lifting and dispersing the smoke, taking action to reduce smoldering, and stopping ignition early to reduce residual smoke. Visual monitoring will be conducted continuously and when smoke begins to become excessive or drifts into sensitive areas, the fire manager will be informed so that appropriate actions can be taken at the burn to modify smoke behavior. In addition, instruments will be placed on Upper Canyon Road to measure particulate matter from smoke in the air. There will be “Real-Time” and Federal Reference Method filter instruments measuring particulate matter. The Real-Time instruments will provide instantaneous data that can be used by fire managers to modify smoke behavior. Data collected by the instruments will be compared to the health-based National Ambient Air Quality Standards (NAAQS). If particulate matter approaches the NAAQS, measures will be taken at the burn to reduce emissions.

Prior to each burning project there will be a wide effort to notify the public that burning will occur. Individuals with respiratory problems or others particularly sensitive to smoke that have identified themselves to the Forest Service will be personally notified about burning.

We appreciate the suggestions on using cutting-edge technologies such as incinerators for disposing of the slash generated from thinning, especially with the added benefits of smoke reduction and possible energy generation. The challenge we face in this Watershed is that due to the lack of roads, steep rugged terrain, and highly erosive soils, it would not be feasible to get the thousands of slash piles to the incinerator or the incinerator to the

piles of slash. There are very few acres in this watershed where the cut material would be close enough to the existing road to utilize such an incinerator. This idea may have more applicability in other areas of the national forest that have roads and/or gentle slopes.

Burning: Timing and Personnel

64. Comment: Conduct prescribed burns in the winter, spring and fall, and ensure adequate staffing to supervise the burns.

- “I suggest doing the prescribed burns on warm winter days, as well as during spring and fall. Please have many people supervising these prescribed burns. There needs to be more respect for the power of the wind.” (Letter 18)

Response: Your concerns are well founded and are addressed in the mitigation section of the DEIS (pp. 27-28). Conducting prescribed burns is not predicated on a specific season as much as on specific weather trends, weather conditions, fuel moistures, fuel types, and other factors that are carefully evaluated prior to igniting a prescribed burn. All burns in the watershed will have a “burn plan” detailing specific staffing requirements and contingency resources, which must be reviewed and approved before burning can begin, thus ensuring adequate staffing will be available.

Slash Burning: Scatter vs Pile

65. Comment: Scatter and burn the slash rather than using a pile and burn technique for slash disposal, to minimize adverse impacts.

- “Regarding the question of piling and burning slash vs. lopping, scattering, and broadcast burning the slash- from an ecological perspective, I think that lopping; scattering, and broadcast burning the slash is generally preferable. Piling and burning can have undesirable consequences: (a) the prolonged high temperatures beneath the slash piles lead to mortality of residual herbaceous plants. This loss of residual plants combined with high nutrient concentrations from the burned biomass creates ideal sites for weed establishment; (b) The nutrients within the slash are not re-distributed throughout the forest; residual trees and

herbs may be nutrient limited and so this lack of nutrients may retard desirable natural responses to the thinning & burning. In contrast, with broadcast burning, soil temperatures remain relatively low throughout the treated area and nutrients in the slash are applied to the plants that will most benefit from them. I recognize that there are specific locations where broadcast burning would be too hazardous, at least in the first round of treatment. In these areas, piling and burning would be the only practical method to use. However, DEIS seems to imply that piling and burning is the primary method to be used, with maybe limited broadcast burning. I suggest that this order of priority be reversed to state that broadcast burning will be employed wherever it is safe and practical, with piling and burning conducted only where broadcast burning is not feasible.” (Letter 648)

- “It may be preferable to use the machine to strip and scatter branches for broadcast burning, while laying cut stem individually at right angles to the slope, rather than leaving the cut trees in slash piles.” (Letter 640)

Response: We agree with the expressed ecological advantages of scattering and broadcast burning the slash compared to pile burning, and we will allow for slash to be scattered and broadcast burned in some specific situations (DEIS, pp. 1,2,16, 53). The DEIS prioritizes the use of slash pile burning over broadcast burning as an added safety precaution to reduce the risk of an escaped fire, which was identified as a key issue (concern) for this project. Pile burning provides better assurance of public and worker safety during a prescribed burn, mostly because piles can be burned under much cooler, wetter conditions compared to broadcast burning the scattered slash (DEIS, pp. 27, 53). In addition, pile burning can be immediately stopped if conditions suddenly become too windy or dry, or if smoke becomes excessive.

In machine thinned areas, however, there are several reasons why we believe stripping and scattering the slash may not be used much, if at all. First, it would require considerably more time, effort and expense than what is currently proposed under the machine thinning alternatives. Each tree would need to be cut and delimbed and the bole placed contour with the slope before the next tree is cut. The machine would have to cover substantially more surface area, thereby increasing the

chance of soil disturbance, especially on steeper slopes. The soil stabilization that might be gained by laying the cut stems at right angles to the slope may be offset by the increase in soil erosion and compaction. With the machine slash-piling method, up to a half dozen trees could be cut and held in the grapple arm before the machine lays the bundle on the forest floor.

Slash Burning: Soils

66. Comment: Use fewer piles to burn slash, to minimize soil sterilization.

- “If slash piles cause soil sterilization, we recommend using a small number of pile sites repeatedly for burning the slash. By not hauling the slash, the number of truckloads per day is reduced to 2-11, which is a reasonable amount of traffic.” (Letter 229)

Response: Soil sterilization occurs during burning when the “residence time” of the fire is prolonged. The DEIS describes the effects of slash pile burning on soils (DEIS p. 71). Residence time refers to the time the fire burns in one place. When piles are large and contain large logs, the heat from the fire has a long duration period or residence time. Limiting the size of the piles (DEIS p. 27) will limit the residence time and mitigate the effects of fire on soils.

Slash Burning: Monitoring

67. Comment: Monitor the effects of both scattering and piling slash on the understory and residual vegetation.

- “As the treatment is implemented, we suggest both scattering and piling of slash and comparing the results. It is crucial to evaluate the effect of slash treatments on the understory, and residual trees. We support the Forest Service decision to make two entries in dense areas where a lot of slash will be generated. The Forest Service should specify where these areas are. We also support the Forest Service decision to avoid having too many contiguous sub-basins covered with slash at any one time.” (Letter 229)

Response: Yes, we agree, and the DEIS states that “Scattering the slash rather than piling it may be used in selected areas and the results compared to burning

slash in piles” (p.16). We are in the process of identifying some areas where scattering the slash could be used. These areas will be monitored for the effects on understory and residual trees. In addition, we will be monitoring small mammal and bird response to these two different slash treatment methods.

Burning: Maintenance

68. Comment: Conduct periodic maintenance burning to return fire to the ecosystem and avoid over dense conditions.

- “It should be made clear that the treatments are not one-time-only, but will require maintenance through the use of periodic prescribed fire to avoid a return to current over-dense conditions.” (Letters 640 and 647)
- “Returning fire to the ecosystem requires a long-term commitment to get it back in after management actions that make the return of fire possible and appropriate. For example, in areas that are grazed, a dense mat of grass is developing, there is little Ponderosa Pine regeneration, and because of unnatural selection, undesirable shrubby vegetation is increasing. These areas, because of the low density of fine, light fuels, are not really suitable for future burning as there is nothing to carry the fire unless livestock are removed for a year or more. A long-term commitment to a prescribed fire program has many implications for management of the watershed. We are concerned that some of these implications may not be recognized.” (Letter 22)

Response: Yes, we agree. Prescribed burning in the Watershed will be done periodically, and the DEIS states that prescribed maintenance burns would likely occur in the future, beginning 4-10 years after this project has been implemented (DEIS, pp. 16, 42, 72, 135). Livestock grazing is not allowed within the Watershed, and within 5-10 years following the thinning and burning treatments we expect there will be sufficient ground vegetation and other surface fuels to carry some low-intensity maintenance burns in portions of the Watershed.

Burning: Fire Regimes

69. Comment: Manage wildfires and prescribed burns to restore natural fire regimes.

- “Because the Forest Service has meddled with forest health by suppressing natural fires, we now have this situation of overgrown forests—I ask that the Forest Service now meddle as little as possible to allow the forests to slowly get back to health—I think we need to restore natural fire regimes by using prescribed fire at seasons, frequencies and intensities that emulate natural fire regimes, and, where appropriate, managing natural fires as prescribe burns.” (Letter 13)
- “We oppose fire suppression in the wilderness areas of the watershed and forest types where the fire regime has not been significantly altered.” (Letter 643)

Response: We agree. Fires should generally be allowed to burn in areas where natural fire regimes have maintained open forest conditions such that large, rapidly spreading crown fires would not likely occur, and where wildfire activity would not threaten lives and homes. We do allow wildfires to burn without suppression in some situations on the forest. However, forest conditions in the Watershed and surrounding areas do not reflect a natural fire regime situation for ponderosa pine ecosystems. Historic land use (DEIS p. 3) combined with fire suppression has created forest conditions that make reintroduction of a historic fire regime extremely risky with potentially catastrophic results. The ponderosa pine forests of the Southwest burned every 5 to 10 years. These historic fires were low intensity ground fires that consumed accumulated ground fuels and thinned out little trees that had seeded in. Forests were open and park-like. Fuels never had the opportunity to accumulate to levels that would permit fires to burn with extreme intensities and severities. The forests of today have excessively high densities of trees as a result of not experiencing frequent surface fires over the past 100 years. Thinning the small trees and mechanical manipulation of the fuels must be done prior to reintroducing fire (DEIS p. 4). The use of fire alone as a tool was considered but eliminated from detailed study (DEIS p. 162) because of the risks associated with burning without prior thinning treatment. Hopefully in the future we will get forest conditions to where the forests of the Southwest can burn with historical frequencies and intensities.

Fire Suppression

70. Comment: Use Minimum Impact Suppression Tactics and avoid fire retardant when suppressing fires in the Santa Fe Watershed.

- “When fire suppression is required, we call for the use of Minimum Impact Suppression Tactics (MIST) designed to control the intensity and severity of the fire. MIST should become core curriculum in fire training, and competency in MIST should become part of the certification process required for firefighting employment. Crew performance evaluations on wildfires should be based on their ability to safely and effectively utilize MIST.” “We oppose the dumping of chemical retardants to suppress fire in the watershed.” (Letter 643)

Response: *Although decisions about fire suppression methods are outside the scope of this particular DEIS and fuel reduction project, we will respond to this comment. Minimum Impact Suppression Tactics (MIST)*

are emphasized and used in wilderness areas across the U.S. In areas outside wilderness, such as in this project area below the Pecos Wilderness, wildfire suppression tactics will be based on topography, fuels, weather and protection of life, property and natural resources. On most large fires we employ various tactics on different parts of the fire, including MIST and other light-on-the-land tactics.

As a precautionary measure requested by certain citizens, the DEIS for this project includes a mitigation measure that restricts dropping fire retardant within 400 feet of surface water (Santa Fe River or reservoirs), to minimize the risk of contaminating the water supply (p. 29). However, fire retardants have been used for years to suppress fires without incurring adverse consequences. The effects of fire retardant on the environment have undergone scientific study, and are known to have less negative effects on the environment than the effects of severe crown fire events. Fire retardants are required to be environmentally safe and in compliance with environmental laws. The Materials Data Sheet (MDS) for fire retardants used by our agency can be obtained from the research and development branch of the USDA Forest Service in Washington D.C.

Soil and Water

Water: Tree Numbers

71. Comment: Leave more than 50-100 trees per acre to avoid increases in water flow in subwatersheds.

- “Forest Trust advocates leaving more than 50-100 trees per acre. We have three concerns in reducing the number of trees too significantly. One concern is the potential for an increase in water flow in the subwatersheds.” (Letter 229)

Response: The soil and water effects analysis conducted as part of the DEIS was supported by a detailed review of the technical literature on the hydrologic effects of forest treatments ranging from mechanical thinning to clear cutting, and from low intensity burning to high severity burns. The literature reviewed included data collected from watersheds ranging in size from less than a hectare (about 2 acres) to tens of thousands of hectares. With respect to impact on subwatershed scale versus entire watershed scale, no obvious trend was noted between study area size and the magnitude of the effects due to treatments or wildfire.

We agree that thinning too aggressively could result in adverse hydrologic effects (e.g., severe runoff). Our effects analysis, however, indicates that an appropriately designed and implemented treatment program can achieve the fire-risk reduction goal of 50 to 100 tree per acre in a fashion that would not lead to severely adverse hydrologic effects (DEIS, pp. 60-73).

Regarding the issue of “appropriate design and implementation” of the treatments, the target tree density was arrived at based on an analysis that considered several factors related to reducing risk of a catastrophic fire and returning the ponderosa forest to a healthy condition, including: ground vegetation response, crown bulk density, historic observations of stand counts, site productivity, and other factors (R. Cassidy, 2000). Related to the site productivity factor, the response of the herbaceous ground vegetation to the proposed reduction in canopy cover was assessed via observations from the Aspen Ridge thin/burn project (also on granitic soils) on this same ranger district. The response on similar treated sites in the Aspen Ridge area to the north appears to range between 40-60 percent ground cover, 5 to 10 years following thinning.

With respect to design, recall that the DEIS describes treatments that will occur only on slopes gentle enough for access by foot or machinery. Excessively steep slopes within the project area will remain untreated

unless they are deemed amenable to low-intensity broadcast burns. Thus, the steepest slopes (i.e., those areas most susceptible to adverse hydrologic effects) will not be affected by mechanical thinning operations. Also recall that the 50 to 100 trees per acre target is simply an average range over the landscape. The actual residual tree numbers will be highly variable from site to site. The adaptive management strategy that is part of the preferred alternatives will allow us to further tailor the treatments based on site-specific data and information.

With respect to implementation, it is important to recall the approach taken to the phasing of the treatments (DEIS p. 18). The entire 7,270 acres will not be treated at once. Rather, portions of the area will be identified as being suitable for treatment, and only approximately 500 to 1,000 (not necessarily contiguous) acres would be treated each year. This will result in the expected first-year increases in runoff and erosion (DEIS, Figures 33 and 39) over only small, non-contiguous areas. Furthermore, the many mitigation measures to be taken as part of the treatment program (DEIS pp. 27-32) will act to minimize hydrologic impacts in treatment areas consistent with the curves associated with “light burns” in Figures 33 and 39.

Soil Types: Water

72. Comment: Include an analysis of soil types and their influence on water quality.

- “The public has not been presented with specific soils data within the drainage. Soil types are an important influence on surface runoff rates which is key to preserving the integrity of the watershed and water quality. We suggest that the public be given this vital information before any decision is made regarding management actions in the watershed.” (Letter 643)

Response: Part of the soil and water effects analysis was based on the Santa Fe National Forest Terrestrial Ecosystem Survey, or TES (USDA Forest Service, 1993), which classified the soils in the watershed to the “family” level of Soil Taxonomy (USDA SCS, 1994). The soil data associated with each soil type that was considered in the analysis is in the publicly available TES publication.

The family level of soil taxonomy is deemed sufficient for the engineering approaches used to evaluate soil and water effects (i.e., the Revised Uniform Soil Loss Equation, or RUSLE, to estimate of erosion, and the Curve Number, or CN, approach to estimate of runoff) in the

DEIS. Given the inherent uncertainty associated with the TES RUSLE and CN approaches to estimate soil and water effects, a detailed literature review allowed us to identify analogue watershed responses to bracket those estimates.

Invasive Plants/Soil: Firewood Gathering

73. Comment: Address the impacts of public firewood gathering on introducing invasive plants and depleting soil nutrients.

- “People have a tendency to overcollect in those areas that are easily accessed and consequently remove too much of the organic matter and nutrients in these collection areas. This further depletes the soil and results in increased runoff and significant erosion.” “I also have a concern about introducing noxious weeds to the watershed through the practice of fuelwood gathering. Last week, I was up at the Cerro Grande Fire site and found some Thistle Rosettes and other weedy species coming into some of the fuelwood gathering areas.” (Letter 647)

Response: *Public firewood gathering was not proposed or envisioned for this project (DEIS p. 17). This is due primarily to the Watershed closure order prohibiting public uses, along with the need to restrict public access to minimize the risk of fire starts, invasive species introduction, sanitation problems, administrative and logistical issues, etc. associated with high numbers of pickup trucks and people driving through and cutting wood within this sensitive Watershed. The roadside wood removal originally proposed for this project would have involved hiring a contractor to remove the wood under strict regulatory controls. Legally controlled and supervised access conducted under a contract can address these concerns and minimize potential impacts. Past experience in the forest indicates “overcollecting” is not generally a problem. In fact, it is more typical for both public and commercial firewood gatherers to “undercollect” or “high-grade” the wood, and leave behind large quantities of the non-merchantable or undesirable wood. Regardless, the decision is to forego wood removal from the national forest lands, while monitoring wood removal from City-owned lands within the Watershed (see Record of Decision).*

Most of the nutrients retained in the vegetation resides in the thin branches and leaves, with less in the larger

pieces more attractive to firewood collectors. This fact coupled with the very small area to be subjected to wood removal suggests that soil nutrient depletion will be very minor. It is true that there will be more ground disturbance in the firewood gathering areas, and that there will be an increased risk of noxious weed introduction (which can be minimized through standard mitigation measures).

Invasive Plants: Seeding

74. Comment: Avoid introducing invasive plants if reseeding or revegetating the area.

- “The Draft EIS specifies that after two growing seasons, if ‘determined necessary,’ native grass seeds or plantings will be introduced. We believe that seeding of grasses should be prohibited due to the near certainty of introducing exotic weed contaminants and the establishment of non-local genotypes at the expense of locally evolved and adapted genotypes. These species can be extremely difficult to remove once established. Natural reestablishment of native ground cover is far safer and more appropriate in the long-run.” (Letter 645)
- I would recommend no planting of grass seeds because of the problems you mention; I was in the watershed last Saturday and saw the burned area on the right side of the road between the two reservoirs—grass is already coming in many places, especially where slash have been scattered on the steep slopes (slows down runoff and allows infiltration—this kind of ‘swale’ treatment should be recommended for all treated areas—Craig Allen has documented wonderful natural grass recovery in eroded areas in Bandelier where slash has simply been scattered, especially on the contour of steep slopes.” (Letter 641)
- “This is . . . what I think would be acceptable in terms of revegetation efforts (extent of, timing, species composition), noxious weed monitoring, and the weed control practices that should be implemented in the watershed following all revegetation efforts. Also, use of non-native cereal grains such as Annual Rye or Pearl Barley and even some native species such as Mountain Brome is

not acceptable. The Forest Service needs to put into this DEIS some commitment to readily produce the seed tags, identify the sourcing, subsample the various seed lots purchased, and put down seed cards if and when they broadcast seed. This information is critical and vitally important for evaluating revegetation success and efficacy, and it also holds the Forest Service to some level of accountability. “ (Letter 647)

- “Many restoration specialists understand that even ‘native species’ seed mixes that are commercially available will almost certainly result in the introduction of invasive weed species. If revegetation is to be used, the preferred methods are transplanting individual plants from suitable nearby areas or local hand-collection of wild seeds for planting in the areas to be revegetated.” (Letter 640)
- “I share the concern expressed by the Watershed Association about seeding burned areas, and I support your plan to do no seeding at all until at least two full growing seasons after the thinning & burning treatments- and then only if detailed, site-specific assessments reveal a genuine need for artificial seeding. If you do seed the burned areas, then I think it is critical to use seeds of native species collected locally.” (Letter 648)
- “While the seed source is limited, we do not support seeding areas, given the high probability of contamination of seed sources with invasive and exotic plants.” (Letter 229)
- “We agree with the need to keep out exotics. We do not rule out the possibility that seeding using locally hand-collected seed may be necessary due to lack of ground cover in the area currently.” (Letter 642)

Response: *We agree, and our preferred approach is to allow natural reseeding from onsite grasses and forbs, or transplanting individual plants if necessary. We don’t expect that seeding will be needed after burning. However, if seeding is indeed determined to be necessary based on monitoring and evaluation results, it would be done with precautions taken to avoid introduction of non-native invasive plant species, and would only occur on small localized sites. It is true that contour felling of trees and scattering of slash will help create “mini-swales” that reduce erosion and enhance infiltration, thus facili-*

tating natural re-vegetation. Therefore, scattering and broadcast burning the slash may be implemented where it can be done safely. We agree that all information concerning the seed source needs to be carefully identified and used in monitoring re-vegetation success.

Monitoring: Soils/Ground Vegetation

75. Comment: Monitor the understory response to treatments and consider leaving more than 50-100 trees per acre to monitor soil erosion.

- “The soils and understory in the Watershed have been degraded over time due to grazing and fire suppression. We urge careful monitoring of the understory response to varying degrees of canopy openings. Large openings may facilitate erosion.” “Forest Trust advocates leaving more than 50-100 trees per acre. The response of the herbaceous layer to such a large reduction in canopy cover is unknown, particularly on granite soils.” (Letter 229)

Response: *We agree and have proposed to monitor changes in the soils and understory vegetation in response to treatments and varying degrees of canopy openings (DEIS pp. 29, 165). The DEIS states that an average of 50 to 100 trees per acre would be retained, and the actual number of trees on a given site will be quite variable. Leaving more trees per acre would greatly reduce the effectiveness in meeting fuel reduction objectives, based on the existing forest conditions and scientific research data combined with the professional judgment of our forest silviculturist and fire management officers (see DEIS p. 16 and “Methodology Used in Developing the Number of Trees to be Retained Within Santa Fe Watershed,” by R.Cassidy).*

Monitoring: Water

76. Comment: Ensure the adequacy of “key locations” and other factors in monitoring plans for water quality and stream morphology.

- “The three sites identified by the New Mexico Environment Department (NMED) for monitoring of water quality and stream morphology

are (1) 80 meters upstream of the wilderness boundary; (2) at the USGS gauge above McClure Reservoir and (3) at the USGS gauge midway between McClure and Nichols Reservoirs. It should be determined whether these are 'key' locations, and whether any further water quality monitoring should be required to ensure that proposed treatments are not resulting in impaired water quality. It may be appropriate to make reference to those monitoring plans that are in place." "NMED plans for stream morphology monitoring include entrenchment and channel bottom particle size distribution. It should be determined whether these plans meet the terms of this section, and if so, it may be appropriate to note in the EIS the commitment to monitoring this parameter." (Letter 640)

Response: *The three monitoring locations are considered "key" based on the following rationale:*

1. *The uppermost location, just below the wilderness boundary, will provide "background" or "reference" data, which will never be affected by the Watershed treatments.*
2. *The middle location, just above McClure Reservoir, will provide data for a small portion of the Watershed that is subjected to treatments. Furthermore, this location is also the site of a USGS-monitored stream gauge that provides complementary flow data for the Santa Fe River.*
3. *The third location, between McClure and Nichols Reservoirs, will provide data with a larger portion of its contributing area within the planned treatment area, and is also colocated with a long-term USGS flow gage.*

At this time, the NMED is considering moving the third (lowest elevation) location downstream for two reasons: (1) the alternative location has established baseline fisheries data, and (2) the alternative location would have a larger fraction of its contributing area within the planned treatment zone. The NMED would welcome input from interested parties as they deliberate on the pros and cons of moving the lowest surface water monitoring site.

The channel-bottom sediment particle-size distribution measurements as part of the NMED stream morphology

monitoring program (DEIS p. 164) meet the objectives of the soil and water effects monitoring. Any observed channels in channel-bottom sediment-size distribution can be readily compared to predictions made in the erosion analyses. The Errata Sheet contains the updated monitoring plan, and the DEIS states that the "monitoring plan may continue to be refined and modified as new relevant information becomes available" (p. 163).

Monitoring: Water, Paired Subbasins

77. Comment: Ensure that the subbasin selected for monitoring hydrologic effects in the paired subbasin study is actually thinned and burned.

- "The paired basin study is set up to monitor changes in peak flows with and without thinning... Post-EIS discussions with the fire specialist for this project ... was recommending that no burn be used on the eastern half of the treated watershed... Only the lower elevations of this watershed would be thinned under current guidelines (if at all), so the treated areas of this component of the pair would be substantially less than originally envisioned. In order to increase the treated area, we recommend that the mechanically thinned area of the eastern portion be extended upslope from the shallow contours. This would necessitate bringing in (a) special crew(s) that have training and experience in safe steep slope contour felling..." (Letter 646)
- "Therefore, moving the project boundary to the west will subsequently leave a portion of the treated basin untreated. We would recommend amending the current proposal to broadcast burn that portion of the unit, with a plan to fully treat the treated basin using thinning and slash-pile burning. In doing so, the effects of treatment on turbidity and hydrograph characteristics will be more readily recognizable if the full subbasin is treated and the information generated from this study will be far more useful for future adaptive management practices within the Santa Fe watershed and elsewhere." (Letter 647).

Response: *It remains somewhat uncertain how much acreage can feasibly be thinned or broadcast burned in the subbasin selected for the paired basin study, although we will make all efforts to ensure that the maximum acreage is treated, based on the site-specific analysis of fuel reduction needs and needs for safe thinning and burning conditions. If some excessively steep portions of the treatment subbasin in the paired subbasin study are not treated, they will still be representative of the nature of treatments throughout this project area. It is important to recognize that treatments will occur across the entire*

project area in a very patchy fashion, and many patches will be untreated because they are too steep for thinning or for safe broadcast burning operations. Therefore, the study subbasin is expected to be representative of other treated areas in the watershed and appropriate for the paired basin study. This does not obviate the need for the monitoring committee to carefully evaluate any changes in the to the proposed treatment plans with respect to the paired basin study, and if necessary adjust the monitoring plans to ensure monitoring goals are met.

Riparian and Aquatic

Riparian Buffers: Need

78. Comment: Protect all vegetation in riparian zones to protect wildlife habitat and water quality.

- “We would like to have a mitigation measure added that emphasizes the importance and wisdom of protecting shrubs and undisturbed habitat in riparian zones.” (Letter 224)
- “I think that leaving all the vegetation in the riparian buffer is a good idea for habitat health and water quality issues; there is certainly no fire hazard in the riparian area because of the wetness of the riparian zone; leaving all the vegetation is the more conservative and safer approach for many reasons, including the public perception one you mention; there are also riparian health reasons which could be demonstrated with some riparian health surveys, which I would be glad to demonstrate.” (Letter 641)

Response: *These comments are consistent with our plan to leave all vegetation in the riparian zone and riparian buffer, as stated in the DEIS (p. 3, 26, 30...). However, it should be pointed out that while riparian vegetation does not burn as readily as conifer vegetation, all vegetation in the riparian zone is vulnerable to burning in a wildfire. The major riparian zones within the Cerro Grande Fire in Pajarito Canyon, Los Alamos Canyon and Guaje Canyon burned severely and with high intensity. Riparian vegetation (narrow-leaf cottonwood, willow, and box elder trees) was burned and killed.*

Riparian Buffers: Location

79. Comment: Require 15-foot riparian buffers ephemeral streams in addition to the one required along the Santa Fe River.

- (The DEIS states): ‘Do not pile slash within 15 feet of perennial streams (Santa Fe River).’ The fourth bullet in this section (page 30) states that thinning activity will not be conducted within 15 feet of the boundary of the riparian zone (greater than 15 feet from the stream itself). The same distance should apply to ephemeral watercourses, since when they flow they could carry contami-

nants and woody debris into the river or reservoirs.” (Letter 640)

Response: *To clarify, the 15-foot buffer mitigation measure in the DEIS applies to ephemeral watercourses with riparian vegetation (DEIS, p. 30). However, most of the ephemeral drainages in the project area are steeply incised, relatively dry, and have little or no riparian vegetation zone.*

Riparian Buffers: Size

80. Comment: Enlarge the width of riparian buffers.

- “Many researchers recommend more than 15 ft for a riparian buffer (some as much as 60 ft for streams channels of the Santa Fe river size); other recommendations relate to the bankfull width of the channel—at least that width on either side—I measured bankfull widths of 30 feet in some places last week. And I very much agree that the same guidelines should apply to ephemeral channels.” (Letter 641)

Response: *We agree, and no treatments will occur in the riparian zone, “riparian is defined in the section on Aquatic Habitat,” DEIS p. 30). In addition, no treatment will occur in the 15-foot buffer zone. Results of adjacent area treatments will be monitored. If the results of monitoring indicate a need to increase the size of the buffers zones, through the process of adaptive management they can be enlarged (DEIS pp. 19, 27).*

Riparian/Aquatic: Monitoring

81. Comment: Consider other methods for monitoring riparian and fish habitat.

- “Aquatic habitat and biota: don’t know what NMED has in mind, but I recommend extensive riparian habitat evaluation at many reaches (perhaps as many as 20) on the main stem and also several reaches on the channels of the watershed; there are several methods, including PFC (proper functioning condition, which the federal agencies prefer) and the NM watershed watch riparian survey; the pfc is more technical and complex, and needs at least 4 ‘experts’ in hydrology and ecology—it is also time con-

suming and comes up with 3 categories of condition: functioning, at risk, and non-functioning. The WW procedure rates 12 parameters semi-quantitatively, coming up with a numerical rating (out of 48 possible points), can be done in an hour by trained non-technical volunteers (training takes a couple of hours), and is very cost-effective; the numerical rating can then be compared on a before/after basis for the same reach.” (Letter 641)

- “Does the SWQB (Surface Water Quality Monitoring Bureau of New Mexico Environment Dept) monitoring plan adequately address fish habitat? No, I don’t think so. I think it would be appropriate to examine the pool riffle sequences and the size and composition of the woody debris inputs into the stream - before, during, and after the treatments.” “NMED has extensive plans for monitoring stream geomorphology, benthic macroinvertebrates and fish population characteristics in the Santa Fe River... The EIS may be improved by noting these plans for detection of changes in fish habitat.” “Would it be possible to examine the quality, composition, and size distribution of the organic debris found in the different reaches of the stream? These are the basic habitat and food materials for aquatic macro invertebrates!” (Also) “What about overstory canopy cover and its relationship to or influence on stream temperature? This could be easily measured with a spherical densiometer and concurrently with the temperature readings.” “NMED water quality monitoring plans include measuring temperature at the three sites noted above, three times a year. Is such

‘grab-sample’ temperature data meaningful? The City is contemplating adding a continuous temperature logger to the data collected at the gauges on the paired sub-basins. Are other temperature records desirable to detect effects of near-riparian thinning?” (Letter 640)

- [Similar comments from Letter 229.]

Response: *Other methods for monitoring riparian and habitat in the Watershed are being considered. We passed the comment letter on to NMED and the monitoring group for consideration in the monitoring plan. Within the treated area, NMED will be monitoring water quality, turbidity, soil erosion, benthic aquatic macroinvertebrates and other parameters. Also see the Errata Sheet for the updated monitoring plan.*

No thinning will take place in the riparian zone, so changes to the existing riparian vegetation would not be expected. Existing pools and riffles within the project area are generally limited by the controlled flow from McClure to Nichols Reservoir and natural events of windstorms that throw down large woody debris or beavers cutting down trees along the river. The benthic macroinvertebrates (aquatic insects) will be monitored because they are the more sensitive indicators of condition rather than the organic debris that can fluctuate based on season, weather, or stochastic events. Direct temperature measurements are more usable data. Measurements with a spherical densiometer are not necessarily related to the temperature of the stream. Trees can be included in the readings that do not contribute to shade affecting the temperature of the stream. Temperatures being gathered should be adequate to detect any need for adaptive management changes in treatments. The plans to detect changes in fish habitat are in the monitoring plan (DEIS p. 168).

Wildlife

Nesting: Treatment Timing

82. Comment: Consider timing treatments, especially in riparian zones to minimize impacts to wildlife.

- “In addition to monitoring, care should be taken to time treatment, especially in the riparian areas, so as to minimize impact on migrant and resident nesting species.” (Letter 649)
- “We oppose spring burning because of the negative impacts to wildlife. Spring burning has been shown to contribute to mortality of nature ponderosa pine by killing fine roots near ground surface, making trees more susceptible to summer moisture stress. There has been little research on direct avian mortality resulting from prescribed fire. However, it is obvious that prescribed fires conducted during nesting season will destroy ground-nesting birds. Therefore, we recommend that prescribed burning not be done during the spring.” (Letter 643)

Response: No treatments are planned in the riparian zone (DEIS page 30). Prescribed burning outside or adjacent to the riparian areas is mainly planned to take place during those times of year when risk of escaped fire is very low (DEIS p. 27) and outside of the nesting season (DEIS pp. 30 -31).

Broadcast burning is most likely to occur in the fall, based on when the most suitable weather and fuel moisture conditions tend to occur (DEIS p.18). Burning slash piles is also frequently conducted in the fall, but may be conducted in the winter or another time during cool, moist conditions. There could be circumstances where spring burning may be desired, as long as all precautionary measures are strictly adhered to (see mitigations and monitoring measures in DEIS pp. 27-28). Burning when soil moistures are high has been shown to lessen the chances of mortality in the mature ponderosa pine. Spring burning is part of the natural fire regime in ponderosa pine forests. Scars in the wood of old trees indicate that fires burned at this time. Ponderosa pine in uncrowded conditions is adapted to survive. Killed trees that remain standing would be snags, an important part of wildlife habitat. If burning is done in the spring, it is usually done very early before the nesting season. Naturally occurring spring burns may impact the nest of ground nesting species but the adult birds would escape the fire. They are known to re-nest as they would if a predator had destroyed the nest. Ground nesting species re-nest once or twice during the

breeding season depending on the adult birds breeding condition and/or favorable weather.

Wildlife: Cumulative Impacts

83. Comment: Include a scientifically based analysis of cumulative impacts to wildlife in the Santa Fe watershed.

- “The DEIS fails to disclose and mitigate the impacts of the proposal on imperiled wildlife species. The DEIS provides a relatively complete list of native vertebrate and invertebrate species that may be affected by management activities proposed in the context of the Santa Fe Municipal Watershed Project. However, the DEIS entirely lacks a scientifically based analysis of past, present, and reasonably foreseeable impacts to these species. Most of the information and analyses required by forest planning regulations, court opinions interpreting these regulations, the Forest Service Handbook and Manual, and the Santa Fe National Forest Plan are absent.” (Letter 230)

Response: The comments appear to be entirely unfounded. The DEIS does a very thorough job of disclosing and mitigating impacts on imperiled (threatened and endangered) species. Relevant mitigation measures are listed in the DEIS on pages 30-31, and include measures specific to threatened, endangered and sensitive species. The DEIS also includes the relevant mitigation requirements from the Forest Plan. The DEIS contains a scientifically based analysis of past, present, and reasonably foreseeable impacts to wildlife including special status species in the cumulative effects sections on pages 78, 87, 98, and 105. These analyses were completed by highly qualified wildlife biologists who discussed their methodology for estimating effects and cited the scientific research literature they utilized. There is no evidence that the wildlife analyses in the DEIS are inconsistent with any laws, regulations or policies.

Snags

84. Comment: Retain snags to provide wildlife habitat.

- “Dead snags, killed by fire, disease, or other natural processes are vital to wildlife habitat. Many birds depend on these snags for

nesting habitat as well as for food. We feel strongly about the need to aggressively protect these snags. While some removal of snags may be required for safety reasons, we feel that as many snags as possible should be left in all parts of the project area.” (Letter 22)

Response: *Yes, we agree. Snags are an important component of wildlife habitat, and while removal of occasional snags may be required for safety reasons, as many snags as possible will be left (DEIS p. 30). Some snags may need to be cut in the fuel breaks because they are a danger to the firefighters who would use the fuel break as a safety zone and because snags are common sources of fire ignitions. When snags are cut, the result is that we gain additional large logs on the ground that play an important role in wildlife habitat functions and provide ground cover for small mammals and ground nesting birds.*

Wildlife Mitigation: Personnel

85. Comment: Specify that wildlife specialists will identify trees containing squirrel nests in areas to be thinned.

- “Terrestrial habitat and associated wildlife”, fourth bullet: “Avoid cutting trees containing a squirrel nest . . .” We recommend specifying that a wildlife specialist will cruise the area to be treated to identify and mark such trees prior to treatment.” (Letter 640)

Response: *A biologist, forester or technician can be readily trained to recognize a squirrel nest. Trained personnel will cruise the area to be treated to identify and mark such trees prior to treatment.*

Wildlife: Mitigations

86. Comment: Implement measures to benefit wildlife abundance and diversity, and avoid extirpation of species.

- “Other important components of this plan that we believe will ultimately benefit wildlife abundance and diversity in the project area include: No treatment directly within the riparian zone; Retain snags (outside of fuelbreak areas) consistent with Forest Plan guidelines; Retain at least five large downed logs per acre; Retain clumps of small trees for cover; Retain all squirrel midden trees

with associated interlocking canopy trees; Retain all oaks (*Quercus* spp.) and other forage shrubs such as *Cercocarpus*, *Ribes*, and *Rubus*; Implementation of pre- and post-treatment monitoring to determine treatment effects on wildlife.”

- “If extirpation of wildlife species is a concern, even a short term concern, the DEIS must specify mitigation measures and conservation strategies designed to reduce these impacts. In no cases, should projects jeopardize the viability of any wildlife species.” (Letter 21)
- “The DEIS also fails to identify mitigation measures or conservation strategies for the vast majority of [sensitive] species that may be adversely affected by the project.” (Letter 230)

Response: *We agree with these comments which support our plans for this project. All the mitigation measures listed in the first comment are in the DEIS as required measures to protect wildlife (DEIS pp. 29-31). The DEIS includes mitigation measures designed to reduce or avoid impacts to threatened, endangered, sensitive species, and other wildlife species. The mitigation measures recognize the need to protect special components of habitat needed for a variety of species. Many sensitive species are affected by factors other than habitat such as disease, human harassment, overcollection, naturally low reproductive rates, or perilous conditions when they migrate to winter habitats outside of the USA where they encounter habitat converted to agriculture or development, pesticides, extreme weather events, and being hunted. The DEIS analysis also considers potential effects to the viability of wildlife populations, and concludes that population viability will not be compromised (pp. 77, 86, 96, 98, 104-105). Even in the event of high intensity wildfire that destroys habitat, such as in the Cerro Grande Fire, gradual re-colonization would take place over several years.*

Birds, Small Mammals: Monitoring

87. Comment: Conduct monitoring of all birds and small mammal populations, as well as beavers, for the duration of the project.

- “We understand that there are currently plans to have researchers from the Forest Service Rocky Mountain Research station conduct a survey for songbirds and owls over a period of five years. We believe that an

effort should extend over the lifetime of the project, and include all birds encountered in the survey.” “We believe that it is essential to conduct inventory and ongoing monitoring of small mammal populations within the project area.” “We also believe that it is important to include an ongoing inventory of beaver populations within the project area. Monitoring of small mammals and beaver was supported at every meeting of the Monitoring Subcommittee, and we believe there is strong public support for this effort.” (Letter 645)

- [Similar comments from Letter 229.]

Response: Yes, there are plans for the Rocky Mountain Research Station to conduct surveys for birds and small mammals for the duration of the project to determine changes in populations as a part of the monitoring requirements. In addition, active beaver dams will be counted to determine the beaver population and detect any changes. This protocol was discussed and agreed to by the monitoring group, partly due to the difficulty in trapping, tagging and counting individual beavers.

Species Surveys

88. Comment: Use population surveys to analyze impacts to threatened, endangered, and sensitive species.

- “There is no evidence that the DEIS is based upon current population and habitat data for any threatened, endangered, sensitive, management indicator, or special status species described. All of the discussions regarding the occurrence or lack of occurrence of these species in the Watershed rest on speculations regarding the presence or absence of habitat. The DEIS references no formal surveys or habitat mapping for any species, save two. Nor does the DEIS include any of the scientifically rigorous analyses of changes in habitat, population abundance and distribution, and population viability required by Forest Service rules and regulations. The ‘analysis’ of impacts to almost every species referenced is limited to brief speculations. . . . Until the Forest Service adequately surveys the Watershed for species of concern, identifies and maps habitat for such species by habi-

tat condition, analyzes predicted changes in species’ and habitat occurrence, abundance, and quality, and adopts mitigation measures and conservation strategies for species that may be adversely affected, obligations to maintain the viability and diversity of wildlife in the Watershed cannot be met.” (Letter 230)

Response: The DEIS does provide clear evidence that the analysis is based on a combination of surveys, field observations, scientific research based on population and habitat data, and the professional judgment of wildlife biologists. Species known to use the habitat types present in the project area were used to determine species for analysis. The species were taken from lists received from Fish and Wildlife Service (FWS) and taken from the New Mexico Department of Game and Fish BISON-M database. The analysis of impacts was made using BISON-M database references from an exhaustive list of scientific research and studies done on the species and effects to changes in habitat, beneficial or negative to populations of species, from different types of actions.

Surveys for Mexican spotted owl and northern goshawk (the two species that have survey requirements) were completed in the Watershed (Project Record). Southwestern willow flycatcher is an endangered species not known or expected to occur in the project area. The analysis for Special Status Species (threatened, endangered, or sensitive species) is found in the Effects on Special Status Species, DEIS pp. 103 –105.

The DEIS also discusses viability to Management Indicator Species as required, on pages 78, 86, 87, 96 and 98. Existing habitat is described in the Affected Environment on pages 43-48. Mitigation Measures for wildlife are in the DEIS on pages 29-31. Conservation strategies for other species or interagency agreements were used for the mitigation measures for species potentially affected. The U.S. Fish and Wildlife Service issued a Biological Opinion on all actions under the Wildland-Urban Interface Projects for all forests in the USDA Forest Service Southwestern Region, which includes the actions planned in this Watershed project. The Biological Opinion recognizes the potential destructiveness of uncontrolled wildfire to habitat of threatened and endangered species, and supports these thinning and burning projects aimed at reducing the fire risk. The monitoring plan for wildlife (DEIS p. 167) has been designed to collect population data and determine changes in wildlife populations before and after treatment.

Goshawk Standards

89. Comment: Specify how goshawk standards will be applied.

- “On p. 30: Terrestrial habitat and associated wildlife, second and third bullets: if no goshawks have been found, is it appropriate to incorporate the management standards that are based on goshawk biology? Can other species benefit from these particular standards? Are there reasons to manage for goshawks in the hope that goshawks may be attracted to the area? This section could stand clarification.” (Letter 640)

Response: *In applying Forest Plan direction to this area that does not have occupied goshawk habitat, we are*

required to manage the area as goshawk foraging habitat. The management standards were designed to create habitat favorable to the prey base of the goshawk (squirrel, chipmunk, rabbit, and medium size birds such as red-shafted flickers) while retaining a component of larger trees for goshawk nesting. The forest structure is currently lacking in the larger mature trees as well as the seedling/sapling component (defined as VSS classes 1, 2, 5, and 6; see DEIS pp. 46-47). The treatments encourage development of these components that are currently lacking, and will enhance the preybase habitat for goshawks, owls and other raptors. There are numerous other species likely to benefit from creating more variable stand densities and additional openings within the project area, as described in the DEIS (96-98, 104-105).

Social and Economic

Volunteers

90. Comment: Use citizen volunteers to help cut trees, haul wood, and monitor treatments.

- “The community needs to be used more as a resource. Why not use community volunteers to manually cut trees, to help haul cut wood out and to help monitor prescribed burns? We who live here have the most at stake and therefore have lots of helping energy. The Forest Service professionals must be in charge, but it is a mistake not to use all that eager energy.” (Letter 18)
- “As a final comment, it is expected that interested members of the public be allowed frequent (e.g., quarterly) access to thinned areas to qualitatively assess conditions for themselves. This is indirectly mentioned in the EIS, but should be spelled out explicitly.” (Letter 646)

Response: *The DEIS states that members of the public are allowed monthly access to the project area, and have been taken on tours to inspect the demonstration treatment areas (pp. 10, 162). We plan to continue to offer guided public tours to thinned areas, and will allow interested citizens to be directly involved in data collection, inspections and other monitoring tasks.*

A lot of thought has been given to the possibility of using citizen groups and community volunteers to accomplish portions of the work within the Watershed. While it does not seem possible to use citizen volunteers for the tree cutting job, due primarily to safety and liability issues, and hauling will not occur under the selected alternative, it does seem possible that we can use volunteers to help monitor the effects of the thinning and burning activities. There is a monitoring group established for this project, coordinated by the Santa Fe Watershed Association that will assist in coordinating volunteers for project monitoring. We used hundreds of volunteers for forest rehabilitation projects on the Cerro Grande burn area, and hope to continue using citizen volunteers on other projects on public lands.

Cost/Benefit Analysis

91. Comment: The Forest Service should conduct a cost-benefit analysis for the proposed project, and use appropriate specialists.

- “The DEIS fails to demonstrate that any of the project alternatives are cost effective or maximize net public benefits. As with any program or project, the Forest Service must insure that the Santa Fe Municipal Watershed Project is designed in a cost effective manner. FSM 1970.2. In addition, the Forest Service must select an alternative that maximizes net public benefits, with consideration given to all market and non-market cost and benefits. FSH 1909.17.11.1. . . . In the case of the Santa Fe Municipal Watershed Project, factors relevant to the analysis of cost effectiveness and net benefits include: (a) the probability of catastrophic fire; (b) the expected market and non-market resource damage from such a fire, which is equivalent to the indirect benefits of the project; (c) the direct benefits of implementing fire risk reduction activities, and; (d) the expected market and non-market costs of the project. Combining these variables in a relationship such as that described in Attachment 1 would reveal whether or not the cost of implementing activities described in the DEIS are worthwhile. In addition, the analysis will reveal which alternative has the highest present net value—a measure that provides a proxy for net public benefits... since there were no economists trained in the kind of expected value analysis required for this project on the interdisciplinary team, the scientific integrity of the entire economic analysis section is in serious doubt...The analyses also fail to address the probability of a catastrophic fire actually occurring—a probability essential for proper characterization of the ‘no action’ alternative. Nor does the DEIS quantify or describe the resource damages that will occur with certainty as a result of extensive logging on over 5,000 acres of land. In a nutshell, the Forest Service has entirely failed to complete an analysis of cost effectiveness or net public benefits...An analysis of financial and economic efficiency is always required.FSM1971. For ‘stewardship’ timber harvest projects such as the Santa Fe Municipal Watershed Project, the Forest Service must demonstrate that timber harvest is the most ‘financially efficient way of achieving the necessary vegetation management.’ FSH 2409.18.26.1.2 In addition,

tion, in stark contrast with the DEIS's allegations, Forest Service rules state that completion of an economic efficiency analysis is 'strongly recommended' and 'particularly useful' where substantial non-market costs and/or benefits are anticipated as a result of the project. FSH 2409.18.13.2; 2409.18.32.12." (Letter 230)

- "The Forest Service has failed to account for a full range of economic benefits and costs...all costs and benefits, market and non-market, to society as a whole must be addressed (Talberth and Moskowitz, 1999)." (Letter 643)

Response: National Forest Management Act (NFMA) regulations define net public benefits as: "An expression used to signify the overall long-term value to the nation of all outputs and positive effects (benefits) less all associated inputs and negative effects (costs) whether they can be quantitatively valued or not. Net public benefits are measured by both quantitative and qualitative criteria rather than a single measure or index." (36 CFR 219.3). "Net public benefits" is not a benefit-cost analysis given a comprehensive economic efficiency framework—one that incorporates a monetary expression of all known market and non-market benefits and costs. Such an analysis is generally used when economic efficiency is the sole or primary criterion upon which a decision is made.

While applying the notion of "net public benefits" as stated in NFMA may be used by decision makers when establishing or revising a Forest Plan, nowhere does NFMA require such a decision rule for projects. The Forest Service does not endorse or expect this use of economic efficiency analysis in projects undergoing NEPA analysis. The agency recognizes that many of the values associated with natural resource management are best handled apart from, but in conjunction with, a more limited benefit-cost framework. This concept is expressed in National Forest Management Act (NFMA) regulations [36 CFR 219] and is referred to as "cost efficiency."

We also recognize that while most non-market valuation methods are, in theory, consistent with the economic concept of value, the application of methods and the usefulness of resulting value estimates can be problematic (Rollins, 2001. "Measuring Ecosystem Values"; as published in Jensen, 2001. "A Guidebook for Integrated

Ecological Assessments," page 230). We relayed this concern in the DEIS (p. 123), "Although such analyses are informative, they would not resolve conflicts because such analyses are grounded in judgments." Furthermore Rollins goes on to state (p. 234) that because of the nature of the resources themselves, it is difficult to exclude users. This means the use of an ecosystem by one person does not necessarily diminish the amount that is available for other people.

As you mentioned, Forest Service Manual (FSM) 1970 and Forest Service Handbook (FSH) 1909.17 contain detailed guidelines for conducting economic and social analysis. However, FSM 1970.3(6) states, "Select cost effective methods of conducting economic and social impact analyses to ensure that the degree of analysis is commensurate with the scope and complexity of the proposed action." Obviously not every project requires the same level of analysis. FSM 1970.6 adds, "The responsible line officer determines the scope, appropriate level, and complexity of economic and social analysis needed." In the case of the Watershed project, the appropriateness of vegetation treatments to help maintain and protect the Santa Fe Watershed as a municipal water source for the City of Santa Fe was determined to be in the best public interest or benefit.

Forest Service Manual direction (FSM 1971.5) states that estimates for benefits and costs for resource outputs should come from credible economic values for these resources. Without an established market available to express ones willingness to accept tradeoffs, it is difficult to determine with much accuracy an economic value (output) for these uses. Currently Forest Service Handbook (FSH 1909.17, 14.1) states that values should only be determined for outputs that are sold or potentially could be sold. There is currently no commonly accepted protocol established to accurately and consistently define non-market values, nor a common methodology for performing opportunity-cost analysis. The current system of using established resource values and costs is probably the best analysis we can use to assist decision makers in making informed decisions.

As for your concern about using a professional economist for the analysis in the DEIS, the Regional Economist (with a PhD in economics and a MS in natural resource economics), along with the Regional Social Science Coordinator completed the economic analysis used in the DEIS (DEIS pp. 137-138).

Funding Implementation

92. Comment: Request adequate Federal money to complete the Santa Fe Watershed project.

- “It is my understanding that the Santa Fe Forest Supervisor is not planning to ask for the very generous amount of money that the federal government has promised to do the job properly. To say it’s going to be done improperly, is probably and understatement.” (Letter 17)

Response: *This project continues to be a top priority for the Santa Fe National Forest and the Southwestern Region. We identified the project in our out-year budget process and requested adequate funding to fully implement the project. We anticipate receiving adequate funding to implement at least three high-priority fuel reduction projects each year on the Santa Fe National Forest.*

Fund With Recreation Fees

93. Comment: Charge a recreation fee to help pay for project costs.

- “Please plan on charging fees for hikers, bird watchers and crosscountry skiers to help pay for this long term project.” (Letter 2)

Response: *Currently there are no Federal laws or regulations that would allow the charging of recreational user fees to help pay for another Federal project. In addition, recreational use of the Santa Fe Watershed has been prohibited since 1932. The funding needed to implement this project will come from Congressional appropriations specifically earmarked for fuel reduction projects.*

Monitoring - Other

Monitor Compliance: Mitigations

94. Comment: Include all the mitigation measures listed in the DEIS in the work contracts and ensure compliance.

- “We believe that all of the mitigation measures listed in the DEIS should be part of the work contract and that if the contractor does not comply with these mitigation measures he should be replaced.” (Letter 224)

Response: We agree. Mitigation measures from the DEIS will be included in appropriate contracts. If a contractor does not follow these measures or any contractual clause, our response will be dictated by the terms of the contract, including the contractor paying for damages, canceling the contract, etc.

Monitoring: Personnel

95. Comment: Assign wildlife monitoring to scientists outside the agency.

- “The first issue of how many wildlife monitoring teams and who they are has aroused emotions. It was only after considerable effort by the environmental members that the USFS even agreed to fund wildlife monitoring. Prior to this, the environmental community had identified 4 types of wildlife monitoring as essential: aquatic species; beavers; birds; and small mammals. Aquatic species monitoring was already slated to be handled by NMED, leaving the other 3 types. There was a proposal put forward by Peter Stacey, a professor at UNM, to monitor these 3 types and correlate them with local variable in the prescriptions. Once funding for wildlife monitoring was secured, USFS personnel quickly switched attention off this proposal to a very simplified proposal put forth by a staff scientist at the USFS regional research station in Albuquerque. ...the possibility of fundamental conflict-of-interest becomes a problem. Although the usefulness of ANY data from ANY group cannot be apriori denigrated, in order that results of wildlife monitoring be both complete and believable, we are forced to strongly recommend that at least one of the monitoring teams be completely from outside the USFS. This team(s) should have funding for all 3 types of wildlife. If, in addition, the USFS research arm wishes to pursue monitoring

as well, we feel this would be a good idea. Having 2 monitoring efforts will increase confidence in overall results. The resulting increase in costs (<\$50K) would be a small fraction of a percent compared to overall project costs (approximately \$5M)”. “We strongly encourage you to assign the monitoring efforts for small mammals to independent or academic scientists. We suggest that openness and competence, costing relatively little, will be very rewarding in terms of public trust of the project.” (Letter 646)

Response: We understand and agree with the desire to fund several types of wildlife monitoring, including birds, beavers, and small mammals, and have agreed to fund all three types of wildlife monitoring (see updated monitoring plan in Errata Sheet). We also understand the desire to have non-biased, independent scientists conduct the monitoring. The monitoring group considered several candidates and reviewed monitoring designs for the wildlife monitoring before agreeing to use scientists from Rocky Mountain Research Station. The Research Station works independently of the National Forest System and is not supervised by a part of the Santa Fe National Forest. The perceived conflict-of-interest was discussed by the monitoring group, and later discussed with the Research Station, who assured the group that they will conduct the monitoring in an independent, open, professional, and scientific manner.

Monitoring: Technical Assistance

96. Comment: Support the role of the Technical Advisory Group and Santa Fe Watershed Association in monitoring plans, data collection and dissemination.

- “The Santa Fe Watershed Association has taken the lead in the establishment of a Technical Advisory Group to oversee the monitoring of this project. We see the role of the TAG as reviewing and advising monitoring plans. This should not necessarily be done only after monitoring plans are complete, but as they are under development. The TAG, as well as the SFWA, is available to answer questions and to meet as schedules permit to decide between proposed plans or comment on plans in development. We applaud the efforts the SF National Forest has made to include public comments in these

plans. It's important to continue to keep the process as transparent to the public as possible. The Santa Fe Watershed also plays an important role in collecting data and making it available to the public. Perhaps these points should be mentioned in the EIS as well." (Letter 640)

Response: Yes, we appreciate the Santa Fe Watershed Association's lead role in establishing a TAG to oversee the monitoring of this project, and we will continue to support the TAG's role in providing review and advice on monitoring plans. We also have a cooperative agreement with Santa Fe Watershed Association for their work in data collection, evaluation and reporting for specific monitoring items in the monitoring plan.

Monitoring: Funding

97. Comment: Ensure adequate (more) funding for monitoring soil erosion and wildlife.

- "We believe that the erosion monitoring component is at present grossly underfunded, and will not be an adequate effort unless it is more comprehensive and better funded." (Letter 645)
- "For erosion, . . . the EIS lists a value of \$2500/year as the intended expenditure. Even by graduate-student standards, this appears to be at least a factor of 3x shy of what will be needed. During the first year or 2 after thinning, erosion (and assoc. turbidity) is likely to be the dominant ecological impact in the thinned areas. It is important to have a clear idea of this as a function of management options so that rational adaptive actions can be taken. We recommend that the final EIS have a level of funding of \$7500 for this item." (Letter 646)
- "The importance of that monitoring cannot be overstated, as this vital riparian community, protected from human impact for more than sixty years, is a rare and essential resource for wildlife. We have actually documented 140 species of birds in the area, and can suggest some nesting species that were not identified in the DEIS. American Peregrine, Northern Goshawk and Mexican Spotted Owl have also been observed. The

rarity of this riparian resource is the most compelling reason to . . . require that the project proceed only with a fully funded monitoring strategy in place." (Letter 649)

Response: We concur with the importance of monitoring, and some people feel that the amount originally estimated for monitoring soil erosion or wildlife (DEIS p. 164) was too low. We are making an exceptional financial investment in the monitoring and evaluation for this project, and continue to search for additional sources of funding, including partnerships and grants. The monitoring plan has been updated to reflect additional funding for monitoring understory vegetation (affecting soil erosion) and wildlife including riparian habitat and species. Please see the Errata Sheet for the updated monitoring and funding estimates. Funding is partially contingent on annual appropriations from Congress.

Monitoring: Scheduling

98. Comment: Coordinate monitoring with the phasing of treatments in different parts of the project area.

- "It will be CRUCIAL to coordinate monitoring plans with the phasing of treatments to ensure the development of baseline information prior to implementation of actions. That is, baseline data monitoring can be phased in where necessary so that an area that may be treated at a later date can serve as a control initially. It is best to have at least two year's baseline data. In some cases, one year can be sufficient. Consider dovetailing data collection for vegetation, wildlife and soils so that the various types of analysis inform each other, rather than having information on wildlife in one area, vegetation in another, soils in still another." (Letters 640 and 647)

Response: We agree that it is important that this type of coordination continue to occur. The monitoring committee continues to meet with agency personnel and others involved in the data collection in order to ensure that the scheduling is well-coordinated and information is shared. In addition, monitoring data for different resources will be consolidated and reported annually (DEIS p. 163).

Monitoring: Stand Data

99. Comment: Collect more stand data for project monitoring and evaluation.

- “The current quantitative data set of stand values within the proposed project is inadequate. The basic problem is that data have been collected on only a portion of the project area and extrapolated to the rest. There are 27 stands in the lower watershed without any stand data compared to 12 stands with data. Data on the remaining stands is essential as a basis for good monitoring and adaptive management. The fuels analysis that was conducted by the Forest Service in 1998 provides information on the natural fuel bed in three layers: ground fuels, intermediate or ladder fuels, and canopy or overstory fuels. These plots could be re-measured as part of the monitoring process to see how treatments have changed fuel loads. Stand information, including species, dbh, and crown form, was also collected as part of the fuels analysis. Considering that there are only 20 plots that fall within the treatment area, and a subset of stand data was gathered, this information cannot be a substitute for establishing additional stand data plots. We recognize that the Forest Service has done an impressive amount of analysis with the existing stand data, but we do not believe the baseline data is fully representative of the area to be treated. We advocate the collection of additional stand data prior to treatment that will be representative of the entire treatment area, and can be a reasonable basis for subsequent monitoring efforts and adaptive management.” (Letter 229)
- “In this case, the public has not been given minimum stand data for more than 60 percent of the stands in the watershed. The information that has been presented is suspect. For example, data from stand 6353-0006 was gathered showing that it was dominated by ponderosa pine. In fact, this stand is mixed conifer. This inaccuracy shows a disregard for the National Environmental Policy Act which mandates that information be of high quality. 40 CFR [section] 1500.1(b).” (Letter 643)

- “The EIS should make explicit that additional stand data is required. SFWA staff believe this data could be gathered in a phased-in manner; that is, an area initially serving as a control could later be treated.” (Letter 642)

Response: We believe that the stand data collected for this project was adequate to meet the analysts needs in completing the DEIS in accordance with NEPA regulations; to develop treatment alternatives and estimate the environmental effects in order to make an informed decision. The stand data was used to develop values for trees per acre, canopy density, the number of stand canopy levels, and species composition. Stand data collected from field exams was stratified and extrapolated to similar stands within the project area. The forest silviculturist determined that having stand data for every stand within the project area was unnecessary in developing treatment alternatives and completing the analysis.

In addition to the stand data collected, fuel inventory data was used to describe the vegetation and fuels in the area, and the silviculturist and forestry/fuels specialist conducted substantial field reconnaissance to validate stand data and gain more knowledge about existing stand conditions. The reconnaissance work performed clearly indicated that stand conditions were uniform when elevation, aspect, covers type, and distance from drainages (slope position) were taken into consideration. The collection of additional stand data for this analysis would have been redundant.

Additional stand data may be desired and collected for the paired subwatershed monitoring work, during baseline monitoring activities. Furthermore, additional field reconnaissance will also be performed as treatment units are laid out on the ground.

The example provided by the commentor that indicated a stand within the Watershed was classified as ponderosa pine rather than mixed conifer thus making all data suspect, can be explained. Many of the ponderosa pine stands in the Watershed have an understory of fir due to decades of fire exclusion. When fir makes up most of the total number of trees in the understory, and pine comprises the more occasional overstory (dominant) trees, some people (and databases) classify the stand as mixed conifer. However, our stand database classifies the stand as a pine cover type based on a plurality of basal area (cross-sectional square feet) from the larger overstory pine trees. An example would be a stand having 40 basal area in pine, 20 basal area in Douglas-fir, and 20 basal area in white fir. This stand would be classified as pine although half of the total stocking is in fir species.

In addition, mixed conifer is not a cover type but an association of many species. Forest tree associations are highly variable in the Watershed as one moves through a mix of different aspects, slopes and elevations. Fir may dominate in a cooler northeast-facing patch when a few yards away pine dominates a south-facing patch. Treatment prescriptions will take into account differences between pine and fir dominated areas. In general, the more fire-resistant ponderosa pine will be favored over the fir, but fir will be retained as needed to achieve desired stocking levels and stand structures. Intensive reconnaissance during unit layout will aid in defining fir and pine dominated areas and may result in different treatment prescriptions.

Monitoring: Variability

100. Comment: Incorporate variability into treatment prescriptions, and monitor the variability across the watershed.

- “The 3rd issue of erosion criteria feedback onto management is not spelled out. Presumably this is due to a lack of (documented) study of past projects, and no modeling. To remedy this, we recommend the variation of prescriptions in a systematic way across the treated watershed. Prescription variables such as final basal area (BA), clumpiness, q-factor, canopy closure, and slash-burn technique, as a function of the % slope would provide useful qualitative (and potentially quantitative) data for adaptive management.”
- “The 3rd issue concerning wildlife monitoring was the lack of specificity for variables that could potentially be correlated with wildlife changes. The EIS has nothing in particular to say about this, while the monitoring sub-group, as mentioned above, only listed slash-burning technique on bird populations. It would be hard to imagine a less likely correlation than this combination. Much more likely to be important are tree-thinning prescriptions (as listed above for erosion issues), ground vegetation, distance from water, and erosion—on small mammals (1st) and birds (2nd). Thus variability in thinning needs to be an important component in wildlife monitoring, and this needs to be explicitly spelled out in the EIS.”

- “It should be emphasized that not all variables contributing to thinning prescriptions need be independently varied. A more typical scenario would be 2 heavily thinned sites, 2 moderately thinned sites, and 2 lightly thinned sites, each monitored for (both) small mammals and birds.” (Letter 646)
- “The DEIS states that the actual number of trees retained will depend on the ‘the existing number of trees, stand structure, canopy cover, slope, aspect, site productivity and other factors.’ Forest Trust supports prescriptions that incorporate variability.” (Letter 229)

Response: *We appreciate your support and agree with the need to implement and monitor variable treatments across the landscape. This project is a fuel reduction project designed to mimic historic fire disturbance processes in ponderosa pine ecosystems and reduce the risk of catastrophic crown fire. Therefore, actual numbers of trees retained will be highly variable over the landscape based on differences in the existing stand structure, canopy cover, slope, aspect, site productivity and other factors. The thinning and prescribed burning are expected to be highly variable in terms of basal area, clumpiness, q-factors, canopy closure and slash burn technique across the project area (see DEIS pp. 96-97). The post-treatment evaluation of monitoring data regarding vegetative ground cover response and subsequent changes in soil stability will consider these types of variables, for adaptive management purposes. We should perhaps note that there are numerous published studies regarding soil erosion and sedimentation effects from thinning and burning operations, some of which were cited in the DEIS (pp. 68-71), and the scientific methods used in the analysis for the DEIS were deemed appropriate according to an independent review by other soil scientists. Furthermore, the variability in thinning will be considered by the Research Station as a component in designing and implementing the wildlife monitoring.*

Monitoring: Vegetation Parameters

101. Comment: Include vegetation ground cover, overstory canopy cover, tree composition and density as parameters in project monitoring plans.

- “On p. 31 Terrestrial habitat and associated wildlife, last three bullets: ensure these parameters are included in detailed monitoring plans. It is unclear whether overstory tree composition, structure and density are included in monitoring plans: Appendix B refers just to abundance by species.” (Letter 640)
- “It does not look like comprehensive vegetation ground cover or overstory canopy cover, tree composition or density will be included in the monitoring plans. These are very important both in a habitat sense and a hydrologic/watershed sense!” (Letter 647)

Response: *Yes, these elements suggested are included in the monitoring plans (DEIS p. 165-166).*

Monitoring: Treatment Effects

102. Comment: Adequately monitor environmental effects to resources in the treated areas.

- “Considering the effort that has been spent on the development of acceptable monitoring guidelines, and the assurances by the Regional Forester that these efforts would be sustained in the treatment, we expect an adequate monitoring component of the Watershed Project. Again, we stress the fact that this treatment project will be prototypical and exemplary, and likely to serve as a model for other fuel reduction forest treatment projects. We believe that it is essential to conduct adequate monitoring of wildlife, both aquatic and terrestrial, and soil parameters in this project.” (Letter 645)

Response: *We agree and thank you for your support of this project as an exemplary model for other fuel reduction projects. The selected alternative includes a comprehensive monitoring plan, including monitoring the effects of treatments on terrestrial and aquatic wildlife, water, soil, air quality, vegetation, fuels, fire behavior, etc. (DEIS pp. 163-169).*

Names of Commenters and Letter Numbers

(Excluding the form letters or petition)

Name	Organization	Letter Number
Armijo-Lakey, Becky		35
Barba Sr., Jacob	Frontiers of Freedom / New Mexico People for the USA	2
Bernstein, Dr. Robert		38
Beyer, Jill		6
Blythe, Joan		221
Buchser, John		227
Carr, Henrik Schlubach		20
Catanach, Clarence	Los Miradores Condo Association	14
Chambers, Grace		222
Chelini, Maxine		25, 27
Clubbe, John		41
Coffland, Robert & Mary Hunt Kahlenberg		44
Durand, Albert & Connie		659
Durand, Constance		12,16
Feather, Bill & Patricia		40
Fleming, Dr. William	University of NM Prof/ SFWA-TAG ¹	641
Fraser, Doug	Sierra Club, Santa Fe Group	224
Freeman, Martha Anne		17
Goodacre, Glenna		9
Gorham, Daniel		39
Grant, Paige & Bonney; + Popp, Fleming, Romme & Tierney	Santa Fe Watershed Association (SFWA and SFWA-TAG)	640, 642
Grossman, George		228
Hitt, Sam	Wild Watershed Alliance	643
Holloway, Colin Lincoln		23
Jervis, Thomas	Sangre de Cristo Audubon	22
Johnson, George		26 / 226
Justice, Jack		1
Kaczmarek, Norman		655
Katherine, Anna		18
Koch, Kay Delle		4

La Farge, John Pen		658
Luehrmann, Paul		660
Maret, Nancy		656
McCorduck, Pamela		8
Merlan, Thomas & Frances Levine		3
Oldham, Carol		36
O'Niell, Kathleen & Robert Easton		657
Peterson, Roger	NM Natural History Institute	42
Pollak, Greg	Santa Fe Forest Watch	646
Porter, Joyce	Lousiana / New Mexico Airport Development Office	11
Pyle, Sasha & Travis & Isabel Gibson		218
Rigoli, Diane		219
Romme, Dr. William	Fort Lewis College Professor/ SFWA-TAG	648
Rudolf, Barry		5
Savage, Melissa, & Henderson, Williamson, Pollak and Waldman	Four Corners Institute, Audubon Society, Canyon Preservation Trust, Santa Fe Forest Watch, The Nature Conservancy	645
Schumann, Martha	Forest Trust	229
Sekavec, Glenn	USDI- Office of the Secretary	37
Snowden, Janet		217
Snowden, Janet	Wild Watershed Alliance	223
Snowden III, James		220
Soeiro, Edie		19
Stevenson, Tod	NM Department of Game & Fish	21
Talberth, John	Forest Conservation Council	230
Tierney, Dr Robyn	Highlands University Prof. Natural Resources Mgmt./ SFWA-TAG	6
Traub, Joseph		7
Trevino, Rosendo	USDA Natural Resources Conservation Service	651
Van Slooten, Shirley		13 / 652
Walke, Greg	Historic Santa Fe Foundation	225 / 650
Watson, Alan "Mac"		28
Williams, Ted		43
Williamson, Kent	Canyon Preservation Trust/Bosque del Rio	649

¹ SFWA-TAG: Santa Fe Watershed Association, Technical Advisory Group

Correction Page to Santa Fe Watershed FEIS and ROD

Prescribed Broadcast Burning

October 14, 2004

Prescribed Burning and Risk of Escape Fire: The following direction is found in the Record of Decision, (ROD) page 9, paragraph 2; and Final Environmental Impact Statement (FEIS), page 28, paragraph 1.

- **Current Direction:** Prior to ignition and throughout burn implementation, monitor and record fuel moistures. Do not broadcast burn when live fuel moistures are below 100 percent. Do not burn complex burn units when the Palmer Drought Index (PDI) indicates a moderate or higher drought index. This will reduce the likelihood of an escape fire and lessen the chance of killing desired trees.
- **Changes to above Direction:** Prior to ignition and throughout burn implementation a fire behavior prescription will be designed and implemented to mitigate the likelihood of an escape fire and lessen the chance of killing desired trees (tree mortality). Fine fuel moistures, slope, wind, probability of Ignition (PI) and scorch height will be the criteria used in the fire behavior prescription to reduce the likelihood of an escape fire and increased tree mortality.
- **Rationale:** Changes to the above direction allow for criteria that actually changes site specific fire behavior. The Palmer Drought Index (values) covers landscape areas and is not related to site specific fire behavior. While live fuel moistures ranging below 120% do affect crown fire initiation, more important factors determining the likelihood of an escape and increase tree mortality are due to wind, slope, fine fuel moistures and Probability of Ignition (PI) with consideration for low live fuel moistures during drought conditions..

This correction has been discussed with the Santa Fe Forest NEPA Staff (Susan Bruin) and she will append this page to the Santa Fe National Forest Watershed FEIS and ROD.



United States
Department of
Agriculture

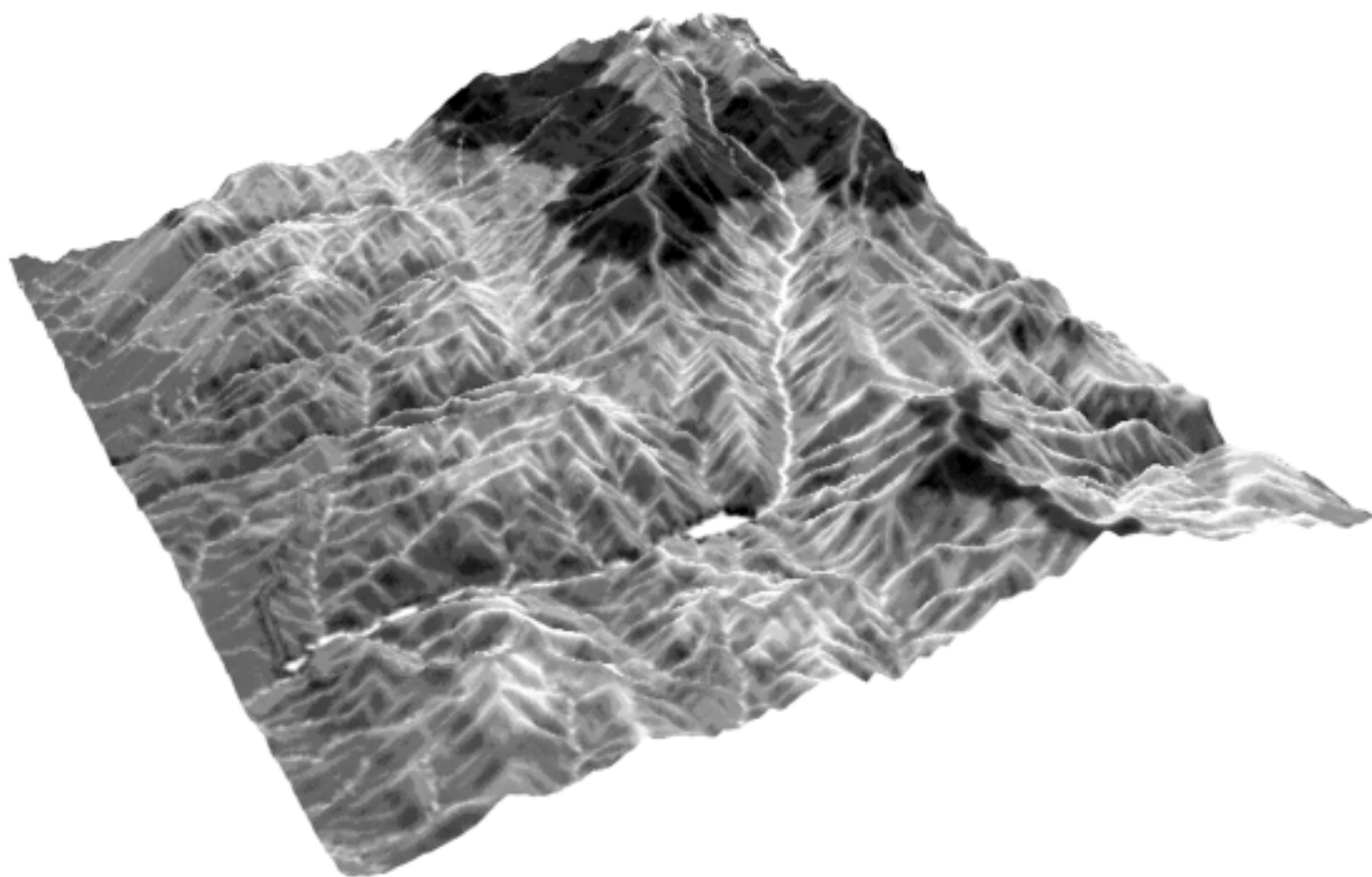
Forest
Service

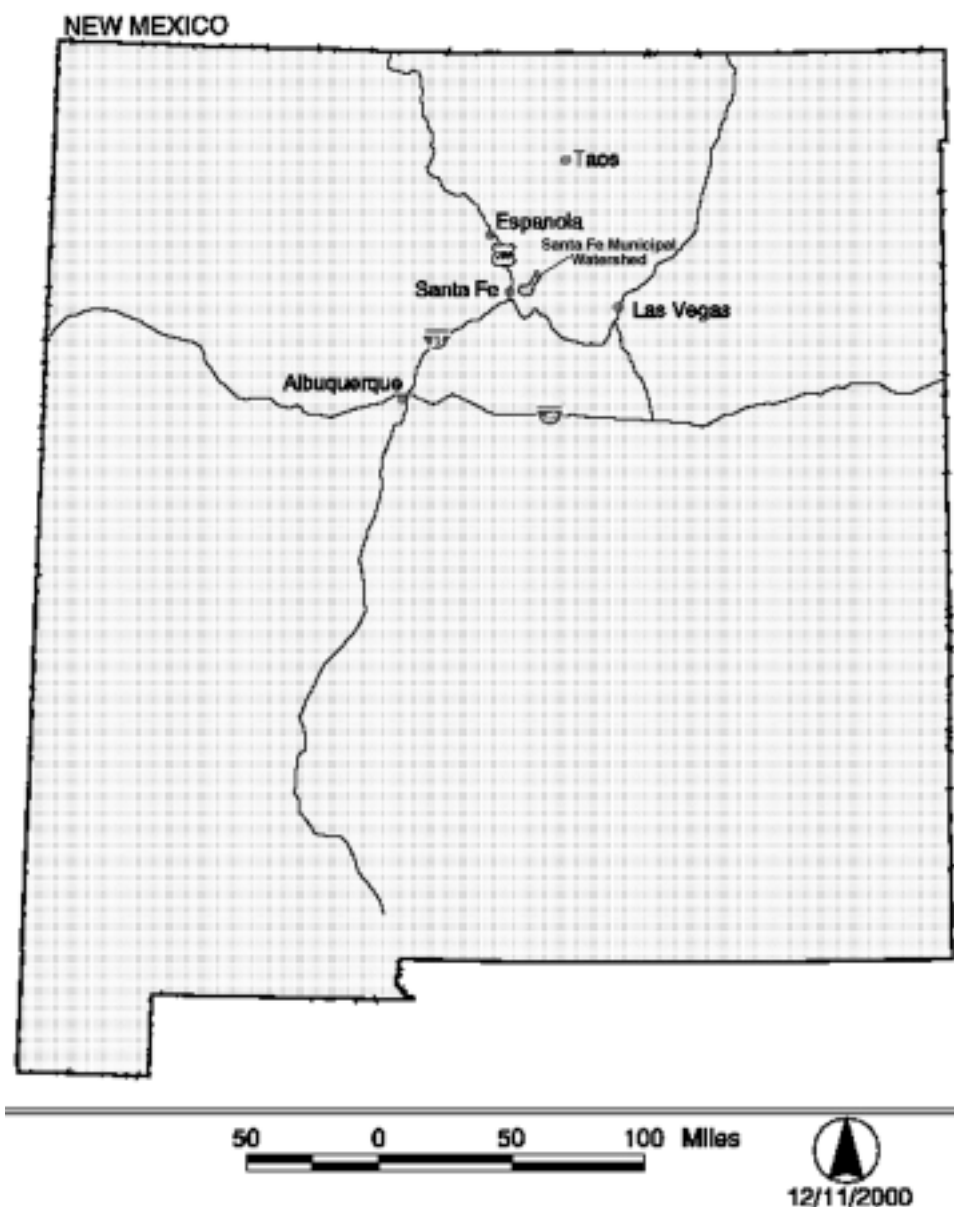
Southwestern
Region



Santa Fe Municipal Watershed Project Final Environmental Impact Statement

Santa Fe National Forest





The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TTY).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice or TTY). USDA is an equal opportunity provider and employer.

Contents

1. Purpose of and Need for Action	1
The Watershed and Project Area	1
Proposed Project	1
Background, Including the Purpose and Need	3
Decision to Be Made	5
Forest Management Direction	5
Public Involvement and Scoping	10
Issues	11
Forest Vegetation, Fuels and Fire Behavior	12
Soil and Water	12
Aquatic Habitat and Biota	12
Riparian Ecosystem and Jurisdictional Wetlands	12
Terrestrial Habitat and Associated Wildlife	12
Special Status Species	12
Air Quality/Smoke	12
Social Environment	12
Heritage Resources	13
Recreation and Scenery	13
Facilities	13
Permits and Agency Approvals Required	13
2. Alternatives, Including the Proposed Action	15
Alternatives Considered but Eliminated from Detailed Study	15
Alternatives Considered in Detail	15
Alternative A: No Action	15
Features Common to All Action Alternatives	15
Alternative B1: Limited Manual Thin/Burn Slash/Broadcast Burn	19
Alternative B2: Limited Manual Thin/Burn Slash/No Broadcast Burn	19
Alternative C1: Manual Thin/Burn Slash/Broadcast Burn	22
Alternative C2: Manual Thin/Burn Slash/No Broadcast Burn	22
Alternative D1: Machine Thin/Burn Slash/Broadcast Burn	22
Alternative D2: Machine Thin/Burn Slash/No Broadcast Burn	25
Additional “Options”	26
Mitigation and Monitoring	27
Prescribed Burning and Fire Behavior	27
Wildfire Prevention and Agency Coordination	28
Forest Vegetation	28
Worker Safety	29
Soil and Water	29
Aquatic Habitat and Biota	29
Riparian Ecosystems and Wetlands	29

Terrestrial Habitat and Associated Wildlife	30
Air Quality	31
Social Environment	32
Heritage Resources	32
Comparison of Alternatives	33
3. Affected Environment and Environmental Consequences	41
Cumulative Effects	41
Past Actions	41
Current and Ongoing Actions	41
Foreseeable Future Actions	42
Forest Vegetation, Fuels and Fire Behavior	43
Affected Environment	43
Effects on Fuels and Fire Behavior	48
Cumulative Effects	56
Soil and Water Resources	58
Affected Environment	58
Effects on Soil and Water	60
Cumulative Effects	73
Aquatic Habitat and Biota	75
Affected Environment	75
Effects on Aquatic Habitat and Biota	77
Cumulative Effects	78
Riparian Ecosystem and Jurisdictional Wetlands	79
Affected Environment	79
Effects on Riparian Ecosystem and Jurisdictional Wetlands	84
Cumulative Effects	87
Terrestrial Habitat and Associated Wildlife	87
Affected Environment	87
Effects on Terrestrial Habitat and Associated Wildlife	95
Cumulative Effects	98
Special Status Species	99
Affected Environment	99
Effects on Special Status Species	103
Cumulative Effects	105
Air Quality/Smoke	106
Affected Environment	106
Effects on Air Quality	108
Cumulative Effects	112

Social Environment	113
Affected Environment	113
Effects on the Social Environment	118
Cumulative Effects	121
Economics	122
Affected Environment	122
Effects for All Alternatives	122
Cumulative Effects	125
Heritage Resources	125
Affected Environment	126
Effects on Heritage Resources	128
Cumulative Effects	130
Recreation and Scenery	130
Affected Environment	130
Effects on Recreation and Scenery	131
Cumulative Effects	132
Facilities	132
Affected Environment	133
Effects on Facilities	133
Cumulative Effects	134
Unavoidable Adverse Effects	135
Relationship Between Short-Term Uses and Long-Term Productivity	135
Irreversible and Irretrievable Commitments of Resources	135
 4. List of Preparers	 137
 5. List of Agencies, Organizations and Persons to Whom Copies of the DEIS are Sent	 139
 6. Literature Cited	 141
 Appendix	
A. Alternatives Considered and Eliminated from Detailed Study	155
B. Project Monitoring Plan	163

List of Figures

1.	Santa Fe Municipal Watershed Project Map.	vii
2.	Project Area and Land Ownerships	viii
3.	Forest Cover Types	2
4.	Elevations, Stream Drainages and Fire Occurrence.	2
5.	Sheep grazing occurred in the canyon throughout the early 1900's.	3
6.	Logging and homesteading occurred throughout the canyon (1882).	4
7.	B.P.O.E (Elks) Cabin (1917).	4
8.	The upper Santa Fe River was popular for fishing and swimming (1910).	5
9.	In 1917: Santa Fe River riparian corridor with little or no riparian vegetation for bank stabilization or buffering capabilities.	6
10.	Current riparian conditions.	6
11.	In 1916: eroded hillside near reservoirs.	7
12.	In 1999: the same hillside.	7
13.	Hillsides in the canyon are currently covered with 80 to 90-year-old trees.	7
14.	The excessive number of trees has suppressed tree growth and shaded-out the grasses and shrubs.	7
15.	Understory trees act as ladder fuels to carry surface fire into larger overstory trees.	7
16.	Crown fires spread rapidly at 3-10 m.p.h., have flame heights that can reach hundreds of feet, and burning embers that start fires miles ahead of the main fire.	8
17.	Crown fires lead to mass erosion and mud slides.	8
18.	Excess runoff after crown fires causes extreme down cutting, such as evidenced in the headwaters of Capulin Creek, after the 1996 Dome Fire.	8
19.	Crown fires lead to soil damage, excessive water runoff and floods.	8
20.	Crown fires threaten homes and communities, as evidenced by the homes in Los Alamos destroyed in the Cerro Grande Fire.	8
21.	Thinning is commonly used to reduce the risk of crown fires and increase herbaceous vegetation.	9
22.	Slash piles and small logs left at demonstration site in Watershed, immediately after thinning.	9
23.	Slow-moving, low-intensity broadcast burns are used to reduce surface fuels, release nutrients and improve soil productivity.	9
24.	Citizens often met with agency specialists to observe current problems and discuss possible solutions.	10
25.	Alternative B1	20
26.	Alternative B2	21
27.	Alternatives C1 and D1.	23
28.	Alternatives C2 and D2.	24
29.	The feller-buncher offers a higher degree of control and safety than manual thinning and slash piling.	25
30.	Feller-buncher at work	26
31.	Percent of Trees in Each Diameter Class (in the PP and PP/DF stands).	47
32.	Annual Water Yield.	59

33.	Projected Time History of Sediment Yield from a Ponderosa Pine Forested Watershed Following Light, Moderate and High Severity Fires	62
34.	Sediment Yield Ratio for Analogue Watersheds	62
35.	Predicted Time History of Sediment Yield in the Watershed Following Catastrophic Fire	64
36.	The 100-Year and 500-Year Flood Zones	65
37.	Post-fire;pre-fire Peak Flow Ratios for Three Analogue Watersheds and the Viveash BAER CN Method	66
38.	Soil Temperature for Light, Moderate, and High Severity Fires	69
39.	Average Increases in Runoff Following Fire of Varying Severities	70
40.	Woody Riparian Vegetation Along the Santa Fe River	76
41.	Beaver dams on the Santa Fe River	76
42.	Large woody debris in the Channel of the Santa Fe River	77
43.	Length-frequency Histograms of Trout in the Project Area	77
44.	Riparian and Wetland Communities in the Project Area	80
45.	Floodplain Cross Section in a Segment of the Santa Fe River with a Narrow Floodplain	81
46.	Floodplain Cross Section in a Segment of the Santa Fe River with a Wide Floodplain	82
47.	Floodplain Cross Section in a Segment of the Santa Fe River Upstream from McClure Reservoir	83
48.	Percentage of Population in Santa Fe Metropolitan Area by Race	114
49.	Upper Canyon Road is a narrow road lined with old homes within a historic district of Santa Fe	115
50.	Noise Level of Equipment Proposed to be Used in the Santa Fe Watershed.	120

List of Tables

1.	Treatment Type and Acres, Alternative B1	19
2.	Treatment Type and Acres, Alternative B2	19
3.	Treatment Type and Acres, Alternative C1	22
4.	Treatment Type and Acres, Alternative C2	22
5.	Treatment Type and Acres, Alternative D1	25
6.	Treatment Type and Acres, Alternative D2	25
7.	Treatment Type and Acres Summary	26
8.	Comparison of Alternatives	33
9.	Fuel Reduction Treatment Effectiveness	40
10.	Predicted Fire Behavior in Fuel Models 8, 9 and 10	44
11.	Canopy Closure by Forest Type	44
12.	Existing Vegetation Structural Stages	46
13.	Trees Per Acre by Forest Type and Diameter Class in the Santa Fe Municipal Watershed Project Area	47
14.	FOFEM Model Predictions of Changes in Fuels Following Broadcast Burning in Unthinned Stands	54
15.	Relative Effectiveness of Fuel Reduction Treatment Alternatives	55

Contents

16.	Annual Soil Erosion (Loss) Rates in the Watershed Based on the Revised Universal Soil Loss Equation for TES Map Units on the Santa Fe National Forest	57
17.	Peak Storm Flows in the Santa Fe River of Various Return Frequencies	59
18.	“Tolerance” and “Potential” Annual Soil Loss Rates from TES Units in the Watershed	63
19.	Santa Fe River Peak Flows Above and Below the City of Santa Fe at the Watershed Outlet	66
20.	Threshold Temperatures for Combustive Loss of Soil Properties for Selected Insensitive, Moderate Sensitive and Sensitive Soil Properties	67
21.	Delineative Geomorphological Characteristics for Classification Using the Rosgen System of Two Segment of the Santa Fe River	75
22.	Trout Density and Mean Length and Weight of Trout at Two Sites Where Fish Sampling was Conducted on the Santa Fe River in the Project Area	76
23.	National Wetland Inventory Community Types Found in the Project Area	79
24.	Density of Riparian Tree and Shrub Species in Bottomland Forest in the Project Area	81
25.	Bird Species that Occur in Montane Riparian Habitat in Santa Fe County and that Nest in Cavities in Live or Dead Trees or that Nest in Large Trees	85
26.	Number of Vertebrate Species in Each of the Five Vegetative Associations Found in the Watershed	89
27.	Bird Species that Use Ponderosa Pine Stands Dominated by 5- to 12-inch Diameter Trees in the 40-100 Percent Canopy Closure	90
28.	Mammal Species that Use Ponderosa Pine Stands Dominated by 5- to 12-inch Diameter Trees with 71-100 Percent Canopy Closure	91
29.	Species Associated with Snag Habitat in the Santa Fe Municipal Watershed	92
30.	Species Associated with Down Logs in the Water	94
31.	Federal Proposed, Threatened or Endangered Species Known to Occur in Santa Fe County	99
32.	Federal Species of Concern Known to Occur in Santa Fe County	101
33.	Forest Service Southwestern Region Sensitive Species for the Santa Fe National Forest	102
34.	New Mexico (state) Endangered, Threatened, and Sensitive Species Known to Occur in Santa Fe County	103
35.	Criteria Pollutants Allowable Increments and Averaging Times	107
36.	Emission Factors for Certain Wildfire Byproducts	108
37.	FOFEM Daily Burning Emission Estimates for Burning Up to 100 Acres of Slash Piles Per Day	109
38.	FOFEM Daily Burning Emission Estimates by Alternative for Wildfire and Broadcast Burning	110
39.	Total Number of Burn Days by Alternative	111
40.	Total Costs for Each Alternative	124
41.	Number of Jobs by Management Alternative	126

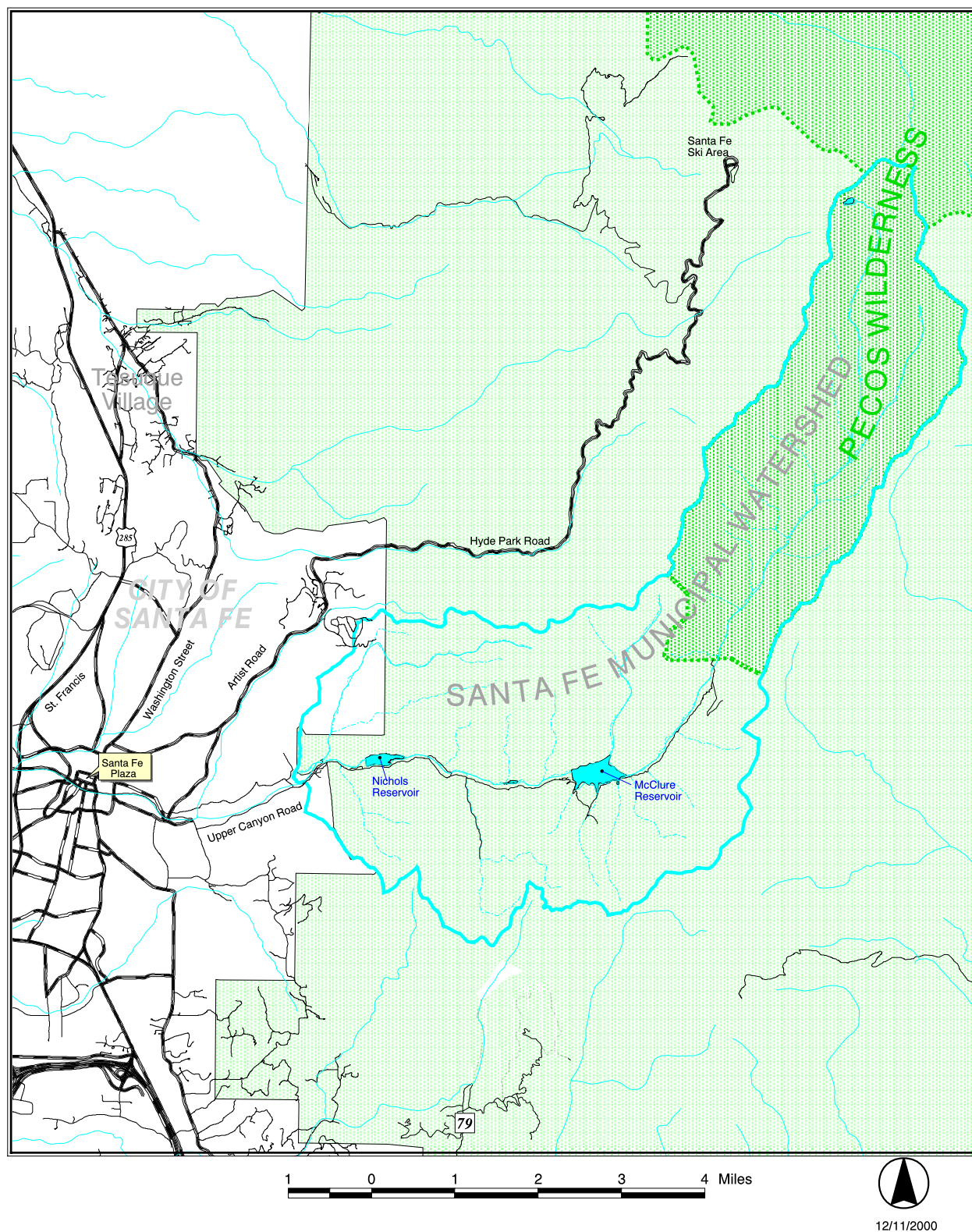


Figure 1. Santa Fe Municipal Watershed Project Map.

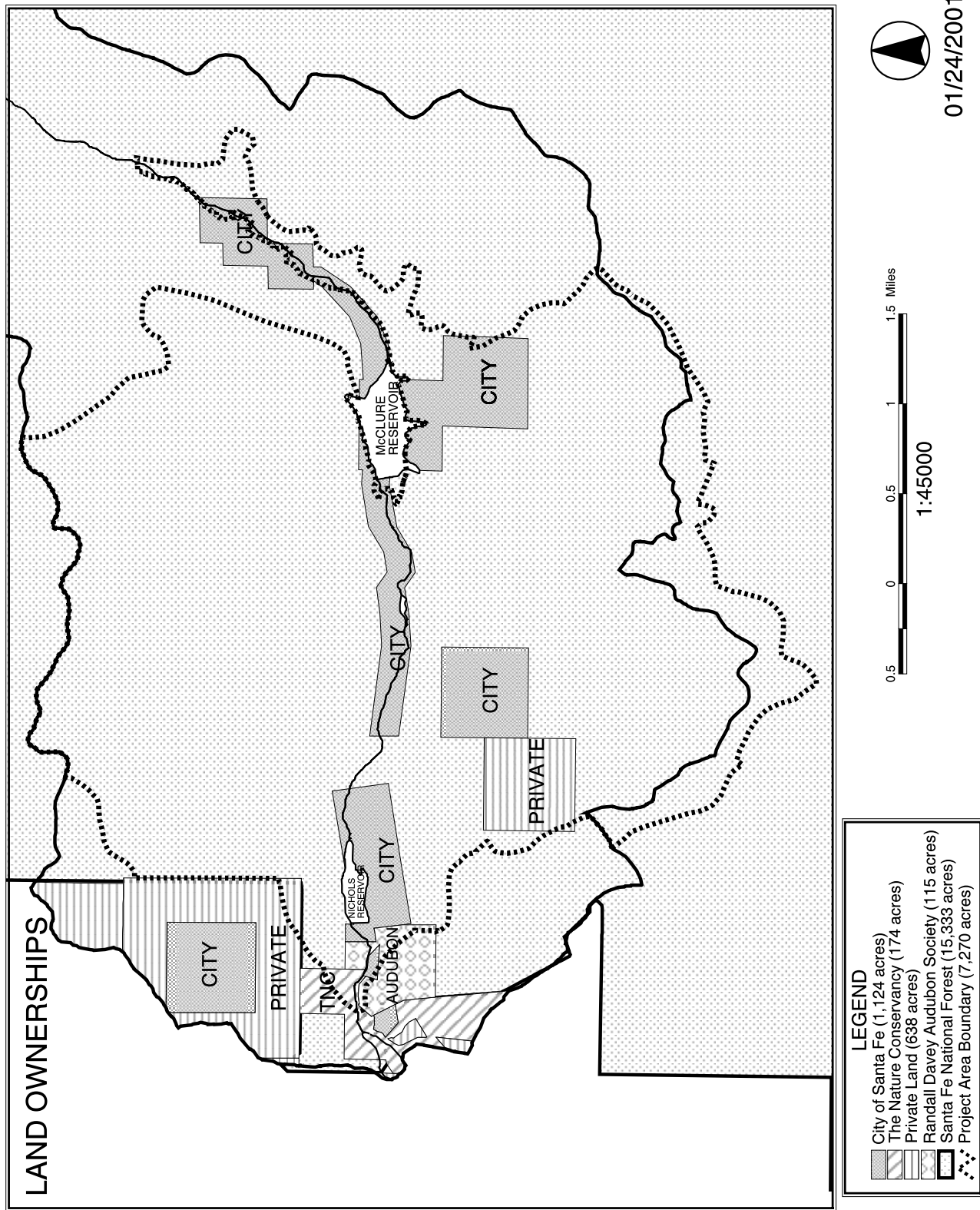


Figure 2. Project Area and Land Ownerships

Chapter 1 • Purpose of and Need for Action

This Draft Environmental Impact Statement (DEIS) documents the National Environmental Policy Act (NEPA) analysis of the site-specific effects of a USDA Forest Service (Forest Service) proposal. The proposal is designed to reduce the risk of a severe crown fire and to restore sustainable forest and watershed conditions in the Santa Fe Municipal Watershed adjacent to the City of Santa Fe, New Mexico (Figure 1). The City of Santa Fe is a cooperating agency with the Forest Service in proposing this project.

The Watershed and Project Area

The Santa Fe Municipal Watershed (hereafter referred to as “Watershed”) encompasses the upper 17,384-acre portion of the entire 174,000-acre Santa Fe River watershed (5th code drainage, code #1302020103) that extends from the Pecos Wilderness to Cochiti Lake. Approximately 40 percent of the Watershed is in the Pecos Wilderness and 60 percent is outside the wilderness. The project area is defined as the maximum area under consideration for treatment with this project. The project area comprises approximately 7,270 acres (42 percent) of the 17,384-acre Watershed, and is located entirely outside the Pecos Wilderness. Within the project area, land ownerships consist of Forest Service, City of Santa Fe, Audubon Society, The Nature Conservancy, and other private lands (Figure 2).

Elevations within the project area range from 7,000 to 8,500 feet. The ponderosa pine forest type covers over 90 percent of the project area, with smaller portions of piñon-juniper woodlands, oak, riparian vegetation, and aspen (see Figure 3, Forest Cover Types). The Santa Fe River is the only perennial (year-round) stream in the project area. Two water-system reservoirs, Nichols and McClure, are located in the project area on the Santa Fe River (Figure 2). Approximately 40 percent of the city’s domestic water supply comes from these two reservoirs. Figure 4 shows the elevations and stream drainages (intermittent and perennial streams), as well as the locations of fires that occurred in or adjacent to the area. Approximately 15 fires were documented to occur in or around the project area over the past 12 years.

The area has a very limited road network, located at the bottom of the canyon. It lies within a designated “inventoried roadless area.” However, there is one main, unpaved access road that begins at the gate at the end of Upper Canyon Road, parallels the river for about 7 miles, and ends at the Pecos Wilderness boundary. There are a few, usable spur roads and historic trails that diverge off the main road. The existing roads provide access to only a very small

portion of the project area (less than 7 percent). Thus, most of this river canyon area is “roadless,” and most of the slopes are quite steep.

Proposed Project

The Santa Fe National Forest, in partnership with the City of Santa Fe (City), is proposing to use a combination of tree thinning and prescribed burning on up to 7,270 acres of national forest and city lands in the Watershed. The Forest Service is currently consulting with private landowners that have in-holdings in the project area, requesting their permission to include their lands in this project. Spending Federal funds on non-Federal lands for watershed restoration purposes is allowed under the Wyden Amendment (H.R. Bill 4328).

The proposed project, developed collaboratively with many interested stakeholders, involves a combination of thinning and low-intensity burning. No roads would be constructed. It involves the following specific actions (described in greater detail in the “Alternatives Considered in Detail” section in Chapter 2):

- The proposed thinning would be a “thinning-from-below,” where the smaller trees would be thinned (cut or “felled”) and the larger trees left standing. Trees would usually be felled on the contour of the slopes and left in place to reduce soil erosion and surface water runoff. The majority of the felled trees would be less than 6-inch diameter, with some in the 6- to 12-inch diameter class, and a small percentage in the 12- to 16-inch diameter class. No trees over 16-inch diameter would be felled, unless it is a dead tree (snag) determined to be a safety hazard (in accordance with the Occupational Health and Safety Act). All of the largest trees as well as most snags would be retained. After treatment, the thinned areas would contain an average of 50 to 100 trees per acre, in a highly variable, clumpy pattern that mimics natural disturbance patterns. The areas along ridgetops that provide the best fuel breaks would be thinned to a lower tree density, averaging approximately 20 to 30 trees per acre. Scattered portions of the project area would not be thinned, such as on excessively steep slopes or in riparian areas.
- In the thinned portions of the project area, most of the small-diameter tree stems—tops and branches (referred to as “slash”)—would be cut up and placed in piles for later burning. In some situations, slash may be cut up and scattered

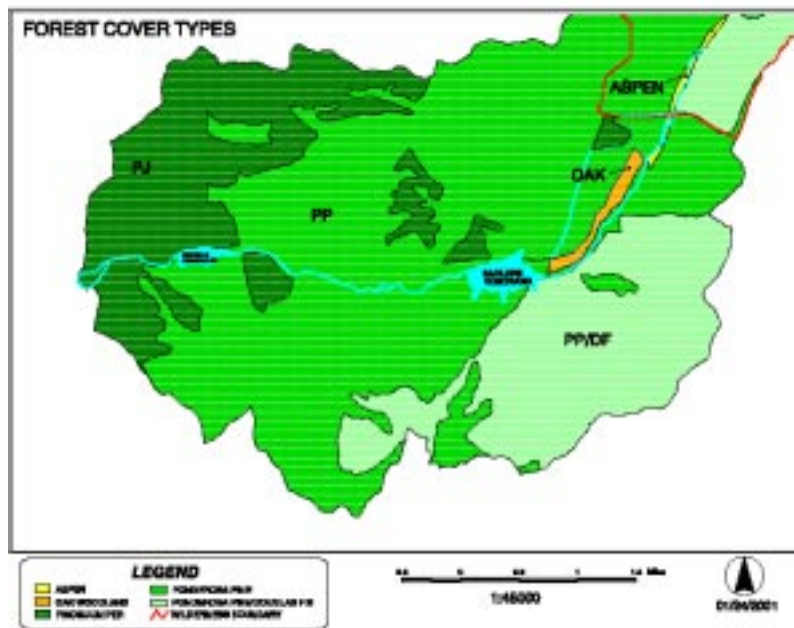


Figure 3. Forest Cover Types.

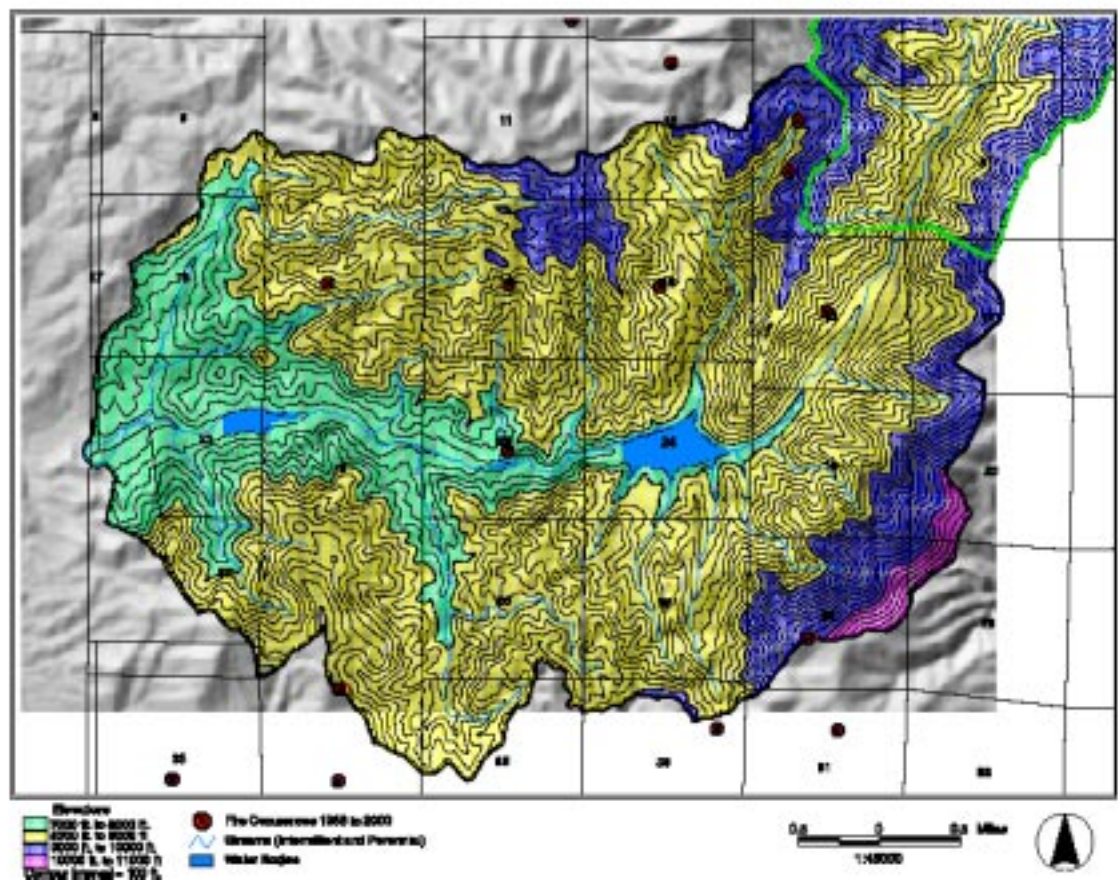


Figure 4. Elevations, Stream Drainages, and Fire Occurrence.

over the forest floor rather than piled. In either case, once the slash is dry, it would be burned in order to reduce the fire hazard created by the abundance of fuels in this small size class. Slash would be burned under very specific weather and fuel moisture conditions, and carefully monitored (see “Mitigations and Monitoring” in Chapter 2). On the limited terrain that is gentle and occurs along existing roads in the canyon bottom (about 560 acres), the slash may be removed from the area (as chips or other material) rather than burning it.

- In the thinned portions of the project area, most of the remaining cut tree stems over 5-inch diameter would be left in place, because there is no road access available for wood removal, and stems of this size class on the forest floor would not pose a significant fire hazard. On the limited terrain that is gently sloping and adjacent to existing roads (about 560 acres), small wood products would be removed for local public use. No timber sales or log-skidding equipment would be used.
- No thinning or slash disposal activities would occur within any riparian zone, or within 15 feet of a riparian zone.
- After completing the thinning and slash burning on operable portions of the project area, low intensity “broadcast” burns may be used to reduce the density of very small trees and surface fuels in some of the unthinned patches on steep slopes. The broadcast burn units may include some of the thinned and slash-treated slopes in order to reduce surface fuels and pine needle accumulations, release nutrients into the soil, and create a good seedbed for growth of herbaceous vegetation.



Figure 5. Sheep grazing occurred in the canyon throughout the early 1900's.

Implementation is proposed to begin in the summer of 2001. The project would be implemented in stages over the next 5 to 10 years, treating approximately 500 to 1,000 acres each year.

These treatment methods have been successfully used to reduce wildfire intensity and severity in many similar areas throughout the western U.S. However, the Forest Service, City, State Environment Department, and non-governmental organizations would conduct monitoring and evaluation, to assess the relative effectiveness and effects of the treatments, and adaptively adjust treatments as needed.

Background, Including the Purpose and Need

Prior to and throughout the 1800's, heavy livestock grazing, homesteading and logging occurred in this canyon. Timber was cut for a multitude of uses, including firewood, railroad ties, and construction materials. This canyon was also Santa Fe's playground for swimming, fishing, and camping. By the 1920's, the lower slopes were substantially depleted of trees and ground vegetation, soil erosion was severe, and the water had become polluted. In 1930, the City issued an ordinance prohibiting bathing, camping, fishing, picnicking, and grazing in the area. In 1932, the Watershed was closed to public access as a means of protecting the water supply. Then throughout the 1900's, the Forest Service had a policy of aggressively suppressing all wildfires. The combination of intensive historic land uses followed by fire suppression resulted in eliminating the beneficial role of low-intensity surface fires in the fire-adapted ponderosa pine ecosystem that dominates the project area.

Scientific research has consistently shown that changes in the historical fire regime in ponderosa pine forests has increased the likelihood of high severity crown fires (Agee 1993, Arno and Harrington 1999, Covington and Moore 1994, Dickman 1978, Lehman and Allendorf 1989, Laudenslaayer et al 1989, MacCleery 1995, Mutch 1993, Sackett et al 1994, Swetnam 1990, Swetnam and Baisan 1996, Weatherspoon and Skinner 1996). This research showed that ponderosa pine forests historically contained more open, park-like stands of primarily large ponderosa pine trees (averaging 20 to 80 trees per acre) and frequently experienced surface fires that thinned out many of the smallest trees. The surface fires common in ponderosa pine forests seldom killed the large, mature pine trees. These surface fires were very important in maintaining openings in forest canopies, a clumpy distribution of large pine trees, and understories of herbaceous ground



Figure 6. Logging and homesteading occurred throughout the canyon (1882). Photo by George C. Bennett. Courtesy of Museum of New Mexico, Negative No. 14828.

vegetation and shrubs. Based on stand examinations and field reconnaissance, the current ponderosa pine forests in the project area appear to be very dense, averaging 500 to 1,000 trees per acre. The majority of the trees are small (less than 16-inch diameter), and there are relatively few large, fire-resistant pine trees.

The trees are currently so crowded that their growth is suppressed, and the heavy shading by these high-density stands of trees has eliminated most of the herbaceous vegetation on the forest floor. The gradual loss of ground vegetation has caused habitat diversity to decline. In addition, long-term water yield data collected since 1913 shows that the increase in the number of trees is correlated with a decline in water entering the reservoirs.

The dense understory of shade-tolerant fir trees is highly susceptible to mortality by fire. These thickets of smaller trees act as “ladder fuels” that quickly carry a surface fire up into the crowns of the taller trees. These ladder fuels, together with the large expanses of closed-canopy forest, create the conditions for a fast-spreading, uncontrollable, high-intensity crown fire. Computer

models used to simulate fire behavior show that during dry, hot conditions, the forest stands in this area can no longer support light surface fires.

A fire starting in the Watershed under adverse fire weather conditions could quickly become a high severity crown fire. Most of the existing forest vegetation would be burned. This Watershed is particularly prone to excessive soil movement and run-off due to the steep slopes and granitic soil type. This type of fire could cause heavy flooding and mass movement of soil, mud and woody debris into the canyon bottom and reservoirs, and downstream into the City. This would degrade water quality and diminish water storage capacity of the reservoirs. The crown fire and subsequent flooding would not only destroy valuable forest and water resources, but these events would pose direct threats to homes, property and people's lives in Santa Fe, particularly for residents on Upper Canyon Road and for downtown businesses along the Santa Fe River. Also, there would be extremely large amounts of smoke from such a fire, lasting for days or weeks.

Thus, this project is urgently needed in order to reduce potential wildfire severity in the Watershed. Thinning-from-below combined with prescribed burning has been found to be a very effective treatment in reducing wildfire severity (Agee 1996, Agee et al 1999, Babbitt 1995, Biswell 1960, Canton-Thompson and Silvius 1999, Edminster and Olsen 1995, Fiedler et al 1997, Graham et al 1999; Harrington and Arno 1999). The thinning followed by low intensity surface burning has been shown to reduce fuel volumes and break up fuel continuity, thereby limiting the ability of a beneficial surface fire to become a destructive crown fire.



Figure 7. B.P.O.E (Elks) Cabin (1917). Photo by William H. Roberts. Courtesy of Museum of New Mexico, Negative No. 150076.

Based on this background and current conditions, the project was designed to meet the following primary purpose and need (objective), and move toward the desired future condition.

Objective: Reduce the risk of a high-severity crown fire, to protect the municipal water supply and restore sustainable watershed conditions. A secondary objective is to increase herbaceous ground cover to improve long-term soil stability and vegetative diversity.

Desired Future Condition: There would be an average of 50 to 100 trees per acre, with fewer trees along the dominant ridgetops (fuel breaks). The vast majority of the trees would be over 12-inch diameter, and there would be an abundance

of snags and down logs. A patchy mosaic of various tree densities would cover the hillsides, with higher densities on north and east-facing slopes and in moist drainage bottoms. There would be many openings in the forest canopy, sufficient to reduce the intensity and spread of a crown fire. There would be more herbaceous vegetation than currently exists, helping to stabilize soils and enhance habitat diversity. Watershed conditions would support small-scale, low-intensity surface fires rather than large, uncontrollable crown fires, thereby promoting ecological sustainability.

For more detailed descriptions of existing and desired resource conditions, refer to the 1998 Report “Existing Conditions in the Upper Santa Fe Watershed” and the follow-up January 2000a report “Assessment of the Santa Fe Municipal Watershed,” which includes desired resource conditions and objectives.

Decision To Be Made

Based on the analysis documented in this Draft EIS and the public comments in response to this DEIS, the Santa Fe National Forest Supervisor will decide whether or not to authorize implementation of one or more of the management alternatives developed for this project. The decision will include:

- Treatment locations and general design features.
- Thinning methods to be used, such as manual or machine methods, or a combination of the two.
- Whether broadcast burning and/or slash burning would be used, and if so, to what extent.
- Mitigation and monitoring measures.

Forest Management Direction

The 1987 Santa Fe National Forest Plan (Forest Plan) as amended sets forth broad, programmatic management direction for the national forest. This DEIS is a project-level analysis, designed in conformance with the applicable Forest Plan management direction (goals, and standards/guidelines). Where appropriate, this DEIS tiers to the Forest Plan FEIS, as encouraged by 40 CFR 1520.20.

The forest-wide standards/guidelines from the Forest Plan that apply to this project are primarily those regarding protection of: heritage resources (pages 58-61), wildlife habitat (pages 61-66), and water and soil



Figure 8. The upper Santa Fe River was popular for fishing and swimming (1910). Photo by Jesse L. Nusbaun. Courtesy of Museum of New Mexico, Negative No. 61588.



Figure 9. In 1917: Santa Fe River riparian corridor with little or no riparian vegetation for bank stabilization or buffering capabilities.



Figure 10. Current riparian conditions.



Figure 11. In 1916: eroded hillside near reservoirs. File Photo



Figure 12. In 1999: the same hillside. C.D. Allen and S. Tharnstrom, USGS.



Figure 13. Hillsides in the canyon are currently covered with 80 to 90-year-old trees. R. Cassidy, USFS.



Figure 14. The excessive number of trees has suppressed tree growth and shaded-out the grasses and shrubs. R. Cassidy, USFS.

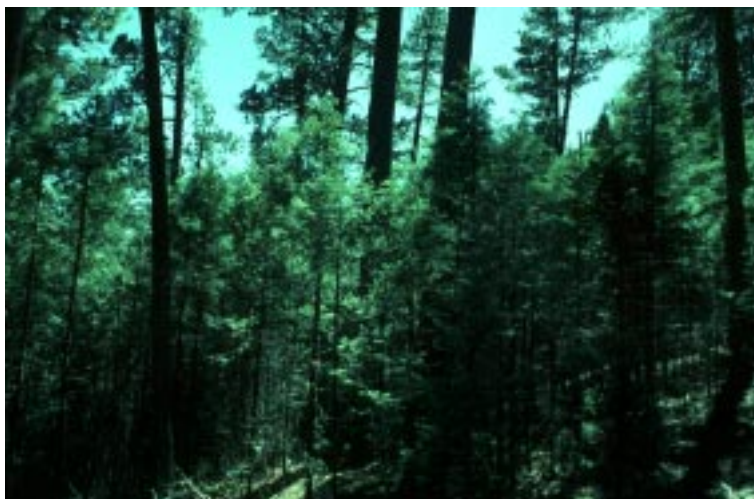


Figure 15. Understory trees act as ladder-fuels to carry surface fire into larger overstory trees. R. Cassidy, USFS.



Figure 16. Crown fires spread rapidly at 3-10 mph, have flame heights that can reach hundreds of feet, and burning embers that start fires miles ahead of the main fire. File Photo



Figure 18. Excess runoff after crown fires causes extreme down cutting, such as evidenced in the headwaters of Capulin Creek, after the 1996 Dome Fire (above). C.D. Allen, USGS.



Figure 19. Crown fires lead to soil damage, excessive water runoff and floods (left). Bandelier National Monument, USGS.



Figure 17. Crown fires lead to mass erosion and mud slides. Ravi Miro Fry, USFS.



Figure 20. Crown fires threaten homes and communities, as evidenced by the homes in Los Alamos destroyed in the Cerro Grande Fire. M. DeGray, USFS.



Figure 21. Thinning is commonly used to reduce the risk of crown fires and increase herbaceous vegetation. R. Cassidy, USFS.



Figure 22. Slash piles and small logs left at demonstration site in Watershed, immediately after thinning. R. Cassidy, USFS.

Figure 23. Slow-moving, low-intensity broadcast burns are used to reduce surface fuels, release nutrients and improve soil productivity. Ravi Miro Fry, USFS.

resources (pages 75-80), and are hereby incorporated by reference. This project was also designed in conformance with the area-specific Forest Plan direction that applies to this management area. The project area lies entirely within management area “O,” and the management emphasis for area “O” is “water quality production.” The Forest Plan does not designate any lands in the project area as “suitable timberlands,” which means the area cannot be managed for regulated commercial timber production. However, trees from the area may be harvested to reduce fuel loads and maintain watershed values. The relevant standards/guidelines for management area “O” are as follows (Forest Plan, pages 155 to 156):

Prohibited Uses

- All recreational and other public uses.
- Utility corridors.
- Livestock grazing.
- Road construction (except as necessary to control wildfire that threatens life, property or water quality).

Allowable Uses

- Prescribed fire may be used to reduce fuels to an acceptable level while protecting watershed values.
- Low impact cooperative research agreements.
- Limited surface use of minerals (however, there are no valid mining claims in the project area).

Other Standards/Guidelines

- Use of fireline construction methods which have the least impact on water quality values.

In addition, Forest Plan Management Areas “H—Wilderness,” “L - Unroaded Recreation,” and “D - Developed Recreation / Scenery” are directly adjacent to the project area on the south, east, and north sides (respectively). The emphases of Management Areas H and L are to preserve primitive or semi-primitive non-motorized recreation opportunities, with a moderate to high probability of experiencing isolation from other people in a predominantly natural-appearing environment. Road construction and motorized uses are not allowed in these management areas (USDA-FS, 1987). The emphasis of Management Area D, along the north side of the project area, is to enhance recreation and scenic viewing opportunities. This area is part of the Hyde Park Road corridor, which is a designated State and Federal Scenic Byway containing many developed recreation trails and sites including Hyde Memorial State Park and Santa Fe Ski Area.

Public Involvement and Scoping

The Forest Service initiated and facilitated a very open and collaborative planning process with interested parties, which began during the initial assessment of existing conditions in 1997. Representatives from many groups, along with several non-agency scientists and other interested individuals remained actively involved throughout the planning process. This project received a high degree of media attention, particularly after the severe wildfires and drought during the summer of 2000.

Highlights of the public participation process included:

- Holding monthly project planning meetings with the Forest Service interdisciplinary team and representatives of many other agencies and non-government organizations, and open to the public, from 1997 through November 2000.
- Conducting monthly public field trips through the project area, throughout the spring, summer, and fall of 1999 and 2000.
- Distributing two watershed assessment reports for public comment, regarding existing and desired conditions (*Upper Santa Fe Watershed Assessment Reports*), Sept. 1998 and Jan. 2000.



Figure 24. Citizens often met with agency specialists to observe current problems and discuss possible solutions. A. Lewis, City of Santa Fe.

- Distributing a scoping letter to notify the public and solicit input about the proposed project, mailed to over 375 individuals and groups, Jan. 2000.

- Publishing in the Federal Register, a *Notice of Intent to Prepare an EIS*, to notify the public and solicit comments on the proposed project, May 31, 2000.
- Holding a “Forest Forum” community event about the project, including an afternoon technical workshop and evening presentations by a panel of renowned Southwestern forest scientists. Sponsored by the Santa Fe Watershed Association, Audubon Society, Nature Conservancy, and State Land Office, June 27, 2000. The Forest Forum was aired on public access television numerous times during the summer and fall of 2000.
- Submitting news releases and information to the media, generating over 40 newspaper articles and editorials, and over 35 letters-to-the-editor, in *The (Santa Fe) New Mexican* and *Albuquerque Journal*, since Sept. 1999.
- Discussing the project on radio talk shows, including a counter-point with Forest Guardians.
- Working with local television news stations on video footage and information used in TV news programs that aired several times during the summer of 2000.
- Special tours of project area for government officials, including State Senators, Congressional Representatives, Santa Fe’s City Mayor and Council, Governor’s Staff, Washington DC Office of Management and Budget, County Commissioners, and others.
- Establishing a website with information about the project, as well as web access to the DEIS and DEIS Summary.
- Conducting eight informal, small-group discussion meetings with east-side city residents who have the highest potential to be affected by the project. Meetings were held Aug. 10, 20, and 24; Sept. 5, 6, and 12; and Oct. 3 and 5. Western Network led this process under a Forest Service contract, together with a Forest Service social scientist.
- Publication of an informative brochure about the project, distributed to City of Santa Fe residents in their water bills (25,000), and to 400 people on the project mailing list, and made available at public libraries and other locations throughout the City.
- Gave presentations about the project at over 17 public meetings, including those sponsored by:
 - ... Forest Conservation Council/Native Forest Protection Alliance, Feb. 23, 2000
 - ... Santa Fe Garden Club, March 9, 2000
 - ... Sierra Club, June 15, 2000
 - ... New Mexico Guides Association, June 21, 2000
 - ... Santa Fe City Council, June 28, 2000
 - ... Interim Legislative Committee on Water and Natural Resources, Aug. 15, 2000
 - ... Thousand Friends of New Mexico, Aug. 23, 2000
 - ... Network Neighborhood Association, Aug. 28, 2000
 - ... Voices of Santa Fe, Aug. 29, 2000
 - ... Santa Fe Watershed Association, Aug. 30, 2000
 - ... Renesan Institute of Lifelong Learning, Sept. 13, 2000
 - ... La Herencia en Santa Fe, Sept. 16, 2000
 - ... Rotary Club Centro, Sept. 19, 2000
 - ... Sierra Club, Sept. 19, 2000
 - ... Lion’s Club, Sept. 19, 2000
 - ... Santa Fe County Commissioner’s Meeting, Sept. 26, 2000
 - ... Bienvenidos, Nov. 7, 2000

Issues

Issues are defined as concerns about the potential effects of a proposed action. The Forest Service interdisciplinary team, along with interested agencies and other partners, identified issues for this project during a long-term public scoping process. The collaborative scoping process was also used to identify which issues should be emphasized as key (significant) issues or deemphasized, in order to narrow the scope of the EIS in accordance with NEPA regulations {1500.4(g)}. The key issues relate to potential impacts of the proposal that cannot be avoided by applying standard mitigation measures. Key issues were used to design management alternatives and special mitigation measures to reduce the risk of adverse effects. This section primarily lists the key issues that are analyzed in detail (in Chapter 3), along with a few other non-significant issues that are required to be included in an environmental analysis.

Some concerns expressed by the public were determined to be outside the scope of the proposed project, such as concerns about commercial timber harvest, road building, thinning in the Pecos Wilderness, and removing mature or old growth habitat. Some other concerns expressed during scoping were not supported by scientific evidence. Concerns about potential crown fires that may occur if we do not implement a fuel reduction project are addressed by the project objective, which is evaluated in this DEIS along with significant issues. Consideration of issues is documented in the project record.

Forest Vegetation, Fuels, and Fire Behavior

Prescribed burns may escape control measures, and threaten the water supply, residential areas and resources in and around the Watershed. Burning forest stands that have not been previously thinned may pose the highest risk of the burn getting out of control.

Leaving accumulations of freshly cut logs and slash on site may attract beetles that can damage or kill nearby trees. This would cause an increase in dead trees, which would increase the fuel hazard.

Soil and Water

Changes in the structure and composition of forest vegetation and soil surface characteristics may increase soil erosion and stream sedimentation. Those surface changes could potentially affect peak flows (floods), water quality, soil properties, and nutrient cycling. If burning slash piles generates high temperatures, it could adversely affect soil properties and vegetative productivity under the piles.

Aquatic Habitat and Biota

Thinning conifers in the canyon bottom near the riparian zone may result in a short-term reduction in shading over the river that may increase water temperature and adversely affect the aquatic habitat and fish.

Riparian Ecosystem and Jurisdictional Wetlands

Thinning and burning may promote the spread of invasive plant species such as Siberian elm and Russian olive, which currently occur in the canyon bottom below Nichols Reservoir. Invasive, non-native plants

can out-compete native species and take over a site. This can result in a decline in habitat quality.

Prescribed burning in the Santa Fe River canyon bottom and along ephemeral drainages may result in killing cottonwood seedlings and saplings, as they are not resistant to fire.

Treatment activities near the riparian zone may disturb species that use the area, such as the existing beaver population.

Terrestrial Habitat and Associated Wildlife

Thinning and burning may result in changes to forest structure and species composition that may affect the quality of terrestrial habitat and associated wildlife species. For example, unintentional burning of snags, or felling of snags that pose worker safety concerns, may reduce nesting or roosting habitat. As another example, a reduction in tree density and canopy closure in ephemeral tributaries may reduce the quality of these wildlife corridors for some species. Habitat changes may also affect population viability for management indicator species identified in the Forest Plan FEIS.

Special Status Species

Thinning and burning may result in changes to forest structure and species composition that may affect the quality of habitat for threatened, endangered or sensitive species that may occur or have suitable habitat in the project area.

Air Quality/Smoke

Prescribed burning, especially broadcast burning, produces smoke that can accumulate in residential areas or other areas where people work, live, or recreate. This can impact their health, especially for people with respiratory problems, and can impair visibility along roads, in the wilderness, or in scenic vistas.

Social Environment

Increased traffic from wood-hauling trucks and other vehicles through residential areas may affect quality of life along the travel route, particularly for residents along Upper Canyon Road and visitors to the Audubon Center. Effects could be pedestrian or vehicle accidents, increased noise, lengthy traffic delays, vibration damage to older homes, and road damage.

Heritage Resources

Thinning and burning activities may potentially damage the integrity of archaeological sites and other areas of traditional heritage or cultural concern.

Recreation and Scenery

Noise from thinning operations or smoke from burning may possibly affect the quality of recreation or enjoyment of scenery near the project area, such as at developed recreation sites or along trails.

Facilities

Burning produces ash that could enter the water supply during rainstorms and damage the water filtration system. This may also affect water quality and taste, especially when burning close to the river and reservoirs.

Permits and Agency Approvals Required

The following permits or authorizations would be required for project implementation:

- Prior to burning, obtain a burn permit from New Mexico Environment Department Air Quality Bureau as required by the New Mexico Smoke Management Memorandum of Understanding.
- Consult with and obtain concurrence from U.S. Fish and Wildlife Service on the Biological Assessment, addressing listed species, in accordance with Endangered Species Act regulations.
- Consult with and obtain concurrence from the New Mexico State Historic Preservation Officer regarding identification, evaluation, and determination of effect of the project on heritage resources to meet the requirements of Section 106 of the National Historic Preservation Act.
- If there is a need for a stream crossing, obtain a Clean Water Act Section 401 water quality authorization from the New Mexico Environment Department and a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers.

Purpose of and Need for Action

Chapter 2 • Alternatives, Including the Proposed Action

The project planning team developed alternatives in collaboration with many interested individuals, organizations, and government agencies, using the available resource information, public comments and professional judgment. Some alternatives were eliminated from detailed study and possible selection, while others were analyzed in detail as documented in this DEIS.

Alternatives Considered but Eliminated from Detailed Study

Ten alternatives were considered but eliminated from detailed study for a variety of reasons. Some of these alternatives received a more thorough analysis than others. However, after at least a partial analysis, they were found to be outside the range of reasonable and economically feasible alternatives, and/or they did not address the purpose and need of this project (described in the “Background Including the Purpose and Need” section). Alternatives eliminated from further study are briefly summarized in the following list in order to reduce the bulk of this section in the DEIS. Appendix A contains descriptions of each of these ten alternatives, along with the associated rationale for eliminating them from further study.

- Treat all dense forest lands within and immediately adjacent to the Watershed, rather than just a portion of the Watershed.
- Build new roads to increase road access, and remove more of the wood.
- Remove the wood using mechanized equipment.
- Remove the wood using horses or mules.
- Remove the wood using helicopters.
- Chip the slash, rather than burning it.
- Thin only the trees 6-inch diameter or less.
- Use prescribed burning only to reduce the fuel load, without cutting any trees.
- Use goats or other animals to reduce the fuel load.
- Eliminate the closure order and allow public access.

Alternatives Considered in Detail

In addition to the alternatives considered then dropped from further study, six action alternatives and the no action alternative were analyzed in detail in the DEIS. Each action alternative was designed to meet the purpose and need (and desired condition) to some degree, by reducing the number of small trees and creating openings in the canopy. Each alternative is consistent with management direction in the Forest Plan.

The planning team initially developed Alternative B1 as the proposed action. After reviewing public comments and identifying issues regarding that proposal, management alternatives B2, C1, C2, D1 and D2 were developed. These alternatives, including their mitigation measures and monitoring requirements, were developed to respond to the issues while still meeting the project objectives. The alternatives vary by the location and acreage to be thinned, the method of thinning (manual or machine thinning), and whether or not broadcast burning is included.

Following the description of Alternative A, the No Action Alternative, this section describes the design features common to all alternatives, then describes each action alternative, including the mitigation measures and monitoring requirements common to all alternatives.

Alternative A: No Action

We evaluated the No Action Alternative in two distinct ways. The No Action Alternative entails not taking any action to reduce fuel loads in the project area. However, routine maintenance and improvement work would continue on the service road to the reservoirs, and on the reservoirs and water supply facilities. The first way in which the No Action Alternative was evaluated assumes “no change” from current conditions, and provides a baseline for comparing the effects of action alternatives. The second way in which the No Action Alternative was evaluated, assumes a large-scale, high-intensity crown fire would occur in this area, based on analysis of existing conditions and computer model simulations.

Features Common to All Action Alternatives

This section describes a number of general design features common to all action alternatives, and is

followed by the section describing each action alternative. Mitigation and monitoring requirements are additional features common to all alternatives, listed in the “Mitigation and Monitoring” section.

No Road Construction or Use of Skidders

The action alternatives would use the existing road and trail network. No new roads would be constructed. In addition, none of the alternatives would use machines or animals to skid (drag) logs, which creates channels that funnel water runoff and erode soil. The rationale for eliminating road construction or log skidding from this project design is described in Appendix A, for the road construction and mechanized harvest alternatives considered and eliminated from detailed study.

Thinning and Slash Treatment

To meet the fuel reduction objectives for this project, the forest canopy in thinned areas needs to be reduced to a 30-40 percent coverage, with patches remaining at higher densities where thinning does not take place, and fuel breaks thinned to a lower density of 20-30 percent. Thinning would retain all of the large mature trees, including all trees over 16-inch diameter, which currently average approximately 15 to 25 trees per acre, along with additional large immature trees, leaving a total of 50 to 100 of the largest trees per acre. The actual number of trees per acre retained on a given site to meet fuel reduction objectives would vary depending on the existing number of trees, stand structure, canopy cover, slope, aspect, site productivity, and other factors affecting fire behavior. In meeting the fuel reduction objective, it is also desirable to end up with at least 20 feet between the crowns of individual trees or small groups of trees. For more detail, refer to Cassidy’s discussion in “Methodology Used in Developing the Number of Trees to be Retained Within Santa Fe Watershed” in the project record. It includes discussion of factors considered such as stand density index, diameter distribution, crown-to-base height, and crown bulk density.

Most of trees that would be cut would be 6-inch diameter or less, which are most abundant, with fewer trees cut in the 6 to 12-inch diameter range and even fewer in the 12 to 16-inch diameter range. The remaining forest would contain the largest, most mature trees, along with patches of trees in other size classes, in a randomly spaced, variable density mosaic that would mimic natural disturbance patterns in ponderosa pine forests.

Extremely steep slopes in the project area would not be thinned, although in some alternatives they may be

included in a low-intensity prescribed burn treatment.

Most of the small trees that would be selected for cutting are white fir and Douglas-fir species, however thinning would not be designed to entirely eliminate any species. The thinning would favor retention of large ponderosa pine since it is adapted to surviving surface fires.

After treatments are complete and trees are regenerating in the treated area (10 to 20 years from now), it would be desirable to use low-intensity burns to reduce the number of seedlings and maintain the desired condition. However, the maintenance burns contemplated for the distant future are too speculative to plan for and analyze as part of this proposal. Long-term monitoring of fuel loads following this project should provide the information needed in the future to complete planning and decision making about maintenance burns.

Thinning and Slash Burning Away From Roads

Road access is very limited in this project area; therefore, most of the thinning (92 percent) would occur in areas away from existing roads. Felled woody material greater than about 6-inch diameter would be retained on site, due to the lack of roads, steep rugged terrain, and because the larger down logs do not pose a significant fuel hazard. The slash (cut tree tops, branches and stems less than 6-inch diameter) would be piled. After the slash dries, it would be burned to reduce the fuel load to acceptable levels (approximately 60 percent or more fuel consumption of the slash). Burning the slash would release nutrients into the soil and promote regeneration of grasses and other plants, restoring ecological processes for fire-adapted organisms. Refer to the “Mitigations and Monitoring” section for stipulations regarding burning of slash piles.

Scattering the slash rather than piling it may be used in selected areas and the results compared to burning slash in piles. Scattering slash may be needed in some areas to carry a low-intensity surface burn. The cut-and-scatter slash option may be indicated for sites where lower burn temperatures are needed to protect a sensitive soil type, or where the pine needle and thick duff layer need to be burned to provide an adequate soil bed for the growth of herbaceous vegetation. Burning the scattered slash would be accomplished under the same precautions and limitations as described for the broadcast burning in the “Mitigations and Monitoring” section.

Roadside Wood Removal

On the approximately 560 acres closest to the roads, the small wood products (such as firewood or latillas) would be removed. Removal of wood products is only feasible on the gentle slopes within about one-quarter mile of the access road and short spur roads. The vast majority of the project area is too steep, rugged, and far from the road for removing the wood. Some of those small diameter logs would be hauled out for use as small wood products, such as firewood, coyote fence posts, and latillas. Removing some of the logs would reduce the total surface fuel load and provide a needed commodity to the local community. Most of the logs would remain on site for nutrient recycling and erosion control.

Most of the wood removed would be distributed by non-profit groups to low-income families. Some may be used or sold by the thinning contractor(s) to off-set some of the contract cost.

The slash along the roadside would be disposed of in one of two ways—either by chipping and removing it, or burning it in piles. The slash may be fed into a chipper, then the chips hauled in trucks out of the Watershed for use as mulch or compost. Instead of chipping, the slash could also be compacted into bales and hauled away. Chipping the slash on 560 acres would produce approximately 100,000 to 150,000 yd³ of chips. Hauling the chips from the Watershed would require a total of about 600 to 900 loads with semi-trucks or 2,500 to 3,750 loads with 40 yd³ capacity trucks. If the slash chipping and hauling turns out to be unfeasible or has unacceptable consequences, then the slash may be left on site to be burned along with the other slash piles.

The 560 acres of thinning and slash treatment along the roads would be completed over 3 years, partly to distribute the wood products to the community over a longer period of time rather than all in one year. Semi-trucks can be used on the lower portion of the project area and smaller trucks are necessary from above McClure Reservoir to the wilderness boundary, due to road alignment. Thus, it would take 516 to 775 truckloads each year for 3 years to remove the chips, assuming 50 percent of each type of truck.

These 560 acres of roadside thinning would also yield a total of about 7,500 to 10,000 cords of firewood (or 2,500 to 3,333 cords annually for 3 years). Removing this volume and weight of “green” wood would require approximately 750 to 1,000 semi-truck loads, or 3,000 to 4,000 5-ton truckloads. Thus it would take 375 to 2,000 truckloads each year for 3 years to remove the wood products, assuming 50 percent of each type of

truck. Refer to the “Mitigation and Monitoring” section for requirements designed to minimize truck traffic impacts in residential areas.

The public would not be allowed to remove wood from the Watershed using pickup trucks for the following reasons: (a) the Watershed is closed to public access and use under a Department of Agriculture closure order; (b) it is important to consistently minimize public access in order to minimize the risk of fire starts or sanitation problems; and (c) it would require 15,000 to 20,000 pickup truckloads to remove the wood products and additional loads if the slash was removed. This would greatly increase truck traffic impacts to the residential area along Upper Canyon Road. Refer to the “Social Environment” section for more detail.

Fuel Breaks

Several fuel breaks would be created to reduce the risk of escape fires during prescribed burning and reduce the rate of spread of a crown fire. The fuel breaks would be strategically located, generally along ridgetops, and thinned to approximately 20 to 30 trees per acre. The largest trees would remain. For the fuel breaks to be effective in inhibiting the spread of a crown fire, thinning must create sufficient spacing between tree crowns and reduce the crown (bulk) density. The slash would be piled and burned. Most snags near the fuel break would be felled in order to make the fuel breaks more effective. Snags often act as sources of fire ignitions, especially during lightning storms. After the thinning and slash burning, a manually lit burn line (“blackline”) or hand-built fireline, could be created on the fuel breaks to clear away additional surface fuels and vegetation to further improve their effectiveness.

Along the southern ridge of the Watershed, the created fuel break would range from 250 feet to 0.5 mile wide to reduce the risk of a crown fire spreading from the dense forests to the south into the watershed. A major threat to the Watershed is from fires that might originate south and west of the Watershed (Apache Canyon area) and be driven in a northerly or northeasterly direction by the prevailing southwesterly winds. Created openings along the southern fuel break could also provide potential landing sites for helicopters engaged in fire suppression or to drop off supplies for workers.

Other ridgelines along the perimeters of the project area and in the interior are very narrow and, therefore, less effective as fuel breaks in slowing down a crown fire. However, for alternatives that involve broadcast burning (Alternatives B1, C1, and D1), these narrower fuel breaks would be very effective at reducing the risk

of an escaped fire. Maps of Alternatives B1, C1 and D1 display some probable fuel breaks, however, the actual width, location and number of the fuel breaks may vary from what is shown on the maps.

Broadcast Burning Objectives and Methods (for Alternatives B1, C1 and D1)

Some areas too steep for thinning and slash piling would be burned at a low intensity¹ to reduce surface and ladder fuels. Some of the thinned areas may also be included in these burn units. These burns would not be hot enough to burn larger intermediate trees over 6-inch diameter or create openings in the overstory canopy.

Each burn unit would be approximately 100 to 800 acres, and some are likely to be smaller. Burn units would be carefully defined on the ground and described in a detailed, site-specific burn plan, which undergoes several reviews. Unthinned stands that are included in a burn unit would be surrounded by firelines and by stands that were thinned and slash-treated, as well as appropriate fuel breaks. The size of each burn unit would depend upon the acreage that can safely be contained as a surface fire, without exceeding smoke management standards. Fuel loading, stand structure and topography would also influence the size of each burn unit. Approximately 8 to 16 burn units would be treated over a 5 to 10-year time period, depending on the alternative selected.

Various ignition techniques and patterns could be used, depending on the specific fuel loading, stand structure, and topography. Often, surface fuels will be manually ignited at the top of a ridge such that the fire burns slowly down the slope. With any type of ignition, ground crews would be used to monitor, contain and “mop-up” the burn (inspect and extinguish embers after the flames have diminished).

The number of units that could be burned each year would depend on weather, fuel moisture, and other factors. Depending upon weather and fuel moistures, broadcast burning would likely occur fewer than 10 days per year. Broadcast burning is most likely to occur during the fall, following the July-August rainy season. Refer to the “Mitigation and Monitoring” section for detailed stipulations about burning.

Contour Felling

In order to reduce soil erosion that might result from thinning and burning, most of the cut trees would be dropped in a staggered pattern along the contours of the steeper slopes, with fewer on the gentler slopes. The thinning would produce over 200 logs per acre suitable as erosion control barriers (5 to 12-inch diameter), based on current tree sizes and density, and assuming the contour logs would average about 25 feet in length.

Project Size and Timing of Treatments

The approximately 7,270-acre project area was selected as the highest priority area that can feasibly be treated within the next 10 years. It constitutes the majority of the forested area in the municipal watershed that lies outside the wilderness. Other densely forested areas within and surrounding the Watershed may be proposed for similar fuel reduction treatment in the future in order to protect the Watershed and wildland-urban interface².

This area of the Watershed below the wilderness was selected because it is dominated by lower-elevation, dry forest types that have undergone the most change since fire exclusion policies were enacted, and have the highest risk of wildfire ignition and highest fuel hazard. Treating this lower-elevation area closest to the water supply reservoirs should provide the best protection from crown fire impacts or post-fire mudslides, and would provide a safer area for fire suppression crews to work to protect the water supply.

Treatments would begin on the south side of the Santa Fe River, including the wide fuel break proposed for the southern ridgeline intended to help prevent a wildfire from spreading into the Watershed from prevailing winds.

There are several reasons why it would require 5 to 10 years to complete this project. First, felling selected trees, cutting off branches and tops, and piling slash on steep, rugged terrain would require approximately three people per acre per day. We would need to have at least 30 workers thinning and treating slash on 10 acres per day to treat the maximum projected acreage of 700 to 1,400 acres per year. Second, the slash must dry for 3 to 12 months before it can be burned, and weather conditions must be suitably cold and moist for slash burning. Some extremely dense stands (over 1,000

¹ Low intensity burns generally have flame lengths of less than four feet; consume primarily surface fuels: needles, twigs, and woody material less than about two-inch diameter, and partially consume the duff layer, rotten wood, seedling and small saplings, with minimal heating of mineral soil.

² A wildland-urban interface is an area where wildland fuels occur in proximity to homes or other structures.

stems per acre) would likely require two separate thinning and slash disposal entries in order to avoid having too much slash to safely burn at one time. Third, the amount of slash that can be burned at one time is limited by the weather and amount of smoke production expected. Last, after the thinning and slash disposal work has been accomplished in one or more sub-drainages, specific weather and fuel moisture conditions must occur in order to conduct a safe, low intensity burn in selected areas that still contain unacceptable fuel loads.

Thinning and slash disposal activities would probably occur in several different parts of the project area concurrently in order to accomplish project objectives within a decade. In addition, thinning crews would be separated in different parts of the project area in order to avoid having too many contiguous sub-basins covered with dry slash at any one time.

Adaptive Management

An adaptive management strategy would be used in implementing the project. Monitoring and evaluating the results of specific treatments and areas will determine if the desired condition is being achieved, and if not, what needs to be changed. Both short- and long-term monitoring would be used. Research and university scientists, as well as city, state, and Federal agencies, and non-governmental organizations would be the primary parties conducting the monitoring and evaluation, and submitting recommendations to the national forest officials. Refer to the “Mitigation and Monitoring” section and Appendix B for details.

Alternative B1: Limited Manual Thin/Burn Slash/Broadcast Burn

This alternative excludes thinning and slash treatment on only 36 percent of the project area, consisting of gentler terrain within about one half mile from the access road. Thus it minimizes risk of injury to workers that can occur from working with chainsaws in roadless, steep terrain, while reducing the amount of labor and time needed to complete the project. In the 64 percent that is not thinned, low intensity broadcast burns would be conducted to reduce some of the surface fuels and very small diameter trees. Appropriate fuel breaks, firelines and natural topographic barriers would surround each broadcast burn unit (see the “Mitigation and Monitoring” section). Some heavily forested slopes may not be included in the broadcast burn units if it appears that the burn cannot be adequately controlled on those slopes due to stand density or other factors.

Table 1. Treatment Type and Acres, Alternative B1.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, and slash disposal (chip-and-remove or burn slash). Possible inclusion in broadcast burn units.	560	8
Manual thinning and slash burning away from roads, including fuel breaks. Possible inclusion in broadcast burn units.	2,010	28
Broadcast burning only, in untreated stands, after surrounding stands have been thinned and slash-burned.	4,700	64

Alternative B2: Limited Manual Thin/Burn Slash/No Broadcast Burn

This alternative would treat a much smaller acreage; a total of 2,290 acres (32 percent of the project area) through thinning and slash reduction (Figure 26). By treating a much smaller portion of the project area, it allows more time to monitor and evaluate effects before treating additional acreage. This alternative takes an exceptionally cautious approach, which would require the Forest Service to conduct another NEPA driven environmental analysis and public involvement process prior to approving treatment of additional stands within the project area. It excludes broadcast burning to address concerns about smoke and the risk of prescribed burns getting out of control.

Table 2. Treatment Type and Acres, Alternative B2.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, and slash disposal (chip-and-remove or burn slash).	560	8
Manual thinning and slash pile burning away from roads.	1,730	24

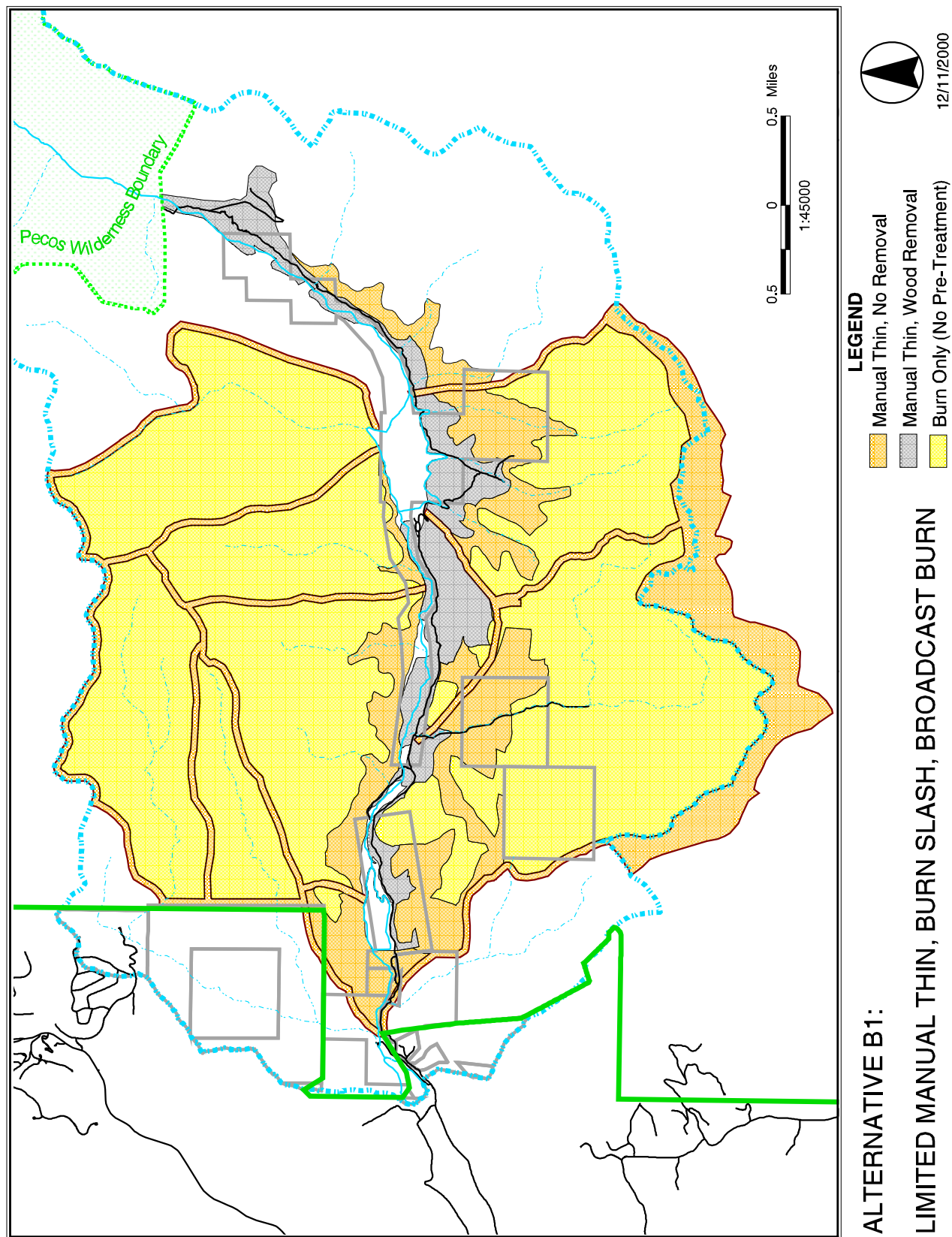


Figure 25. Alternative B1.

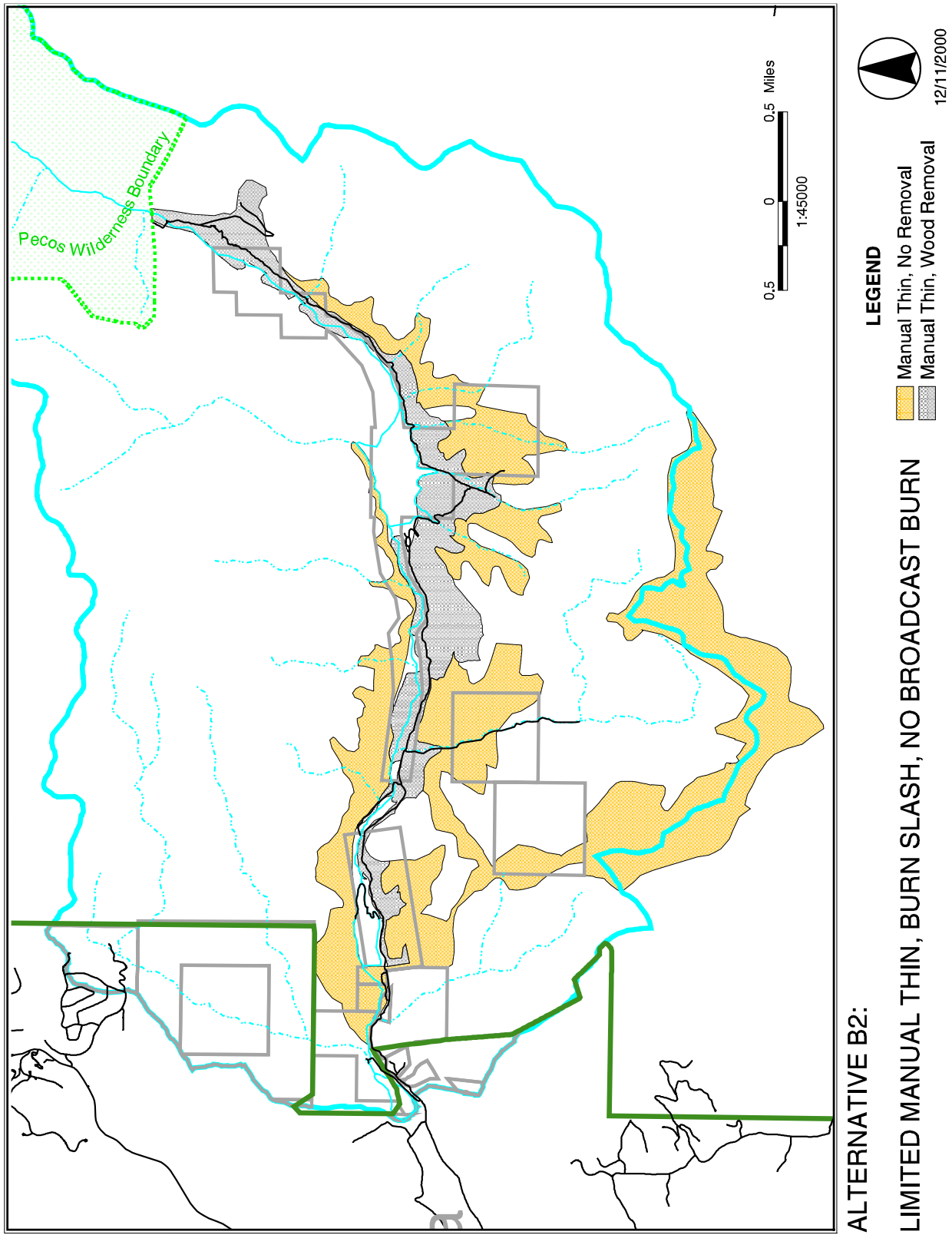


Figure 26. Alternative B2.

Alternative C1: Manual Thin/Burn Slash/ Broadcast Burn

This alternative would treat the entire 7,270-acre project area through a combination of manual thinning, slash treatment, and broadcast burning (Figure 27). It is similar to Alternative B1 except it involves more thinning and slash treatment (70 percent), and only 30 percent broadcast burn-only acreage. It involves manual thinning with chainsaws on all operable terrain (up to about 55-65 percent slopes), including slopes over a mile from roads. A portion of the remaining inoperable slopes would be included in broadcast burn units.

This alternative was developed to increase the degree of control in achieving desired stand structure and composition. Thinning more acres manually with chainsaws rather than with prescribed burning alone, not only improves control over stand structure, but would allow for a greater amount of fuel reduction and canopy openings, to more fully meet our project objectives. It was also developed to reduce the total amount of broadcast burning in dense, unthinned stands while treating the entire project area, in order to address issues associated with broadcast burning, such as risk of escape fire and amount of smoke.

Table 3. Treatment Type and Acres, Alternative C1.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, and slash disposal (chip-and-remove or burn slash). Possible inclusion in broadcast burn units.	560	8
Manual thinning and slash pile burning away from roads, including fuel breaks. Possible inclusion in broadcast burn units.	4,520	62
Broadcast burning only, in untreated stands, after surrounding stands have been thinned and slash-burned.	2,190	30

Alternative C2: Manual Thin/Burn Slash/ No Broadcast Burn

This alternative would treat 4,900 acres (about 68 percent of the project area) through thinning and slash reduction, without any broadcast burning (Figure 28). It leaves 32 percent of the project area untreated.

Like Alternative C1, this alternative was developed to provide for greater control in achieving the desired stand conditions and fuel reduction objectives, by increasing the acres to be thinned compared to Alternative B1 or B2. Like B2, it was also developed to address the issues associated with broadcast burning in dense, unthinned stands, by eliminating the broadcast burn treatment altogether.

Table 4. Treatment Type and Acres, Alternative C2.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, plus slash disposal (chip-and-remove or burn slash).	560	8
Manual thinning and slash pile burning away from roads.	4,340	60

Alternative D1: Machine Thin/Burn Slash/ Broadcast Burning

This alternative would treat the 7,270-acre project area, and is the same as Alternative C1 except machines would be used to cut and pile the trees (Figure 27).

Like Alternative C1, this alternative was developed to fully meet the fuel reduction objectives by thinning as many acres as possible (up to about 55-65 percent slope). It was developed to improve worker safety and operational efficiency by minimizing the number of workers exposed to the hazards of cutting trees and treating slash on steep, rugged terrain far away from roads. It was also developed to reduce the labor time needed to accomplish fuel reduction objectives. This alternative could be completed in 5 to 7 years, compared with 7 to 10 years for Alternative C1. Like Alternative C1, it includes broadcast burning on slopes too steep for thinning and slash piling, in order to more fully meet project objectives.

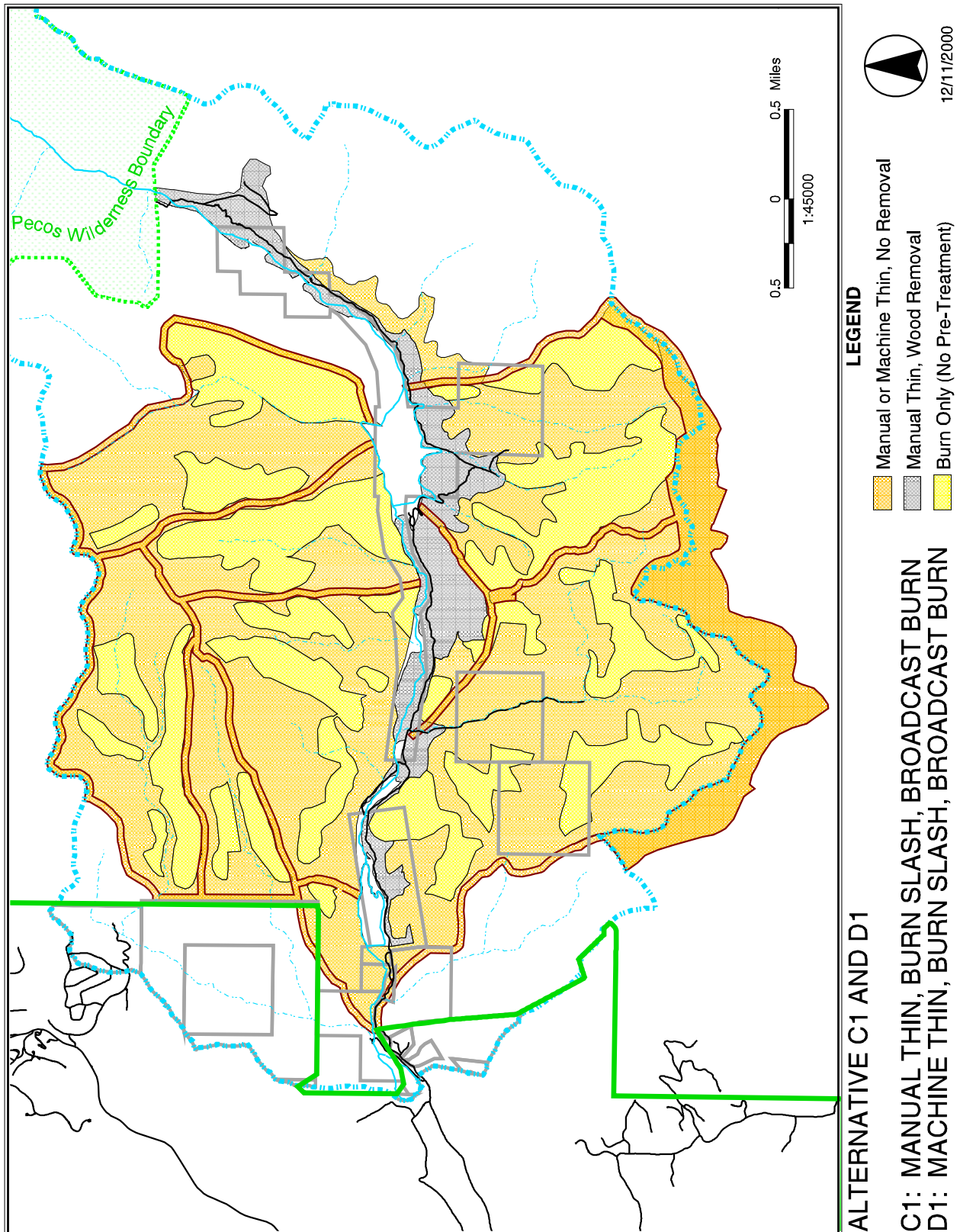


Figure 27. Alternatives C1 and D1.

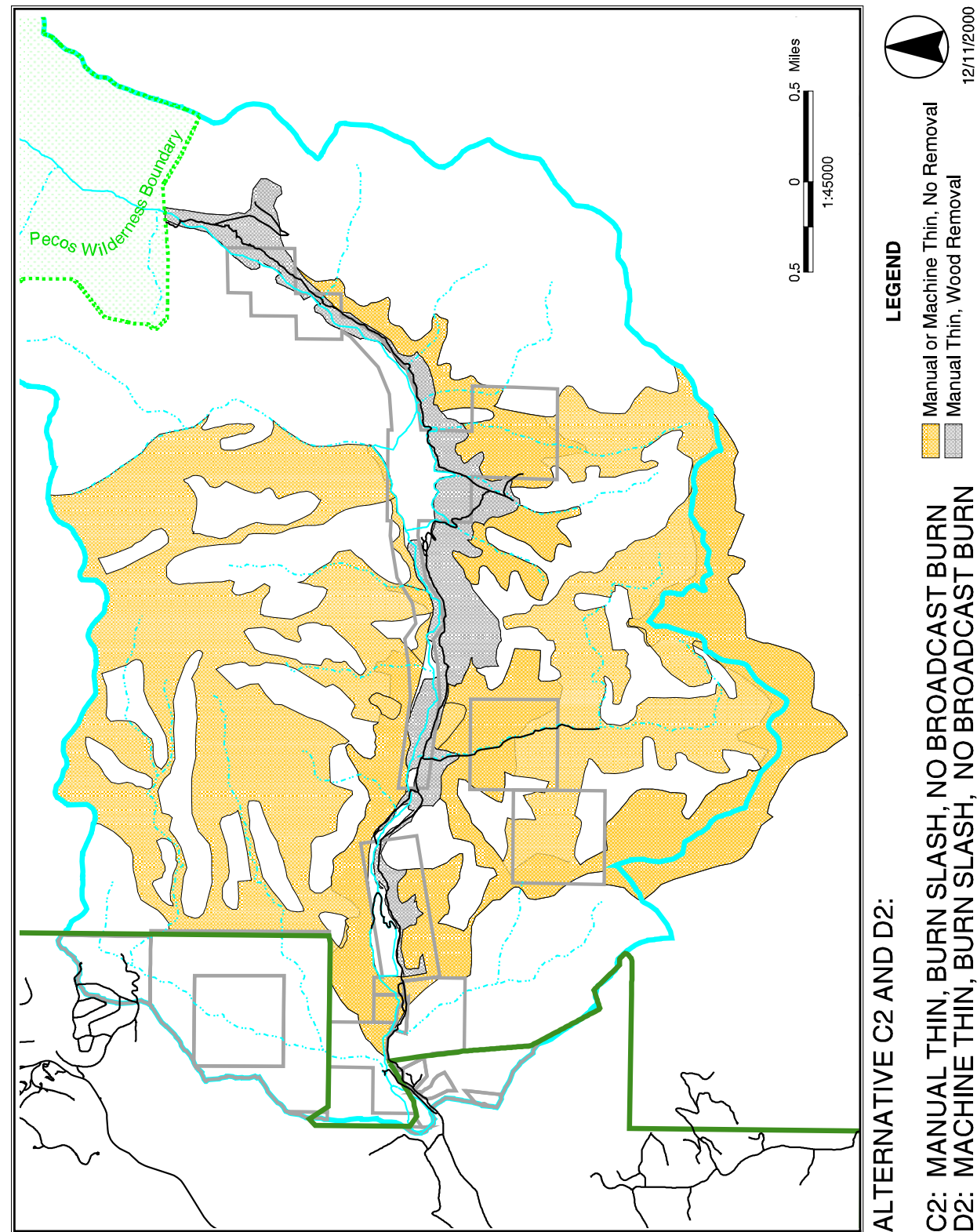


Figure 28. Alternatives C2 and D2.

The machines used for thinning would be track-mounted “feller-bunchers”. Each machine is about 8 feet wide and uses a 24-foot boom-mounted grapple arm and saw-head to grab and cut trees within a 22-foot radius. The machine’s flexible arm controls movement of the cut tree and can avoid damaging surrounding trees. The feller buncher exerts only about 7 pounds per square inch of pressure on the ground. The feller-buncher can operate in deep snow and maneuver easily around trees. It can access the Watershed by existing roads and does not create new roads or skid trails. One machine can cut and pile trees on 3 to 4 acres per day. After it grabs and cuts a tree, it fully suspends the tree in the air until it is placed in a desired location. There is no skidding (dragging) the cut trees.

On most of the area, the machine would lay the cut trees in front of the machine, which would then drive over the piled trees. The piled trees act as a cushion for the machine, reducing the risk of soil compaction. On very steep slopes (35-55 percent), the feller-buncher would pile cut trees to each side of the machine at a 45° angle, with the tree crowns facing the same direction. The machine would not drive over these piles due to slope steepness.

The piles of cut trees would be burned after the branches and stems less than 5-inch diameter are sufficiently dry, yet the trunks remain too moist to burn. The remaining unthinned 2,190 acres would be included in broadcast burns.

Table 5. Treatment Type and Acres, Alternative D1.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, and slash disposal (chip-and-remove or burn slash). Possible inclusion in broadcast burn units.	560	8
Manual thinning and slash pile burning away from roads, including fuel breaks. Possible inclusion in broadcast burn units.	4,520	62
Broadcast burning only, in untreated stands, after surrounding stands have been thinned and slash-burned.	2,190	30

Alternative D2: Machine Thin/Burn Slash/No Broadcast Burn

This alternative would treat a total of 4,900 acres (about 68 percent of project area) through thinning and slash reduction (Figure 28). It leaves 32 percent of the project area untreated, where slopes are too steep for thinning and slash piling. It uses the same feller-buncher machines and tree stacking methods described for Alternative D1 and treats the same acres as Alternative C2.

Like Alternative D1, this alternative was developed primarily to thin as many acres as feasible while improving worker safety and operational efficiency, and meet fuel reduction objectives within a shorter period of time compared to manual thinning (Alternative C1). Like Alternatives B2 and C2, it was developed to eliminate broadcast burning in order to address the issues associated with broadcast burning in untreated stands.

Table 6. Treatment Type and Acres, Alternative D2.

Treatment	Acres	Percent of Area
Roadside manual thinning, wood removal, plus slash disposal (chip-and-remove or burn slash).	560	8
Manual thinning and slash burning away from roads.	4,340	60



Figure 29. The feller-buncher offers a higher degree of control and safety than manual thinning and slash piling.



Figure 30. A feller-buncher in operation.

Additional “Options”

The following two options offer minor variations that may be applied to any of the action alternatives. Each option only applies to a very small portion of the project. They were developed to address specific issues.

Option A for 560 Acres: No Wood Removal

This option applies to the 560-acre roadside thinning treatment area, but no wood products or slash would be

removed from the Watershed. This area would be treated the same as the other thinning areas located away from roads. This option eliminates potential impacts to residential neighborhoods from trucks hauling wood along Upper Canyon Road and other residential areas. It reduces the potential for traffic hazards, noise, dust, vibration damage to old homes, road damage, driving delays through the single-lane section of Upper Canyon Road, or other conflicts with residential uses of the road.

Option B for 100 acres Within the 560 Acres: Thin the Larger Conifers (up to 24-inch diameter)

This is another option that could be applied to approximately 100 acres of the 560 acres of roadside thinning areas. This option would be applied to 10 or 11 scattered patches of dense conifers that exist along the flatter part of the canyon bottom where site productivity is higher than in the uplands, but outside of the riparian zone of the Santa Fe River. In these patches, many conifers are larger than the same-age conifers on the upper slopes, because of the more favorable growing conditions (better soil and more moisture). In these patches, the conifers have shaded-out most of the herbaceous vegetation and suppressed riparian vegetation along the river. Below McClure Reservoir, these larger conifers are mostly ponderosa pine. Above McClure Reservoir, the larger conifers are mostly Douglas-fir and white fir, with an understory of over 1,000 seedlings and saplings per acre. Under this option,

Summary of Treatment Acres by Alternative

	Alternatives						
	A acres	B1 acres	B2 acres	C1 acres	C2 acres	D1 acres	D2 acres
Thinning & slash disposal along roads, with wood product removal.	0	560	560	560	560	560	560
Thinning and slash burning away from roads, leaving tree trunks on-site. Possible inclusion in broadcast burn units.	0	2,010	1,730	4,520	4,340	4,520	3,450
Broadcast burning only, in untreated stands, after surrounding stands have been treated.	0	4,700	0	2,190	0	2,190	0
Total Treatment Acres	0	7,270	2,290	7,270	4,900	7,270	4,900

most of the existing conifers in these small patches would be felled, up to a maximum 24-inch diameter rather than 16-inch, leaving approximately three to five of the largest conifer trees per acre. The larger tree trunks would be left on site, and the slash would be burned.

The purpose of this option is to open up these thick conifer-dominated patches to reduce the risk of severe crown fire close to the water supply, and to enhance the growth of grasses and shrubs that have superior root systems compared to conifer tree roots for holding soil in place, and for filtering sediment and ash runoff. Without this option, these objectives would not be met on these high-productivity sites.

Mitigation and Monitoring

The mitigation and monitoring measures contained in this section are common to all action alternatives unless otherwise noted. They were developed in collaboration with many interested individuals, organizations and governmental agencies. Mitigation measures are prescribed to avoid, minimize, or compensate for adverse environmental effects that may occur from project implementation. They were designed primarily to address issues listed in Chapter 1.

Monitoring is used as an adaptive management strategy to determine whether the treatments and mitigation measures were implemented as planned, effects were consistent with those predicted in the EIS, and treatments were effective in moving toward desired conditions. Monitoring measures listed in this section are marked with an asterisk (*) next to the bulleted statement. A more detailed monitoring plan for this project is attached as Appendix B. Detailed monitoring design plans for each resource component of the monitoring plan are contained in the project record. An active group of citizens, organizations and government agency representatives continues to work together in a long-term partnership to ensure that the baseline data is collected prior to starting the project, and monitoring is adequately implemented and evaluated. A non-profit conservation organization is coordinating the monitoring and evaluation activities for this project. See Appendix B.

Prescribed Burning and Fire Behavior

- Keep the size of slash piles generally less than 6 to 8 feet in diameter by 5 to 6 feet high.

- Burn slash piles during times of cool temperatures and high humidity when the fuels surrounding the piles have high fuel moisture.
- Avoid having tightly compacted piles in order to increase ventilation, combustion and fuel consumption. During the burning, tend the piles to assure that larger pieces of fuel are consumed.
- Consider covering the piles with plastic when they are built, to keep the piles dry for later burning.
- Develop detailed broadcast burn plans, and conduct broadcast burning only in accordance with those plans. Several Forest Service officials will review the burn plans. Burn methods must be those proven safe and effective, and be modeled using a fire behavior computer model to validate they will meet burn objectives with minimum risk of fire escape.
- Design burn units to reduce the risk of escape, based on size of unit, accessibility, topography, fuel type, fuel load, weather, time of year, etc.
- Ensure the perimeter of each broadcast burn unit is surrounded by existing openings such as reservoirs, streams, roads, or trails, or treated areas where fuels have been reduced. Firelines may be built around the burn unit by clearing the fuels to mineral soil with hand tools.
- Locate fuel breaks where they will be most effective in controlling the burns, such as along ridges, drainages or other topographic breaks, taking into consideration fuel type and fuel loading.
- * Prior to ignition and during the burn, monitor the current and 3 to 10-day weather forecasts from the National Weather Service Fire Weather Forecaster in Albuquerque, NM, plus daily spot weather forecasts, for trends in temperature, relative humidity, wind, frontal passages, etc.
- * Prior to ignition, monitor (via computers) the forest's 5-day energy release component (ERC) from the forest's weather stations. The ERC is related to energy or heat that will be released in a fire. The ERC is an indicator of the relative dryness of the fuel, which dictates how hot a fire will burn. Do not broadcast burn when the ERC is above 65. All large wildfires on the forest have occurred when the ERC has been above 68.

- * Prior to ignition and throughout burn implementation, monitor and record fuel moistures. Do not broadcast burn when live fuel moistures are below 100 percent. Do not broadcast burn complex burn units when the Palmer Drought Index (PDI) indicates a moderate or higher drought index. This will reduce the likelihood of an escape fire and lessen the chance of killing desired trees.
- Prior to burning, complete the “go/no go” checklist, risk assessments and daily review checklists in the burn plans.
- Prior to ignition, ensure that there are adequate fire engines and water tanker trucks on site and contingency suppression resources available, as indicated in the site-specific burn plan. Do not ignite broadcast burns when the Southwest Area’s “preparedness level” is at III or higher. This indicates that contingency resources may not be available due to other fire activity in the Southwest.
- For some of the more complex broadcast burn units, consider having a helicopter with water dropping capability, and/or an air tanker available on standby. Also consider laying down fire (water) hose around the perimeter of the broadcast burn unit and having portable water tanks and pumps in place prior to ignition.
- Ensure that fire personnel implementing broadcast burns have the appropriate knowledge, skills and qualifications for a complex-rated burn. Personnel conducting the broadcast burns should also be qualified for fire suppression positions as a contingency in the event of an escape fire situation.
- Plan for and locate burn implementation personnel in safe and strategic areas for monitoring and containing the broadcast burn.
- Exclude certain areas from the broadcast burn unit where because of stand density or topography, there would be a risk of high intensity fire behavior and escaped fire.
- * Patrol the area to ensure that the prescribed burning stays within the burn unit (for both slash burning and broadcast burning). Patrol daily until the burn has been declared out. Have an aerial observer over the area when broadcast burning the complex units. If a fire should spread

outside the burn unit, all ignitions will cease until the spot fire is controlled. The prescribed fire burn boss will decide if the burn should continue based upon prescription criteria and observed fire behavior.

- After the flames from the broadcast burn have subsided, mop-up (extinguish) any hazardous heat concentrations along or adjacent to the fireline that could threaten to cross the line.
- * During the broadcast burn, monitor and record the observed fire behavior, and compare it with predicted fire behavior in the burn plan. Evaluate the results to modify future burn plans and burns.
- * After implementation, monitor the reduction in live fuel loads, including changes in canopy structure and ladder fuels, and compare with project objectives.

Wildfire Prevention and Agency Coordination

- Continue to participate in fire prevention and public education outreach activities with other agencies. Continue to work with communities and private landowners in creating defensible space and implementing FIREWISE concepts. Maintain an active role in the Sangre de Cristo Interagency Fire Protection Association and the Santa Fe Wildfire Cooperators.
- Use an interagency approach for fire prevention patrolling in and around the Watershed during fire season. Make personal contacts with area residents regarding fire prevention, reporting suspicious activity, or reporting wildfires.
- If a wildfire occurs, follow the “Santa Fe Watershed Fire Operations Plan.” Continue to review and refine this plan with all responsible agencies to ensure communication, coordination, and advance planning for fire emergencies.

Forest Vegetation

- * Monitor down green logs in May or June to determine whether or not they are attracting *Ips* beetles. If so, adjust the timing of the thinning to occur after July 1st.

Worker Safety

- Complete a “job hazard analysis” and hold daily safety meetings during burn operations to reduce accidents.

Soil and Water

Many of the following measures are derived from the Best Management Practices (BMPs) contained in Forest Service Handbook 2509.2 “Soil and Water Conservation Practices Handbook.”

- Minimize the size and number of wood piles (log landings) along the road to minimize the amount of soil disturbance. This can be accomplished by loading the wood onto haul trucks immediately or as soon as possible after the wood is moved to the road.
- Directionally fell “contour logs” on steep slopes as soil erosion barriers (previously described as a feature common to all action alternatives).
- *Before prescribed burning, monitor soil moisture levels. Soil moisture levels should be at least 11-15 percent to maintain long-term soil productivity and improve the chance for vegetative response after burning.
- * Monitor the change in soil erosion (movement) to ensure it is within acceptable limits. If soil erosion exceeds standards, take corrective action and modify treatments as needed. (Forest Plan, pages 76 and 80).
- * After two full growing seasons following a thinning and burning treatment, measure the amount of vegetative ground cover. Apply native grass seeds (or plantings) where determined necessary by the forest soil scientist to re-vegetate specific bare soil areas for erosion and sediment (runoff) control, such as where ground vegetation is less than 10-20 percent coverage. A realistic goal for the granitic soils in this area is to achieve 30-50 percent ground cover.
- After the first growing season following slash pile burning, check the soil under the piles. Where necessary and feasible, rake, till, and seed areas under burned slash piles to promote vegetative response.
- Do not exceed low to moderate fire intensity during broadcast burning (flame height of 1 to 4 feet) to help maintain soil productivity, minimize erosion, and prevent detrimental amounts of ash,

sediment, nutrients, and debris from entering water bodies (consistent with features common to all action alternatives).

- Prohibit vehicle use of roads or trails in the Watershed during periods of wet weather unless the roads have a stable surface and sufficient drainage to prevent undesirable erosion or sediment runoff impacts.
- If fire suppression becomes necessary, do not allow any fire retardant drops within 400 feet of surface water (Santa Fe River or reservoirs), to minimize risk of contaminating the water supply.
- * Monitor water quality in key locations to aid in identifying and correcting any problems and to ensure that water quality will continue to meet drinking water standards (Forest Plan, page 80).
- * Monitor changes in peak flows before and after thinning, as well as subsequent changes in stream morphology, to determine whether treatments are causing any detrimental affects to the stream channel.
- * Monitor changes in the amount of fine sediment in the streambed, and the amount of turbidity resulting from project implementation.

Aquatic Habitat and Biota

- * Monitor changes in fish habitat, before and after implementation, to ensure that thinning and burning activities do not adversely affect aquatic habitat or fish.
- * Monitor for increases in stream temperature following any thinning in the canyon bottom near the riparian area, which could degrade aquatic habitat.
- * Monitor changes in the number of active beaver dams before and after treatment, to ensure that treatment activities are not having adverse affects on the existing beaver population.

Riparian Ecosystems and Wetlands

- Do not pile slash within 15 feet of perennial streams (Santa Fe River) to reduce the chance of ash entering the water following slash burning.
- Avoid piling slash in or adjacent to patches of young cottonwoods in the riparian corridors, to protect them from mortality during burning.

- Manage riparian areas in accordance with legal requirements regarding floodplains and wetlands; protect the productivity and diversity of riparian-dependent species, emphasizing protection of soil, water, vegetation, wildlife, and fish resources. Manage in accordance with Forest Plan guidelines regarding ground cover, shade, bank cover, streambed sedimentation, plant composition, plant structure and crown cover (Forest Plan, pages 79-80).
- Do not conduct thinning activities within the riparian area or within 15 feet of the riparian area (riparian is defined in the section on Aquatic Habitat).
- Locate log landing areas outside sensitive areas including riparian areas, wetlands and wet meadows, and special status species habitat (Forest Plan, page 73). Once landings are no longer needed, rip and re-vegetate landing sites as needed to recover site productivity (Forest Plan, page 78).
- Directionally fell trees away from all stream channels to help reduce slash accumulations within drainage bottoms and to avoid the need to turn trees around in or near riparian corridors. (Forest Plan, page 78)
- Retain all willow, alder, and cottonwood trees in riparian areas. This is consistent with features common to all alternatives.

Terrestrial Habitat and Associated Wildlife

- If any proposed, threatened, endangered, or sensitive plant or animal species are discovered during project implementation, stop work in the immediate vicinity of the species until a Forest Service wildlife biologist or plant ecologist has investigated and recommended the appropriate protective measures. These measures may include restricted operating periods, no-activity zones, protection or creation of snags, or other measures.
- If a northern goshawk nest is found, stop work within 30 acres of the nest site. Do not conduct broadcast burning during May or June within the nest area to avoid the potential for crown fire or smoke to drive the birds off or consume the nest tree (Forest Plan, Appendix D, pg. 10).
- Apply other standards/guidelines for potential northern goshawk habitat, as detailed in Forest Plan, Appendix D, pages 6-10, including the following features common to the design of all action alternatives: retain large snags and down logs wherever possible; retain old age trees and the mature/old forest structure; sustain a mosaic of vegetation densities, age classes and species composition across the landscape; increase herbaceous vegetation to provide for goshawk prey species and to maintain satisfactory soil conditions; use R3 protocol to survey for goshawks (surveys were completed; no goshawks found); have variable canopy coverage (averaging about 40 percent) with openings up to 4 acres each while retaining at least two small groups of trees per acre with minimum 12-inch diameters.
- Avoid cutting trees containing a squirrel nest or having large piles of cones at the base of the tree, as well as any adjacent tree with a crown interlocking the nest tree and a diameter equal to or greater than the nest tree.
- Retain (do not cut) at least 15 percent of the mature and older mast-producing stands in pin-yon-juniper and oak zones (Forest Plan, page 65).
- Within one-quarter mile of perennial water (Santa Fe River) do not burn two slash piles per acre so they may be used as potential nest cover for wild turkey. These piles should be at least 3-feet high by 10-feet wide (Forest Plan, page 65).
- Retain all sound snags, except within fuel breaks and 100 to 300 feet from the edge of fuel breaks if the snag may pose a hazard during broadcast burning. Retain at least 220 snags or potential snags per 100 acres where consistent with fuel management objectives. Particular attention will be given to retaining trees with dead or broken tops, heart rot, and lightning scars, in order to maintain and promote habitat for cavity nesting or roosting species (Forest Plan, page 72).
- Retain trees over 20-inch diameter within 200 feet of major ridges, cliffs, and openings (except snags that must be cut for fuel breaks), to provide perch and roost trees for raptors. This requirement is consistent with features common to all action alternatives (Forest Plan, page 66).
- Retain at least five large down logs per acre where consistent with fuel loading objectives. The desired goal is to have logs at least 11 inches in diameter and 15 feet long, in various stages of decomposition (Forest Plan, page 62).

- When cutting trees over 12-inch diameter, leave two or three of the stumps per acre at a height of 12 inches above the ground to serve as plucking posts for raptors and feeding and “lookout stations” for small rodents.
- Wherever possible without sacrificing fuel reduction objectives, retain two thickets of small trees per acre for cover and foraging areas for flammulated owls and neotropical migratory birds.
- Expand aspen stands where possible by reducing the amount of shading and competition from conifers, and using prescribed burns to stimulate sprouting of aspen (Forest Plan, page 74). This measure is consistent with features common to all action alternatives.
- Retain (do not cut) oaks (*Quercus gameli*) and shrubs, such as wild rose (*Rosa spp.*), mountain mahogany (*Cercocarpus montanus*), Rocky mountain maple (*Acer glabrum*), currants (*Ribes spp.*), and raspberry (*Rubus spp.*).
- * Monitor the effects of treatment on wildlife habitat, recording changes in the following key habitat components: overstory tree composition, structure and density; and retention of existing snags over 12-inch diameter and hardwood trees over 10-inch diameter.
- * Monitor for changes in populations of breeding birds and small mammals.
- * Monitor for increases in invasive plants where soil is disturbed by management activities. Take corrective actions as indicated by monitoring results.
- Plan activities so that air quality will meet applicable Federal, state and local regulations, including protection of Class I air sheds such as the Pecos Wilderness (described in air quality section of EIS) (Forest Plan, page 80).
- The amount of soil in piles and windrows will be minimized to reduce smoldering.
- Conduct visual monitoring continuously through the burn periods. Behavior of the smoke plume will be monitored as well as viability conditions along all major roads in the area of the burn.
- If smoke becomes a serious problem, stop ignition or initiate fire suppression to reduce the generation of smoke.
- Notify the local agencies and the public through radio, TV, newspapers, and/or personal contacts at least a week in advance of the broadcast burns as well as a day before the burn.
- Obtain a burn permit from the State Environment Department at least a month before ignition as outlined in the New Mexico Smoke Management Memorandum of Understanding.
- * Monitor particulate matter from smoke. As a minimum, set up a particulate matter monitor device along Upper Canyon Road to record particulate levels of smoke that may drift down canyon into the city during the evening or morning hours after burning. If particulate matter reaches 80 percent of the National Ambient Air Quality Standards, take corrective measures to reduce smoke and notify the New Mexico Environment Department Air Quality Bureau.
- If smoke starts to settle and limit motorist visibility along Hyde Park Road, Canyon Road, U.S. Highway 84/285, or other major travel ways, take immediate measures to alert motorists of the danger, contact the appropriate state or local traffic control agencies, and close roads where necessary to avoid traffic accidents.
- Continue to provide educational materials on the benefits and tradeoffs of prescribed burning, including signs along Hyde Park Road, contacts in campgrounds, and so on.
- Include educational information in firewood permits on correctly storing and burning firewood to minimize smoke.

Air Quality

Most of the following measures are derived from the USDA Forest Service NEPA Air Quality Analysis Desk Reference, 1995, and the EPA Prescribed Burning Background Document and Technical Information Document for Best Available Control Measures, 1992.

- Avoid broadcast burning on days when mixing heights are less than 1,641 feet and transport winds are less than 4 mph, in order to get the best lifting and dispersion of smoke. This should allow for burning to occur during periods of sufficient atmospheric instability, but not during extreme instability, to improve smoke dispersal.

Social Environment

The following measures would apply if the selected alternative includes hauling wood products out of the Watershed, which could affect residential areas on the east side of Santa Fe.

- Use the largest trucks possible within the size and weight limits of the roads as well as the safety standards (determined by Forest Service and City road engineers), to minimize the number of truck trips through residential areas.
- Ask City officials to ensure that speed limits along the haul route are enforced during haul periods. Stipulate in the contract that multiple violations (citations) may result in contract termination.
- Ask City officials to place a speed monitoring device at an appropriate location along Upper Canyon Road, to increase the awareness, visibility and enforcement of safe driving speeds.
- Notify property owners and residents along the haul route about scheduled haul periods, using the media, mailings or other means of notification.
- Restrict hauling on Upper Canyon Road to avoid weekends, holidays and peak weekday rush hours. Generally allow hauling Monday through Friday, approximately 9:00 or 9:30 a.m. to 3:30 or 4:00 p.m. This is intended to minimize the risk of traffic accidents, lengthy traffic delays, or other impacts along that very narrow residential street.
- Post warning signs about truck traffic where appropriate to reduce residential traffic impacts during haul periods.
- * Monitor: traffic citations issued to haul truck contractors; reported accidents; frequent, lengthy traffic delays; or other traffic-related impacts from this project. If indicated, consider as possible corrective measures: using a convoy of several trucks at one time, pilot vehicles, warning lights, flaggers, or other methods.
- * Monitor reported damage to the road or houses purported to be the result of vibration from haul truck traffic from the Watershed.

Heritage Resources

- Survey for and mark heritage resource sites according to specifications provided in FSM 2309.24 and FSH 2361.28.

- Avoid all known (marked) heritage resource sites during tree thinning, firewood collecting, constructing firelines, maintaining and improving roads, and other land disturbing activities associated with the project.
- Avoid burning perishable remains on heritage resource sites, and protect heritage resources having exposed burnable materials, through one or more of the following methods (determined by a Forest Service archaeologist): digging or burning firelines around the site; clearing fuels away from the site; directing the fire away from the site; foaming and/or covering wooden structures with a fire shelter; or other protective measures. Exclude burning entirely from sites if protective measures cannot be effectively applied.
- Directionally fell trees away from known (marked) heritage resource sites.
- Do not build slash piles in or near heritage resource site boundaries.
- If previously undocumented heritage resource sites are discovered during project activities, stop all work in the immediate vicinity of the site and do not restart until authorized by a Forest Service archaeologist.
- If it is not possible to avoid or protect heritage resource sites during thinning or burning operations, or if mitigation measures prove unsuccessful, then data recovery may be conducted.
- If Native American tribes or other traditional communities express concerns about traditional use areas that may be affected by management activities, mitigation may include avoidance of those areas during operations, or other measures determined through consultation with the affected tribe or community.
- * Monitor to determine if any heritage resource sites were damaged during thinning or burning operations. If any site has been damaged, a Forest Service archaeologist will determine the appropriate corrective actions to take to minimize the risk in the future. If damage to a heritage resource site is discovered during project implementation, stop all work within the immediate vicinity of the site, evaluate the damage and determine what corrective measures are needed. Do not resume work until authorized by a Forest Service archaeologist.

Comparison of Alternatives

The Comparison of Alternatives table (Table 8) displays the primary differences among the alternatives with respect to how well they meet the purpose and need (project objectives), and how they address the key issues. It summarizes the main effects of each alterna-

tive. Effects are described in detail in Chapter 3. The comparison table combines Alternatives C1 with D1, and C2 with D2, because there are no significant differences in effects between those alternatives. The effectiveness of the fuel reduction treatments is summarized in Table 9.

Table 8. Comparison of Alternatives.

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
FOREST VEGETATION, FUELS & FIRE BEHAVIOR						
Objective: Effectiveness in reducing crown fire severity. (See Table 9 for detail)	Does not meet objec- tive. Analysis predicts a large, high severity crown fire.	Low to Moderate effectiveness. Treats nearly 100% of project area, but only about 35% with thin- ning, and 65% by burning only, which is less effective than thinning.	Least effec- tive. Treats only about 36% of project area by thinning, and no broadcast burning.	Most effec- tive. Treats nearly 100% of project area, with about 70% thin- ning and 30% burn- ing.	Moderately effective Treats about 70% of project area with thin- ning, but no broadcast burning.	A. No difference. B. Most effective fuel reduction on 100 acres closest to water supply.
Prescribed fire getting out of control.	No risk from prescribed fire. Very high risk of a serious wildfire out of control for 24-48 hours.	Little risk due to mitigation & monitoring, but involves the most broadcast burning in untreated fuels.	Very little risk due to mitigation and monitor- ing of slash burns; excludes broadcast burns.	Little risk due to mitigation & monitoring, but includes broadcast burns (mostly through treated fuels).	Little risk due to mitigation & monitoring of slash burns; excludes broadcast burns.	A. Negligible increased risk from burning on 560-acres along roads, rather than removing fuels. B. Slight in- creased risk from higher fuel load on 100 acres.

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
SOILS & WATER						
Objective: Increase herbaceous vegetation; long-term soil stability	Significant loss of ground cover and soil productivity.	Average increase of 30%-50% in ground cover on treated acres 3-5 yrs after treat- ment.	Similar to B1, but on only 36% of project area.	Same as B1.	Similar to B1, but less responsive without broadcast burning, and only on 70%	A. No differ- ence. B. Significant increase on 100 acres closest to water.
Erosion, sedimenta- tion, and water quality	Major increase in soil move- ment including mass ero- sion, with up to 400-fold increase in annual sediment yield, grow- ing to at least 1,571-3,249 ac-ft in 10 years; not returning to pre-fire level for up to 15 yrs. Loss of at least 50% reservoir capacity 10 yrs after fire; impacting water supply. Major water quality impacts, greatly exceeding standards.	Minor, short- term increase (2-4 fold); return in 3-5 yrs to current sediment yield of approx 0.4 ac-ft/yr. No loss of reservoir capacity. No measur- able water quality impacts.	Similar to B1, but less short-term erosion due to limited acreage treated.	Same as B1	Same as B1	No difference
Water yield	Beneficial increase of at least 25%, returning to pre-fire levels over 10-20 years.	No measur- able increase		Same as B1	Same as B1	No difference

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
SOILS & WATER (Continued)						
Peak flows and flood hazard	Peak flows exceeding 3,000 cfs, inundating entire 100-yr floodplain; 15 years to return to pre- fire levels. Flooding of low-lying residential areas and downtown Santa Fe; potential floods along Rio Tesuque & upper Pecos River.	No measur- able change in peak flows or flood hazard.	Same as B1	Same as B1	Same as B1	No difference
Soil proper- ties, nutrients & nutrient cycling	Adverse impacts to most soil properties. Nutrient cycling processes disrupted.	No measur- able adverse impacts. Beneficial increase in soil produc- tivity in treated areas. Beneficial effect on nutrient cycling from broadcast burns.	No measur- able adverse effects. Minor increase in soil produc- tivity in treated areas. No beneficial effects on nutrient cycling.	Same as B1	Same as B2	No difference
AQUATIC HABITAT AND BIOTA						
Fish habitat quality	Adverse impact from increases in sediments, water tempera- ture, & other factors. Reduction in aquatic insects, and high mortality in trout population.	No measur- able impact to aquatic habitat, aquatic insects, or trout popula- tion.	Same as B1.	Same as B1.	Same as B1.	No difference

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
RIPARIAN HABITAT & WETLANDS						
Increase in invasive plants	Yes, especially Siberian elm.	No measurable increase.	Same as B1.	Same as B1.	Same as B1.	No difference
Effect on cottonwood seedlings, beavers and other riparian habitat or species	Short-term reduction in cottonwoods & woody riparian vegetation, but rapid recovery. Short-term loss of beaver dams and ponds; with gradual recovery. No long-term impacts on riparian species.	No measurable loss of cottonwood seedlings, or impact to riparian habitat. Very minimal, short-term disturbance to beaver and other species, not affecting population viability.	Same as B1	Same as B1	Same as B1.	A. No difference. B. Minor reduction in large trees, but no measurable impact on habitat or population viability.
SPECIAL STATUS SPECIES						
Threatened, endangered, & sensitive species	Adverse effects to potential habitat. (No TES species known to occur or likely to occur in project area).	No adverse effects. Some beneficial effects to potential habitat.	Same as B1 but beneficial effects over a smaller area.	Same as B1 but beneficial effects over a larger area.	Same as B1 but beneficial effects over a larger area.	No difference

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
TERRESTRIAL HABITAT AND WILDLIFE						
Habitat quality and wildlife, including management indicator species (MIS)	Widespread tree mortality, including large, mature trees; conver- sion from forest to grasses, shrubs and bare soil. Increase in aspen. MIS: Increased habitat for hairy wood- pecker (snags) and elk (openings); adverse impacts to Rio Grande cutthroat trout and potential spotted owl habitat in Wilderness; populations of MIS remain viable.	Minor disturbance effects during operations, but no adverse impacts to habitat or populations. Beneficial effect on habitat quality; increased ground vegetation, down logs, aspen, and diversity of forest struc- ture. No adverse effects on habitat for MIS; some beneficial effects.	Same as B1, but beneficial effects over much smaller area, and beneficial effects reduced without broadcast burning.	Same as B1 but with beneficial effects over a larger area and en- hanced by broadcast burning.	Same as B1 but with beneficial effects over a larger area; beneficial effects less than C1/D1 by not broadcast burning.	No difference
SOCIAL						
Traffic, noise, vibration, and bike and pedestrian safety	Increase in traffic-related impacts and noise in adjacent neighbor- hood, including helicopters and planes, due to wildfire suppression activities.	Increase in truck traffic and related quality of life impacts; 2-50 trucks/day during haul periods, for 3 yrs, to remove wood from 560 acres. Possible truck vibration impacts to older adobe homes and road (Upper Canyon Rd).	Same social impacts as B1	Same social impacts as B1 C1 poses higher risk to worker safety, due to manual thinning and slash piling on steep slopes.	Same social impacts as B1 C2 poses higher risk to worker safety, due to manual thinning and slash piling on steep slopes.	A. Avoids impacts to residential neighborhood by not removing wood. B. Slight increase in truck traffic from remov- ing more wood on 100 acres.

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
AIR QUALITY (SMOKE)						
Visibility & health effects	Significant adverse effects over large area; greatly exceeding air quality standards; 4-6 times the daily particulate compared to prescribed burns; thick smoke lasting up to 14 days. Visibility severely reduced, impacting traffic in local areas. High risk of adverse health effects for many people.	Smoke within acceptable levels; No prolonged heavy smoke or air quality alerts; likely within standards; 28-56 total burn days. Visibility within acceptable levels. Possible adverse health effects for a few people.	Same as B1, but with only 17-34 total burn days, and the least amount of smoke due to no broadcast burning, and the small acreage of pile burning. No adverse effects to visibility or health or anticipated.	Same as B1, but with 53-98 total burn days.	Same as B2, but with 43-86 total burn days.	No difference.
HERITAGE RESOURCES						
Archaeological sites and traditional cultural properties	Probable damage or destruction of known and unknown heritage resources by wildfire or fire suppression activities.	Low (slight) risk of damage or destruction due to mitigations and monitoring, including survey and site avoidance.	Same as B1; least risk due to less acreage treated and no broadcast burning.	Same as B1	Same as B1, with slightly lower risk due to no broadcast burning.	No difference

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
ECONOMICS						
Cost of treatments (PNV). Jobs: Safety and Efficiency Differences	Cost of fire suppression, watershed rehabilitation and reservoir dredging would likely exceed \$152 billion.	Cost: \$2.1 million. 66 Jobs	Cost: \$1.5 million. 61 Jobs	C1: \$3.7 million; 111 jobs, mostly local. Lower degree of worker safety and labor-time efficiency. D1: \$3.8 million; 44 jobs, most from out of state. Better worker safety and labor-time efficiency.	C2: \$2.9 million; 96 jobs, mostly local. Lower degree of worker safety and labor-time efficiency. D2: \$3.4 million; 45 jobs, most from out of state. Better worker safety and labor-time efficiency.	A. Reduces cost by approximately \$600,000. B. No difference.
RECREATION AND SCENERY						
Recreation sites and trails in Hyde Park Road corridor	Long-term adverse impacts to aesthetic quality from loss of forest vegetation, and blackened hillsides. Damage to developed recreation sites and trails in Hyde Park corridor, reducing recreation opportunities. Increase in aspen (fall foliage) viewing opportunities.	No adverse impacts, except very minor, short-term noise & nuisance smoke in adjacent recreation use areas.	Same as B1.	Same as B1.	Same as B1.	No difference

Table 8. Comparison of Alternatives (Continued).

	Alternative A with severe wildfire	Alternative B1	Alternative B2	Alternatives C1/D1	Alternatives C2/D2	Options A and B
FACILITIES						
Water treatment plant	Increase in sediment and ash clog; impacts to water treat- ment chemical process; long-term unpleasant odor and taste of drinking water.	Minor increases in turbidity, would not affect water system.	Same as B1	Same as B1	Same as B1	No difference
Key: ac-ft = acre-feet cfs = cubic feet per second MIS = management indicator species PNV= present net value						

Table 9 compares the estimated effectiveness in reducing fuels and potential wildfire severity on any untreated acreage compared to treated acreage, based on some of the key factors affecting fire behavior. Other key factors, such as weather and topography, are outside our control. Fuel reduction effectiveness would be greatest on areas thinned manually or with machines, followed by slash treatment and broadcast burning (Alternatives C1/D1). Broadcast burning in dense stands without thinning first would not be nearly as effective in meeting fuel reduction objectives.

Table 9. Fuel Reduction Treatment Effectiveness.

Factor Affecting Fuels/Fire	Untreated Acreage	Treated Acreage
Tree size class (average): diameter class of the trees that are most abundant.	Less than 12-inch diameter, with over 80% of trees less than 6-inch diameter (except in canyon bottom where trees are larger).	Greater than 12-inch diameter.
Stand density index (range).	30%-60%	10%-25%
Crown base heights (average).	Less than 20 ft. from the ground; abundant ladder fuels that promote crown fires.	Greater than 20 ft. from the ground.
Canopy cover (average).	Greater than 40%; supports crown fire spread.	Less than 40%.
Crown bulk density (average).	Greater than threshold of 0.1 kg/m ³ .	Less than threshold of 0.1 kg/m ³ .
Tree species composition.	Fire-susceptible tree species most abundant.	Fire-resistant tree species most abundant.

Chapter 3 • Affected Environment and Environmental Consequences

This chapter describes the existing conditions and potential environmental and social effects associated with each alternative, including the No Action Alternative.

Each section begins by listing the issues and/or project objectives that were the focus of the analysis for that resource topic, and then describes the current environment that would be affected by the proposal. The subsequent environmental consequences (effects) sections describe the estimated effects expected from each alternative - the No Action Alternative Without Wildfire, the No Action Alternative With Wildfire, Alternatives B1, B2, C1, C2, D1, D2, as well as Options A and B. The effects analysis for each issue and objective included consideration of direct, indirect and cumulative effects, both short-term and long-term.

This chapter summarizes some of the more detailed information from the individual analysis reports in order to reduce the length of this EIS and improve readability. The individual analysis reports are in the project record and available for public review. Where there are differences between the information contained in the original analysis reports and the information in this EIS, the EIS takes precedence. The EIS was reviewed and edited by various scientists outside the Forest Service as well as by the primary authors several times throughout the interdisciplinary process after the original reports were written.

Cumulative Effects

At the end of each resource section is a discussion of cumulative effects for that resource. Cumulative effects are the effects from other land uses that are not part of this proposed project, which may have an additive effect when combined with the effects expected from the proposed actions. The cumulative effects analysis considered land uses outside the project area if they could have an additive effect on the resources affected by the proposal. The geographic extent for which cumulative effects were considered varies for each resource issue. As the project area has been closed to most land use activities since 1932, there are very limited and minor land uses within the area that could contribute to cumulative effects. The interdisciplinary team considered past, present, and reasonably foreseeable future actions that could contribute to cumulative effects, including but not limited to the following actions.

Past Actions

- Historic land uses prior to the closure order, previously described (e.g. agriculture, livestock grazing, tree cutting, recreation). These historic uses influenced the current conditions in the Watershed.
- Road improvements and maintenance on the service road in the project area, such as installation of culverts, blading, and other drainage control measures implemented in 1998-1999 to reduce sediment runoff from the road.
- Thinning and slash piling or scattering on demonstration sites totaling 7-9 acres within the project area (Fall 1999).
- Upgrades and reconstruction of upper Pecos canyon campgrounds within the past 5 years. These recreation sites lie approximately 4-5 miles northeast of the Watershed (e.g. Cowles, Winsor Creek). A large crown fire in the Watershed could impact these sites.
- Fires caused by lightning and campfires have occurred within the area. There are little or no ongoing environmental effects from these past fires, as they were rapidly suppressed and did not occur during extreme fire danger and drought conditions.

Current and Ongoing Actions

- Vehicle and pedestrian traffic throughout the canyon bottom related to: routine maintenance of the road, reservoirs and water gauging stations; government personnel doing reconnaissance, collecting data, monitoring environmental conditions, or completing management activities in the demonstration sites; daily security patrols; researchers and others with special use permits collecting data, conducting surveys or doing monitoring; and guided tours for the public or government officials.
- Road maintenance, such as placing gravel where needed to help stabilize the road surface and reduce runoff, or blading the road surface.
- Unauthorized recreation use (e.g. building campfires, fishing, hiking, mountain biking) and sanitation issues related to that use (e.g. humans, dogs). It appears that having security

patrols in the area has reduced the amount of unauthorized use compared to previous years; however, there is evidence that these activities continue to periodically occur.

- Year-round recreational activities just outside the project area along the Hyde Park Road corridor, such as camping, hiking, picnicking, mountain biking, cross-country skiing, downhill skiing, snowshoeing, viewing fall foliage, and many others. Also, the operation and maintenance of campgrounds, trailheads, picnic areas, Santa Fe Ski Area, and Hyde Memorial State Park.
- Residential growth against the west and south sides of the project area (e.g. Cerros Colorados). This contributes to the potential for a wildfire to start in the wildland-urban interface, as well as adding to the potential for homes and properties to be impacted by a crown fire in the Watershed.
- Recreational hiking trails exist just outside the southwest project area boundary and these trail networks will continue to increase.
- Audubon Center activities, such as summer day camps, special workshops and educational events, operations and maintenance of facilities. This contributes to the traffic, noise and use of the Upper Canyon Road residential area.
- Residential use of Upper Canyon Road, including jogging, biking and driving. Upper Canyon Road is the only access road to the project area, and current road uses are considered in terms of cumulative effects to residents in that area.
- Water treatment plant activities conducted by City employees. The water treatment plant lies just outside the project area near the Audubon Center, along Upper Canyon Road.
- Fire prevention activities with residents living near the Watershed.
- In the winter, smoke from woodstoves and fireplaces occurs in the airshed that may be affected by smoke from the proposed project.
- Santa Fe River watershed enhancement activities occurring downstream from the project area, such as bank stabilization, riparian plantings, and other projects.

Foreseeable Future Actions

Foreseeable future actions were determined to be those that are planned or scheduled (e.g. funds and resources committed and on the agency's Schedule of Proposed Actions). Other possible future actions within or adjacent to the project area that are highly speculative and tentative at this time were considered but not analyzed for their potential cumulative impacts due to the lack of certainty and the limited information available for such an analysis.

- Slash burning in the four demonstration sites, totaling 7-9 acres.
- Manual thinning of trees less than 6-inch diameter on approximately 300 acres along roadsides, on City lands within the project area. Currently under contract by the City, this action was approved by the City Council in order to get a headstart on reducing fuels in the Watershed.
- Reconstruction of Black Canyon Campground (estimated schedule for reconstruction activities is 2004-2006, depending on funding).
- Installation of interpretive signs along Hyde Park Road to enhance public education.
- New developments at the Santa Fe Ski Area as planned under the 10-year master development plan, such as a new ski lift.
- Routine traffic and road maintenance activities on Upper Canyon Road and other nearby residential streets. A sewer line is scheduled for replacement along this road within the next year or two.
- Increases in traffic, including haul truck traffic, from the City's contractors beginning thinning and chipping in the Watershed. This may have social effects along the haul route.
- Prescribed "maintenance" burns could potentially be proposed in portions of the project area 4-10 years after this project has been implemented, in order to maintain desired fuel and resource conditions. However, the location, timing, methods and magnitude of potential future maintenance burns are highly uncertain and speculative at this time, and would not occur for over a decade into the future.
- Prescribed burns that could be conducted on other jurisdictions within the same airshed as the project, including burning on lands managed by the National Park Service, Bureau of Land Man-

agement, several northern Pueblos and private lands. The location, timing, methods and magnitude are highly uncertain and speculative at this time. Review and approval of smoke management plans by the State Environment Department, along with appropriate pre-burn interagency communications and smoke monitoring actions, should avoid concurrent burning that could result in exceeding air quality standards.

- Fires caused by lightning and escaped campfires within the Watershed may occur in the future, but are also extremely unpredictable and speculative.
- One wildland-urban interface fuel reduction project was identified just outside the project area in the Apache Canyon area. However, funds and resources are not yet available to complete the NEPA planning for this possible project, and it has not yet been proposed. The possible treatment locations, methods, timing and magnitude are highly uncertain and speculative at this time.
- Other wildland-urban interface projects that involve thinning and prescribed burning are currently being planned in other parts of the Santa Fe National Forest, mostly in the Jemez Mountains on the west side of the forest, as well as throughout the region and nation. However, the effects from these future projects outside the Santa Fe watershed and vicinity would not be expected to add to the effects from this proposed project.

Forest Vegetation, Fuels, and Fire Behavior

The project objective for forest vegetation, fuels, and fire behavior is to:

Reduce the potential for crown fire initiation and spread within the Watershed by reducing surface, ladder and crown fuels.

Issues related to forest vegetation, fuels, and fire behavior are:

Prescribed burns may escape control measures, and threaten the water supply, residential areas and resources in and around the Watershed. Burning forest stands that have not been previously thinned may pose the highest risk of the burn getting out of control.

Leaving accumulations of freshly cut logs and slash on site may attract beetles that can damage or kill nearby trees. This would cause an increase in dead trees, which would increase the fuel hazard.

Affected Environment

The best available information was used to evaluate the affected environment and potential effects of each alternative. Information on forest vegetation and fuels came from a variety of sources, including stand examinations, fuel inventories, aerial photo interpretation, extrapolations from similar stands, scientific research literature, and field reconnaissance by professional foresters and fuels specialists. The affected environment and effects on nearby residential properties is described in the section, "Social Environment."

Fire Risk

Fire risk is the potential for a fire to ignite or start. If the Watershed and forested area immediately surrounding the Watershed were divided into four equal quadrants oriented with the four cardinal directions, 34 percent of the wildfire ignitions over the past 20 years have occurred in the southwest quadrant. The communities of Apache Canyon, Arroyo Hondo, and Canada Corral are in this quadrant, which increases the potential sources of ignition. This quadrant is exposed to southwest winds. A fire beginning here would be pushed by these winds toward the Watershed.

Fuel Models

Fuels, weather and topography combine to determine how hot and fast a fire burns. Fuel conditions are defined by quantity and arrangement and have been categorized into 13 standard descriptive fuel models (Andersen 1982). Fuel models are used as one of the inputs in the BEHAVE computer model to determine flame height and rate of spread for a wildfire. The dominant models in the Watershed are fuel models 8, 9 and 10. Fuel models 8, 9 and 10 represent "timber litter" models, where the fuel to carry a surface fire consists mostly of needles, twigs, and branches from trees. Fuel models are based on the surface (dead) fuels rather than live trees. Fuel model 8 has slightly less surface fuel than fuel model 9, which has slightly less surface fuel than fuel model 10. Most of the project is represented by fuel models 8 and 9. Fuel model 10 typically occurs on north and east slopes where there are more down logs and other woody debris. Fires burn

Table 10. Predicted Fire Behavior with Fuel Models 8, 9, and 10.

Fuel Models	Model 8	Model 9	Model 10
Flame Length	1 to 2 ft.	2 to 3 ft.	4 to 5 ft.
Rate of Spread	105 ft./hr.	495 ft./hr.	521 ft./hr.

differently in the different fuel models under the same weather conditions. During average worse fire conditions (not extreme) when dead fuel moisture averages 8 percent, live fuel moisture is 100 percent, and the effective wind speed at mid-flame height is 5 miles per hour (mph) a fire in the various fuel models will have the characteristics identified in Table 10.

Slope and Aspect

Slope affects fire spread and intensity. Fire burns faster and hotter upslope than downslope or on level ground. Slopes in the Watershed are steep with the majority ranging between 30 percent and 50 percent.

The Santa Fe River roughly divides in half the canyon or project area, with one half facing north (north aspect) and the other facing south. Both sides contain sub-drainages and intersecting ridges that run perpendicular to the river. The intersecting ridges create east and west-facing slopes that differ in vegetation and fuels. South and west facing slopes are exposed to prevailing spring and summer winds and afternoon sun, and tend to be hot and dry. North aspects tend to be cooler and moister.

Wind

During fire season, winds blow up the canyon predominately from the southwest to the northeast. Wind speeds increase as wind is funneled through the Watershed. High winds make fires burn hotter and spread faster. On-site weather observations show that 10 to 15 mph winds at eye level in the spring and early summer are common.

Forest Canopy and Crown Bulk Density

One factor affecting fire behavior is crown bulk density, which is the mass of crown fuel per unit of crown volume. Increased numbers and sizes of trees result in more fuel in the crowns. Crown bulk density of 0.17

pounds per cubic yard (lb/yd³) can sustain a crown fire (Agee 1996). Crown bulk densities in the Watershed average 0.52 lb/yd³ to 0.67 lb/yd³ based on tables converting tree size and density to crown bulk density. This means forests in the Watershed can sustain a crown fire.

Another factor affecting crown fire spread and intensity is the canopy closure. Table 11 displays canopy closure estimates by the primary forest types in the project area. Canopy closure averages 50 percent in the project area, with higher closure on north and east-facing slopes. At over approximately 40 percent canopy closure, tree crowns are close enough together to allow fire to rapidly jump from tree to tree as a "running crown fire."

The area queried for the canopy cover (Table 11), as well as for vegetation structural stages and trees per acre, extends from the City/National Forest boundary on the west to the wilderness boundary on the east, within the project area. It excludes the 200 acres of canyon bottomlands along the Santa Fe River, due to the substantial difference in the site productivity, number of trees per acre and tree sizes in that unique portion of the project area. Data were derived from stand exam inventories and field reconnaissance. Stand exams were conducted in each of the major vegetation types in the project area, at various elevations and in different Terrestrial Ecosystem Survey (TES) map units. Stands that were not inventoried with stand exam plots were determined to be representative of the inventoried stands and TES units, based on field reconnaissance.

Table 11. Canopy Closure by Forest Type.

Forest Type	Percent Canopy Cover	Acres
Piñon-Juniper	0 to 39	1,000
	40 to 59	400
	60 to 100	50
Ponderosa Pine	0 to 39	200
	40 to 59	5,100
	60 to 100	800
Ponderosa Pine/ Douglas-fir	0 to 39	100
	40 to 59	1,650
	60 to 100	250

Fire Weather

Fire season in New Mexico occurs from April 1 to July 20. It is characterized by low humidity, strong winds and unstable atmosphere.

Species Composition

Vegetation is described in terms of major forest species type, diameter class, number of trees per acre, and percent canopy cover. Forest types are defined by the dominant and co-dominant tree species in the overstory. Figure 3 in Chapter 1 shows the major forest types within the project area, which are:

- Piñon pine and juniper (*Pinus edulis* and *Juniperus monosperma*);
- Ponderosa pine (*Pinus ponderosa*);
- Ponderosa pine - Douglas-fir (*Pseudotsuga menziesii*) with an abundance of white fir regeneration in the understory (*Abies concolor*);
- Gambel oak (*Quercus gambelii*); and
- Quaking aspen (*Populus tremuloides*).

Outside the project area at the higher elevations and within the wilderness portion of the Watershed, the major forest types are mixed conifer, spruce-fir and aspen.

Ponderosa pine forests cover the lower and middle portions of the Watershed and the majority of the project area. Historically, ponderosa pine in the Southwest experienced low-intensity fires every 5 to 20 years (Touchan and Swetnam 1991; Covington and Moore 1994, Weaver 1951). The lack of low-intensity, high-frequency surface fires in the ponderosa pine zone has encouraged major changes in the species composition over the past 80 to 90 years. The historic fire regime generally created and maintained open, park-like ponderosa pine forests (Biswell et al. 1973; Brown and Davis 1973; Cooper 1960; Hall 1976). Without frequent low-intensity fires, species composition has shifted to greater numbers of white fir and Douglas-fir, which are shade-tolerant species that do not survive fire as well as ponderosa pine (Schmidt 1985). The thick bark of large ponderosa pine trees promotes survival in low- to moderate-intensity fires (Biswell et al 1973). Long-term fire exclusion from the area has altered the fire regime, which resulted in substantially altering the species composition, tree numbers, tree sizes, and species adaptations to fire survival. Wildfire ignitions occurring under current conditions are likely to become large scale, stand-replacing crown fires.

Crown fires in the ponderosa pine type are absent in the local and regional fire scar records (Touchan and Swetnam 1991), indicating that current stand conditions are a historic aberration attributable to modern human-caused fire exclusion.

Piñon-juniper woodlands are primarily on the western edge of the project area, within some private lands and adjacent to the City. Historically in the Southwest, woodlands were quite varied in their relative stand density (Albert 1848a, 1848b; Leopold 1951). The pattern of tree patches in woodlands is influenced by soil depth, nutrients, microbes, drought, plant competition, fire, grazing, and insect-pathogen attack (Gehring and Whitham 1995; Klopatek et al. 1990; Leopold 1924). Some of the existing piñon-juniper stands in the project area are sufficiently open to subdue a running crown fire. However, there are dense patches where herbaceous vegetation is lacking and a running crown fire could quickly spread from tree to tree. Additional site-specific field reconnaissance of the piñon-juniper in the project area is needed to determine which stands actually need to be thinned to meet fuel reduction objectives.

Oak fields occupy a section of dry, rocky, south-facing slopes near McClure Reservoir and could be an indication of a past fire disturbance. The Gambel oak in this area grows as a shrub in association with other shrub species such as wavyleaf oak (*Quercus undulata*), mountain mahogany (*Cercocarpus montanus*), and skunkbush (*Rhus trilobata*). Conifers are slowly invading these oak areas.

Mixed-conifer, spruce-fir, and aspen occur primarily outside the project area at higher elevations east of the project area and in the wilderness portion of the Watershed. In the mixed conifer zone, historic mean fire return intervals were 15 to 30 years (Touchan and Swetnam 1991), and stands were dominated by ponderosa pine and Douglas-fir overstories. Small to medium-size stand-replacement crown fires occurred in historic mixed conifer fire regimes as evidenced by the interspersed, variable-sized aspen stands. The lengthening of the fire return interval has allowed the development of dense understories of white fir regeneration. Large, old ponderosa pine trees are showing signs of decline as they compete with the younger mixed conifer. Ponderosa pine regeneration is absent.

Aspen is a short-lived species that regenerates by sprouting following fire (Gruell and Loope 1974). Aspen stands are usually quite wet and do not easily burn. Aspen provides important diversity and wildlife habitat values within the coniferous forest landscape. Aspen is another species that is gradually declining and may be eliminated due to the lengthening of fire

return intervals. However, aspen clones can persist underground in a suppressed state with a conifer overstory for extended periods (Barnes 1966). The aspen stands in the upper watershed are over 100 years old, declining in vigor, and being replaced with shade-tolerant fir trees.

Spruce-fir forests of the Southwest historically experienced larger, high-intensity, stand replacement crown fires at mean intervals of over 100 years (Allen 1989; Veblen et al. 1994; Grissino-Mayer et al. 1995). Spruce and fir grow at the highest elevations in the Watershed and have not experienced fire in 150 years. The impacts from a large-scale, high-intensity fire in the spruce-fir upstream from the reservoirs, near the source of the municipal water supply, would be disastrous. But effects would be less serious if the stands of conifers downstream were less dense. The recent Viveash and Coffee Pot Fires both burned in the spruce with severe impacts to their respective watersheds.

Surface Fuel Accumulations

The dead and down fuel loading is considered heavy (Sackett 1979), ranging from 14 tons per acre at low elevations to 55 tons per acre at high elevations. Surface fuel loading is gradually increasing. Trees that are growing close together are under stress from competing for moisture and nutrients with nearby trees. Stressed trees are susceptible to mortality from insects and disease. As the trees die and fall over, surface fuel loading increases. Trees are dying, especially on the cooler north- and east-facing slopes in the mixed conifer, due to past spruce budworm attacks. Areas that are now fuel model 8 are becoming fuel model 10 (which has more branches and logs on the surface than a model 8) as the dead trees fall over and add to the fuel load.

Ladder Fuels and Crown-to-Base Heights

The structure and composition of forest vegetation affects fuel loads and fire behavior (Van Wagner 1977), as well as wildlife habitat, soil, and other resources. Multi-storied stand structure and continuous overstory forest canopies create conditions conducive to crown fires (Van Wagner 1977). Ladder fuels are the small understory trees growing beneath larger trees. These small trees provide for a continuous vertical fuel arrangement that encourages crown fire initiation (Van Wagner 1977), by carrying surface fire into the crowns of the overstory trees. The ladder fuels tend to be

sparser on the south and west aspects than on north and east aspects. The fuels inventory showed that approximately 400 trees per acre contribute to ladder fuels on the east slopes in contrast to approximately 100 trees per acre on the south slopes.

One measure of ladder fuels is crown-to-base height, or the distance from the ground to the bottom of the tree crowns. Low crown base heights have been shown to initiate crown fire behavior (Alexander 1988). The existing ladder fuels generally begin at about 4 to 5 feet from the ground. The crown to base heights average 5 feet on the south slopes and are within 1 foot of the ground on many of the north and east aspects due to the presence of shade tolerant fir species. The desired condition is to have crown-to-base heights averaging 10 to 20 feet from the ground by reducing ladder fuels (understory trees).

Vegetation Structural Stages

Vegetation Structural Stage (VSS) is a classification based on the tree diameter class most frequently represented in an even-aged stand. It typically was applied during past even-age timber management practices and currently has limited applicability for fuel reduction treatments. Most stands are not managed as even-aged stands but are managed to mimic historic, sustainable conditions. Most stands are now managed to have high

Table 12. Existing Vegetation Structural Stages.

VSS	Diameter (inches)	Forest Type	Acres	Percent
1	< 1	Oak	313	3
2	1 to 5	PJ	500	5
3	5 to 12	PJ	950	10
		PP	1,600	16
		PP/DF	400	4
4	12 to 18	PP	4,300	44
		PP/DF	900	9
5	18 to 24	-	0	0
		-	0	0
6	> 24	-	0	0
Uneven	N/A	PP	200	2
		PP/DF	700	7

structural diversity across the landscape and within each stand, comprised of patchy mixtures of trees in different size classes. However, the distribution of pre-dominant diameter classes (VSS) is used in this analysis for comparing pre-treatment and post-treatment diameter class distribution. Keep in mind that most stands in the project area are 2-storied stands, and the VSS class indicates the most prevalent size class within the 2-storied stand (Table 12). Multi-storied stands were classified as “uneven-age.”

Trees Per Acre by Diameter Class and Forest Type

Trees per acre by forest type and diameter class (Table 13) are also used in this analysis, primarily for comparing pre-treatment and post-treatment forest composition. Similar to VSS, this table shows that the majority of the trees in the project area are less than 6 inches diameter. In the two ponderosa pine zones that constitute the vast majority of the area that would be thinned, the diameter distribution is shown in Figure 31.

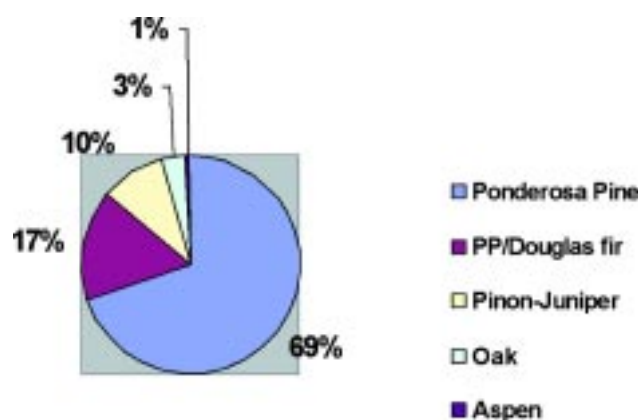


Figure 31: Percent of Trees in Each Diameter Class (in the PP and PP/DF stands).

Table 13. Trees Per Acre by Forest Type and Diameter Class in the Santa Fe Municipal Watershed Project Area.

Forest Type	Diameter Class (inches)	Range of Trees Per Acre	Average Number of Trees Per Acre
Piñon-Juniper	0 to 5.9	50 to 200	125
	6.0 to 11.9	10 to 80	40
	12.0 to 17.9	5 to 10	7
	18.0 and greater	0	0
	Total: 65 to 300		Total: 172
Ponderosa Pine	0 to 5.9	400 to 600	500
	6.0 to 11.9	60 to 80	70
	12.0 to 17.9	40 to 60	50
	18.0 and greater	10 to 25	15
	Total: 500 to 760		Total: 625
Ponderosa Pine - Douglas-fir	0 to 5.9	800 to 1,000	900
	6.0 to 11.9	80 to 120	100
	12.0 to 17.9	60 to 70	65
	18.0 and greater	15 to 25	20
	Total: 900 to 1,200		Total: 1,085

Stand Density Index

The Stand Density Index (SDI) measures competition between trees, or the relative density of the stand. SDI levels above 50 percent indicate that trees are under stress due to competition between trees. The higher the SDI, the more competition between trees. The more competition between trees, the more stress they are under which results in slow growth and high mortality rates. SDI levels above 50 percent are a concern because of the susceptibility of those stands to insect attack. SDI values in the Watershed range between 30 and 60 percent.

Forest/Fuels Composition in the Canyon Bottom

There are approximately 200 acres in the flat canyon bottom within the project area. The canyon bottom includes the Santa Fe River and the service road. This canyon bottom area has much higher site productivity than the slopes above the service road. About 140 acres lie between the two reservoirs and 60 acres lies

between the upper (McClure) Reservoir and the wilderness. The two dams and reservoirs have altered water flow and flood events in the Santa Fe River corridor. The lack of periodic flooding in the floodplain has created conditions where in some portions of the canyon bottom, conifers are out competing the hardwoods (e.g. cottonwood, alder, willow) as well as grasses and forbs. Conifers occupy about 50 percent of the 200 acres (approximately 11 patches totaling 100 acres) with the remainder of the area composed of riparian species and meadows (see the section, "Riparian Ecosystem and Jurisdictional Wetlands").

The scattered conifer patches below McClure Reservoir are predominately ponderosa pine, with a very sparse vegetative ground cover. The 60 acres above McClure Reservoir consists of an overstory of ponderosa pine, Douglas-fir, white fir and aspen, with an understory of predominately white fir seedlings, averaging in some places over 4,000 seedlings per acre. Site productivity is higher in the canyon bottom and tree sizes are larger than on the slopes of the canyon. The diameters of the majority of the trees in the overstory are between 12 and 24 inches, which is larger than trees of the same age occupying the canyon's side slopes. These conifers are relatively young (80 years or less), despite their large diameters. This canyon bottom corridor has occasional conifers over 200 years old with diameters greater than 24 inches.

Basal area is a measure of the amount of wood biomass contained in the tree trunks. The conifer stands in this area near the river have average basal areas exceeding 150 square feet per acre (ft²/acre), which is considered high. The fuel ladders, high crown bulk density and high basal areas would allow a crown fire to spread at high-intensity through these conifer patches.

Live Fuel Moisture

Low live fuel moisture is critical to crown fire initiation and spread. Crown fire potential increases when foliar moisture content drops below 120 percent of dry matter content (Agee 1996), which typically occurs in the Southwest in May or June and under drought conditions. The live fuel moistures were 80 percent prior to the Cerro Grande Fire. Agee (1996) determined that it takes a flame height of 4 feet to initiate crown fire when foliar moisture content is below 120 percent and crown to base heights are less than 5 feet.

Effects on Fuels and Fire Behavior

Alternative A

No Action Without Wildfire

Under this alternative there would be no attempt at reducing the fuel hazard or duplicating the historic low-intensity fire regime in the Watershed. Wildfires would be suppressed because of the risk of unacceptable environmental and social consequences of letting a crown fire spread through the Watershed. However, suppression would become more difficult as conditions worsen with time. The fuel hazard would continue to gradually increase.

Based on current growth rates, some of the stands would not exceed 18-inch diameters (VSS 5) for at least two decades. Most stands may remain in the 5-inch to 18-inch diameter classes (VSS 3 and VSS 4) or may decrease in size class as larger mature trees die and fall over, leaving smaller trees that because of their crowded condition are growing slowly. Conifer invasion in the oak and aspen areas would continue.

Stand density in the ponderosa pine types would continue to increase due to growth of existing understory trees. The competition from the immature understory would increase the stand densities and contribute to increases in the mortality of mature trees, resulting in more fuel. More of the pure ponderosa pine stands would shift toward mixed ponderosa pine/Douglas-fir/white fir type. These fir-dominated stands are more susceptible to tree mortality during dry periods, which can already be seen in the number of dead trees resulting from the dry winter of 1996. The shift toward fir increases fuel ladders and encourages a species mix that is incapable of surviving even low-intensity fire and is susceptible to spruce budworm outbreaks. Without the proposed fuel reduction treatments, it would be a matter of time before a high-intensity crown fire would occur.

No Action With Wildfire

The models used to predict fire behavior and fire effects are based on simplistic assumptions and have limitations. However, the internal consistency of a well-disciplined model allows it to be used to assess the impacts of changes in important variables (Albini 1978). Inherent in the fire models are the assumptions of: homogeneous fuels, fires spread in an elliptical shape,

point ignition, simplified weather, continuous surface fire and no extreme fire behavior such as whirlwinds (Rothermel 1972). The numbers derived from the models should be used to compare a range of results for different treatments rather than being viewed as absolute values. Prescribed burns and wildfires were modeled using the BEHAVE, RXWINDOW, NEXUS and FOFEM fire models for various exposures, fuel models and alternative treatments.

The models were used to analyze the susceptibility of the project area to crown fire. Representative stand conditions were selected to predict the potential for crown fire initiation and spread and the relative effectiveness of fuel reduction treatments.

Predicted Surface Fire Behavior. Analysis of weather data for the 20-year period from 1976 to 1996 showed a 37 percent chance of having a day during the fire season that would exhibit "average worst fire conditions." A fire burning under these conditions would be difficult to control. There is a 20 percent probability of having an ignition occur on a worse fire condition day in any given year. These probabilities are probably conservative given that according to climate studies, 1976 to 1996 were the wettest 20 years since 136 B.C. (Mayer-Grissino 1995).

Using the BEHAVE computer program, fire spread and flame lengths were modeled under conditions typical during fire season and in fuels and topography characteristic of the area. Under the average worst fire season conditions, with a temperature of 87 degrees F, relative humidity 17 percent, and 20-foot winds at 9 mph a fire would generate flame lengths 4 to 6 feet, sufficient for crown fire initiation when crown to base heights are 5 feet and less, and live fuel moistures are less than 120 percent. A crown fire under these conditions can be expected to generate flame heights of 70 feet to 150 feet (Rothermel 1991) and throw burning embers far ahead of the fire. These embers would have a probability of 70-100 percent of starting more fires if they came into contact with receptive fuel, demonstrating how difficult it would be for suppression forces to contain the fire.

Observations of prescribed burns and wildfires on the Española District indicate that computer-modeled flame lengths for surface fires may be underestimated. The BEHAVE fuel models assume a uniform fuel bed. Fuel beds almost always have pockets of "jackpot" fuels, typically large down pitchy logs where fire intensities can increase. Heavy infection by the parasite dwarf mistletoe in ponderosa pine can encourage crown fire initiation and spread (Koonce and Roth 1950). Ponderosa pine heavily infected with dwarf mistletoe "brooms"

become drier, and the brooms are highly flammable and increase fire intensity (Arno and Harrington 1999, Hawksworth 1995). This parasite is prevalent in ponderosa pine throughout the project area and other dense ponderosa pine stands on the Santa Fe National Forest. Dwarf mistletoe surveys revealed almost 50 percent of the ponderosa pine stands on the forest exhibit some level of infection (pers. comm., D. Conklin, Regional Forest Pathologist).

Predicted Crown Fire Behavior. Nomograms that predict crown fire characteristics have been developed for crown fires in the Northern Rockies (Rothermel 1991) and have been validated on fires in northern New Mexico where similar tree types exist in mountainous terrain. The analysis done in 1998 on the risk of crown fire initiation and spread in the Valle Ecosystem Management Area accurately predicted the size, shape, and direction of the Cerro Grande fire after the first day of exhibiting crown fire behavior. The analysis predicted the fire would grow to 1,500 acres in one burn period; the size after the fires first run was 1,300 acres. Only one burn period between 1 p.m. and 6 p.m. was assessed. This period of time is when fire behavior is the most active. Assessing only one burning period does not imply the fire would stop; the fire could easily pick up and run again on another day.

Crown fire scenarios were modeled using nomograms, assuming the fires started within the Watershed or within 1 mile of the Watershed boundary. However a fire could begin at a greater distance than 1 mile from the boundary and still burn into the Watershed within a few hours. Modeling crown fire spread shows that with 20 mph winds at a 20-foot height (20-foot winds), a crown fire could spread a distance of 5 to 6 miles in the first 5 hours. This means any ignition within 5 to 6 miles of the Watershed; especially fires starting to the south/southwest of the Watershed are a concern.

Crown fires were modeled with a sustained 20-foot wind of 20 mph under three different seasonal scenarios: early spring before green up, late spring after green up, and summer drought. The south/southwest orientation and funneling effect of the narrow Santa Fe River canyon guarantee that the 20 mph figure is conservative, sustained wind speeds of over 40 mph were experienced on the 3rd and 4th days on the Cerro Grande Fire.

Modeling crown fire in the early spring before green up shows a fire in 5 hours growing to 2,900 acres. Crown fires overwhelm the effects of slope, and burn downhill and across slopes without slowing down. The Oso Fire in 1998 made a sustained run down a 30 percent slope for over three-quarters of a mile. The Cerro Grande Fire

burned downhill from 10,000 feet at Cerro Grande Peak to New Mexico Highway 501 at 7,200 feet. If the fire were to begin in the lower portion of the Watershed and the winds were pushing it from the southwest, it would burn through Hyde State Park, across New Mexico Highway 475, through Big Tesuque Campground, and into aspen stands below the Santa Fe Ski Basin. If the fire were funneled up through the Santa Fe River Canyon, it would burn the entire canyon above McClure Reservoir. A fire of this size would overwhelm suppression forces.

In the late spring after green up scenario, the fire is not as intense nor is it spreading at the same speed as the previous scenario. After 5 hours, the fire would range from 900 to 2,300 acres. Flame lengths would be 50 to 60 feet with rates of spread ranging from 0.5 to 1.0 mph. Assuming that an ignition occurs on an exposed ridge northwest and just above McClure Reservoir, Hyde Park could be threatened and the canyon above McClure could be devastated depending upon wind direction.

Under drought summer conditions, the model shows a fire could grow to 11,000 acres within 5 hours. With the fire starting 2 miles southwest of the Watershed boundary, the canyon above McClure would be burned and depending on wind direction, the fire has the potential to reach Black Canyon Campground. This scenario demonstrates a fire does not have to start within the Watershed to endanger the Watershed. If this fire began within the Watershed and the winds were from the south/southwest, the Little and Big Tesuque drainages would be burned. The magnitude of these crown fires and the distance they can travel in a short period dictates a landscape approach must be taken to protect the Watershed.

The spread distance may be limited by a significant decrease in wind speed or rise in humidity, or by the occurrence of rain or snow or the fire may spread to the limits of fuel suitable for sustaining a run. In non-drought times, north slopes and high elevations can have moisture levels wet enough to stop a fire. Similarly, nighttime humidity recovery can raise fuel moisture and have the same result. In late summer and during periods of drought, nighttime moisture recovery and high elevation moisture are reduced and cannot be depended upon. High mountain ridges devoid of tree canopy can prevent a crown fire from continuing, but the ever present danger of spot fires beyond the ridge must be considered. Long range spotting is not addressed in these scenarios. The spotting models are applicable to surface fires and torching tree crowns, but no model is known for predicting the spotting distance from active crown fires. When crown fire is in a steady

state however, spotting distances of up to 1.5 miles can be expected (pers. comm., J. Chonka, USFS Fire Behavior Analyst, July 2000).

Predictions made about crown fire behavior are based upon the crown fire being wind-driven. However, the analysis also showed that a plume-dominated fire is possible in the Watershed under any of the fire weather scenarios analyzed. Plume-dominated fires often have sudden wind bursts that occur in any direction, causing the fire to burn with high rates of spread in all directions. In this situation, downslope runs are just as likely to occur as upslope or cross-slope runs, and the magnitude, intensity, and severity of such a fire are difficult to predict. If the fire were to become plume-dominated, the predictions would no longer be meaningful.

For any of the scenarios described, fire suppression would be costly and effective courses of action limited. A Wildland Fire Situation Analysis was done for the fire occurring under a drought summer scenario. A Wildland Fire Situation Analysis uses a decision matrix to determine appropriate suppression strategies and alternatives, and the costs associated with those actions.

The Wildland Fire Situation Analysis for the drought summer scenario, assuming no change in weather, shows the fire growing to at least 46,000 acres before there is a chance of containment. The Vieveash Fire of 2000 that burned in very similar topography, soils and vegetation in the Sangre de Cristo Mountains near the Watershed burned over 30,000 acres in a 48-hour period before suppression forces could become effective. All of the major wildfires in Northern New Mexico over the past 2 decades burned for at least 2 days before suppression forces were effective. The main factors influencing the growth of a fire in the Watershed are the lack of breaks in fuel continuity, limited road access, and steep canyon topography conducive to large fire growth (prevailing winds during fire season funnel up through the canyon). The fallback outcome, that is the next largest size the fire would get to before there is a chance of containing it, is 52,000 acres with only a 16 percent probability of stopping it there. Worst case predicts the fire would grow to 100,000 acres before it could be contained.

Suppression costs estimated by a regional fire management specialist, based on the drought conditions scenario fire, ranged between \$37 and \$43 million. Suppression cost for the Cerro Grande Fire on the Santa Fe National Forest exceeded \$20 million at the time of containment, and suppression crews continued to work on the perimeter of the fire for several weeks longer. Time to

containment for this potential catastrophic fire in the Watershed could be as long as 60 days. These costs do not consider the costs of land and watershed rehabilitation or property reconstruction. (See the section, "Economics"). The environmental impacts of suppression activities would also be extensive. As an example, the Viveash Fire burned through similar stand conditions, although there was an extensive road system unlike the Watershed. During the Viveash, there were 21 miles of bulldozer lines constructed, 9 miles of road widened with bulldozers for use as containment lines, and 7 miles of hand line constructed. The bulldozer lines had to be built where they would be most effective in containing the fire with little regard to soil erosion hazards or slope. Aircraft dumped 333,000 gallons of retardant and 560,000 gallons of water on the fire. Similar impacts would be expected in suppressing a fire in the Watershed.

Effects for All Action Alternatives

The first part of this analysis describes in detail how the proposed thinning, slash treatments, and broadcast burning in stands that had not been thinned would affect forest vegetation, fuels and fire behavior for all of the action alternatives. The second part of this analysis presents a summary of the key differences among the alternatives, describing their relative effectiveness and effects.

Summary of Effects on Factors Affecting Fire Behavior

VSS and Diameter Class

The mechanically thinned areas would be expected to immediately increase by one VSS class. Stands currently dominated by 5 to 12-inch diameter trees (VSS 3) would become dominated by 12 to 18-inch trees (VSS 4) immediately after thinning from below. Thinning from below means felling the smallest trees in the stands and leaving the largest trees standing. A few of the VSS 4 stands would become VSS 5 (18 to 24 inches) immediately after thinning. The immediate increase in VSS size class would result from removing the smallest trees from the stand, which would increase the average diameter of the stand.

Crown Base Heights

Crown base heights would be raised to the desired average of approximately 20 feet or higher (from the ground surface) in thinned areas, due to reduction of

ladder fuels. A 20-foot crown base height requires 8-foot flame lengths to ignite the overstory when live fuel moisture is at 70 percent, a percent common in drought conditions.

Trees Per Acre and Stand Density Index

The number of trees would be reduced to about 50 to 100 of the largest trees per acre in the thinned areas outside the fuel breaks and to 20 to 30 of the largest trees per acre within the thinned fuel break areas. SDI would be reduced to about 20-25 percent in thinned areas and to about 10-15 percent within fuel breaks.

Crown Bulk Density

Crown bulk density in thinned areas would be reduced to less than 0.17 lb/yd³ and would be reduced the most within fuel break areas.

Canopy Cover

Canopy cover in the thinned areas would be reduced to less than 40 percent, (except in the canyon bottom). The crowns of the remaining trees would gradually grow and expand, and within 10 to 15 years after treatment, the canopy cover would once again approach 40 percent. The more productive the site, the faster the canopy cover would increase. Canopy cover in fuel breaks would be reduced to 10-20 percent and would take a longer time to approach 40 percent closure.

Canopy cover in the areas broadcast burned with no prior thinning would remain high, with 70-80 percent staying at or above 40 percent canopy cover and the remaining 20-30 percent reduced to below 40 percent canopy cover.

Effects of Thinning and Slash Treatment in the Canyon Bottom

There would be 10 to 25 large trees per acre in the canyon bottom after conifers less than 16-inch diameter have been thinned from below. The 10 to 25 trees per acre would have approximately 12,000 to 30,000 ft² of crown cover (assuming a crown radius of 20 feet). Based upon ocular estimates, less than 50 percent of the roughly 100 acres treated would be sufficiently open to allow herbaceous ground vegetation to establish and thrive. The crowns of remaining conifers would continue to expand and would soon reoccupy any gaps created by the thinning. Rushes, sedges,

willows (in moist areas) and grasses (in drier areas) would not respond to this temporary reduction in conifer cover if thinning is limited to trees 16-inch diameter or less. Therefore, this would only minimally meet the project objective of increasing vegetative ground cover in the productive canyon bottom area.

Retaining all conifer trees over 16-inch diameter in the canyon bottom would reduce the effectiveness of this fuel reduction treatment since there would still exist a continuous canopy and high crown bulk density in more than 50 percent of the 100 acres proposed for thinning.

General Effects of Thinning Treatments

Using the NEXUS computer model to validate effectiveness of treatments, a risk rating was devised. All areas mechanically thinned (followed by slash treatment) would be at low risk to crown fire initiation and spread. Low risk can be defined as conditions where surface fuels have been reduced to a fuel model 8 or 9, crown to base heights are above 20 feet and crown bulk densities are below 0.17 lb/yd³. Areas treated with broadcast burning only (without any mechanical thinning) would be at a moderate risk of crown fire initiation and spread through that area under high wind conditions. Moderate risk can be defined where surface fuels and crown base heights have been reduced, but minimal reduction has occurred in canopy cover and crown bulk densities.

Research has validated what resource management professionals have observed for many years -that the most effective fuel reduction treatment involves mechanical thinning followed by burning the slash to reduce surface fuels (Agee et al 1999, Arno 1996, Buckley 1992, Edminster and Olsen 1995, Graham et al 1999, Gruell et al 1982, Helms 1979, Nakamura 1996, Pollet and Omi 1999, Scott 1998, Van Wagtendonk 1996, Weatherspoon and Skinner 1996). Numerous studies have documented that crown fire should drop to the ground when it reaches the thinned and slash-treated areas (Agee 1996, Kalabokidis and Omi 1998, Pollet and Omi 1999, Scott 1998, Van Wagner 1993). Examples of crown fires where the severity was lessened within treated conifer stands compared to adjacent untreated stands include: Cleveland Fire 1992 in Calif., Paddock Fire 1992 in Oregon, Star Gulch Fire 1992 in Idaho, Aspen Fire and Henry Peaks Fire 1994 in Montana, LeClair Fire 1994 in Oregon, Robinson Fire 1994 in Wyoming, and Wind Fire 1995 in Oregon (Pollet and Omi 1999).

During the recent Cerro Grande Fire on the Santa Fe National Forest, the fire dropped to the ground in thinned and burned units. The 1998 Oso Fire showed

dramatically the effects of thinning and burning on wildfire behavior. Without exception, the running crown fire dropped to the ground and became a low-intensity ground fire in the thinned and slash-burned areas. Torching and spotting potential would also be reduced for any wildfire burning in the treated area. These fuel treatments have been found to reduce fire hazards to homes within the wildland-urban interface (Schmidt and Wakimoto 1988). Our fire behavior models show that under extreme fire conditions, with 2 percent fuel moisture in the 3-inch diameter fuels and effective wind speeds at 6 mph, flame lengths would be 4 to 5 feet within the areas that had been thinned and broadcast burned.

In addition, the thinning and slash treatment would enhance the chance of successful wildfire suppression in treated areas (Green 1977), primarily along road corridors and in the fuel breaks along ridges. Studies have demonstrated that well designed fuel breaks are very effective in reducing crown fire severity when fires enter these zones (Agee et al 1999, Omi 1996, Weatherspoon and Skinner 1996). The effectiveness of fuel breaks greatly increases when fuels outside the fuel break are also treated (van Wagtendonk 1996). Aerial fire retardant drops are also more effective in thinned areas where the retardant can reach the ground and is not intercepted by tree crowns. During the Cerro Grande Fire, retardant drops were done along the New Mexico Highway 501 fuel break. The fuel break had been thinned, however, the slash had not been disposed of. Even with large amounts of dry slash on the ground, the retardant drops were successful because the retardant was able to penetrate the tree canopy.

Thinning along the road and adjacent to the river would create a strategic buffer protecting the water supply from the direct effects of a crown fire. This buffer would probably reduce the severity of fire effects. A wildfire burning into the thinned patches may become a ground fire that would leave the organic layer on the soil surface and the crowns of the trees intact. The growth of ground vegetation following treatment would help prevent soil erosion from the immediate area as well as serve as a filter that minimizes sediment delivery to the river.

Effects of Thinning on Insect-Caused Tree Mortality

The Ips bark beetle species are attracted to fresh cut logs and woody slash where they find ideal conditions to lay their eggs in April and May. Beetle numbers can increase to the point that they attack live trees in the surrounding area. Beetle numbers can increase over several years, especially where thinning occurs for several consecutive years in the same localized area and creates green slash during April and May. Stressed

trees like those in the project area are particularly susceptible to beetle attack. During 2000, observations made by staff from the Southwestern Region Pest Management Section of the Lincoln National Forest indicate that stands not previously thinned are at the highest risk from beetle attack when Ips populations increase. If beetles kill trees, dead and down fuel loads would increase. Monitoring of beetle activity would be conducted to decrease the risk of beetles becoming a problem. Mitigation measures identified in the section, "Mitigation and Monitoring," can be taken if beetles begin to attack and kill unacceptable numbers of green trees.

Effects of Slash Treatment Methods

Slash accumulations immediately after thinning would be an additional 15 to 20 tons per acre, enough to create 40 to 60 piles per acre, based on plots taken in the Watershed demonstration areas where slash was piled. The piles would only cover approximately 10 percent of the treated acreage. Extremely dense areas may require two thinning and slash burning entries to accomplish objectives. Burning piles in the fall, winter or very early spring when fuel moisture is 15-20 percent (assuming the piles are constructed properly) would result in at least 60-80 percent fuel consumption in the piles. This would leave a maximum of 8 tons per acre of residual slash, which would be an acceptable level. Burning slash piles under calm wind conditions (20-foot winds at 4 to 10 mph) with sustained flame heights of less than 10 feet, results in a maximum spotting distance of 500 feet-the maximum distance a burning ember could be carried. If the surface fuel is moist or covered with snow, the probability of fire spreading from burning embers is zero.

Slash piles could become a fuel hazard by late spring and through the fire season of the following year if an area was thinned and slash piled in late summer or early fall. This situation of leaving slash piles to dry during the fire season has commonly occurred throughout the Southwestern Region without resulting in any major fires events. Risk of a fire igniting in the slash should be minimal due to prohibiting public use of the Watershed, having daily security patrols, and applying the mitigation measures described in the section, "Mitigation and Monitoring." If a fire were to ignite in the dry slash, it would be highly unlikely to develop into a spreading crown fire, due to the lack of continuous surface, ladder and crown fuels in the treated areas.

Trees adjacent to the burning slash piles could be scorched. Experience on this and other adjacent national forests has seldom shown tree mortality from

pile burning. Since piles would be burned under conditions when surrounding surface fuels would not ignite, there would be little or no reduction in surface fuel load or depth.

Chipping slash and removing the chips on the 560 acres of roadside thinning would avoid the effects of burning piles. There would be no additional temporary fuel hazard, no escaped fire risk, no tree scorch, and no smoke on those acres. However, chipping is only feasible near the roads.

Scattering the slash followed by low-intensity broadcast burning could be used in some selected areas to reduce fuels. Using cool broadcast burns on thinned, slash-covered ground would require drier conditions compared to burning piled slash. Broadcast burning scattered slash would spread a low-intensity surface fire over 75 percent or more of the burn unit. This type of burn mimics natural low-intensity fires and has many beneficial side effects in fire-adapted pine forests (Weise 1996). There should be no adverse effect on soil from this type of burning as long as soil moisture guidelines were followed (see the section "Soil and Water Resources"). Larger diameter fuels (i.e. greater than 6-inch diameter) would not be consumed due to higher fuel moistures. Experience with this type of burning in this part of the Southwest has shown that tree trunks take about 7 years to deteriorate before they would be potentially consumed by a prescribed burn (Reinhardt 1991). Risk of an escape fire would be low from this type of broadcast burn through thinned areas with slash scattered on the ground, as long as mitigation and monitoring measures are followed.

Effects of Broadcast Burning in Unthinned Stands (Alternatives B1, C1, D1)

Burning unthinned stands is logistically difficult and in some cases may require multiple entries with surface-level prescribed fire to reduce fuel loads to an acceptable level. However, many research studies have shown that low-intensity prescribed burns are effective in reducing surface fuels, seedlings and small-diameter saplings that can act as ladder fuels (Biswell 1960, Biswell 1989, Harrington 1987, Kalabokidis and Wakimoto 1992, Sackett 1980, Wagle and Eakle 1979). The computer programs RXWINDOW and FOFEM can be used to determine the specific weather and fuel moisture conditions needed to obtain desired results. Burning provides substantially less control over tree stocking results compared to thinning with chainsaws (Stephens 1998). Stand structure and fuel quantity and arrangement after a prescribed burn would be highly variable.

A low-intensity prescribed burn would be used primarily in areas too steep to thin and pile slash (manually or with machines). The objective is to further reduce fuel loads in the project area, particularly surface and understory ladder fuels. A low-intensity broadcast burn generally kills understory trees less than 5-inch diameter, and reduces needles, twigs and branches on the forest floor, but does not reduce trees over 6-inch diameter. The fire may occasionally kill larger trees of fir species, particularly white fir. These “cool” burns would not sufficiently reduce canopy cover (create openings) or reduce crown bulk densities on the majority of the burned areas. Crown bulk densities in the “broadcast burn only” areas would not be reduced to below the desired threshold and could sustain crown fire spread through those portions of the project area.

A tree's survival during broadcast burning depends on: the tree species, size, vigor, live fuel moisture, fuel loading, topography, aspect, wind speed, air temperature and slope position (Harrington 1990). Most broadcast burning would be done in the fall when live fuel moistures are usually well above the critical crown fire threshold of 120 percent. The higher the live fuel moisture, the less likely that burning would kill green trees. Furthermore, fall burning occurs at a time when trees are generally dormant. Broadcast burning would likely result in crown scorch at the base of tree crowns. Scorching kills and prunes the lower branches, which beneficially increases the crown base height. Needle layer accumulations would likely return to pre-burn conditions within a year as the scorched needles fall. Many years of experience on the Santa Fe National Forest conducting broadcast burning in untreated stands in the fall shows that surface and ladder fuels would be effectively reduced but the overstory continuity of fuels would not be significantly reduced. The expected increase in herbaceous vegetation and shrubs would not be expected to affect surface fire behavior (Scott 1998), other than providing a medium for the surface fire to remain on the surface rather than in tree crowns.

Restoring fire to ponderosa pine forests can be used to meet important ecological objectives (Mutch and Cook 1996). Low to moderate intensity burning under conditions when duff moisture is above 75 percent would maintain the organic humus layer and minimize exposing bare soil. There would be no loss of long-term site productivity (Peterson 1994). The burning would increase the diversity of stand densities across the landscape in the project area while reducing fuel loads.

With these three broadcast burn alternatives, there would be a slightly increased risk of the burn escaping the containment (burn unit) area. Alternative B1 would have the higher risk of an escape fire because under Alternative B1 there would be less pretreated (thinned and slash treated) acreage surrounding the unthinned broadcast burn units compared to Alternatives C1 and D1. Risk of escape fire would be much lower for C1 and D1, due to creating fuel breaks and other thinned areas around smaller unthinned broadcast burn units. The risk would be considered low for all alternatives assuming that the standard mitigation and monitoring measures listed in the section, “Mitigation and Monitoring” are properly applied.

Historic weather data shows a high probability of having a “burn window” for a low-intensity burn in the first week of October. An example of such conditions would be temperatures between 50°F and 60°F, relative humidity 20-24 percent, fine fuel moistures 5 percent on south or west slopes and 9 percent on north or east slopes, with 20-foot winds at 20 mph. Wind speeds near the ground would be substantially lower, averaging 4 to 10 mph. The Results of the First Order Fire Effects Model (FOFEM) for the conditions just described are shown in Table 14 for north and east aspects (N/E) and south and west aspects (S/W). Total surface fuel loads would be reduced 50-70 percent, and trees less than 5-inch diameter could be reduced as much as 30 percent. However, experience with FOFEM indicates the model over predicts tree mortality and fuel consumption, especially in 5 to 12-inch trees. Years of experience

Table 14. FOFEM Model Predictions of Changes In Fuels Following Broadcast Burning in Unthinned Stands (over-predicts tree mortality from low-intensity burns)

Factor	Existing Condition N/E aspect	After Burning N/E aspect	Existing Condition S/W aspect	After Burning S/W aspects
Trees/acre <5 in	516	4-160	323	3-97
Trees/acre 5-12 in	201	126-240	101	66-68
Crown base height	< 5 ft	>10-20 ft	< 5 ft	>10-20 ft
Crown bulk density	>0.1 kg/m ³	0.1-0.2 kg/m ³	>0.1 kg/m ³	0.03 kg/m ³

broadcast burning untreated stands on projects such as Mesitas, Highway 144 (Blanco), Comanche Canyon, Aspen Ranch and others throughout the forest, demonstrate that low-intensity burns would not kill the 5 to 12-inch diameter trees.

Summary of Key Differences Between Action Alternatives

The effects analysis conducted for the forest vegetation and fuels resource indicates that the more acreage treated to reduce fuels, the more effective it would be in reducing wildfire intensity and spread and the severity of impacts. Fire behavior observations following the Oso and Cerro Grande Fires indicate fuel reduction needs to be completed over large contiguous areas to effectively reduce the risk or impacts of a high-intensity crown fire. As more of the landscape is treated, it becomes more “fire safe” (Agee 1996). In the 1994 Wenatchee fires and the Cerro Grande Fire, areas that had had been thinned and prescribed burned or burned within the past 20 years reduced wildfire behavior, but the tops of the stands were scorched from heat produced other places on the landscape that had not been treated. The treated areas were at a scale of several hundred acres. This was not large enough to be effective at reducing fire severity as most of the trees died.

Mechanical thinning-manually or with machines-followed by slash treatment, is the most effective way to achieve desired fuel reduction objectives. Therefore, the difference in effectiveness among the various treatment alternatives is directly correlated with the number of acres mechanically thinned. In addition, alternatives that include broadcast burning along with extensive mechanical thinning and slash treatment would be more effective than those that exclude broadcast burning, because they leave the steep slopes and fine surface fuels untreated (Martin et al. 1989). Table 15 displays the relative differences in fuel reduction effectiveness among alternatives. There is no measurable difference in the expected effectiveness between

the manual and machine thinning alternatives that apply the same treatments to the same acreage (e.g. Alternatives C1 and D1, and Alternatives C2 and D2). The rest of this section describes in detail the various effects and effectiveness of these fuel treatments on forest vegetation and fire behavior.

Alternative B1 (Moderately Effective)

The combination of thinning in strategic locations along ridgetops and burning with low intensities the remainder of the area would be moderately effective at reducing the risk of crown fire initiation and spread. Low intensity broadcast burning is not as effective in reducing the risk of crown fire initiation and spread as thinning followed by slash burning, since low intensity burning alone does not reduce canopy cover or crown bulk density.

Alternative B2 (Least Effective)

This alternative would be the least effective of the alternatives at mitigating the behavior and/or severity of a running crown fire. A wind-driven crown fire could spot across even the wide south-side fuel break and spread through the continuous canopy of unthinned forest within the project area. This alternative would also do little to reduce the potential for plume-dominated fires. However, the thinned areas and fuel breaks would reduce the intensity and rate of spread, and some crown fires might drop to the ground within the treated areas. Thinned areas give fire suppression crews an area to “burn out” from to reduce fuels in the path of a wild fire. Aerial fire retardant drops would be more effective in thinned than not thinned areas. Thus, this alternative increases the chance of wildfire suppression in the treated fuel break and road corridor areas. This alternative has the least risk of an escape fire situation due to creating and burning the least amount of slash and not broadcast burning.

Alternatives C1 and D1 (Most Effective)

Thinning all acreage that is safe and feasible to thin and treat slash on substantially reduces the probability of a large, high-intensity crown fire. It also creates extensive buffers around smaller unthinned areas that would be broadcast burned, further reducing fuels. It may be possible under these alternatives to burn at slightly higher intensities compared to Alternative B1, since under C1 and D1 the unthinned broadcast burn patches

Table 15. Relative Effectiveness of Fuel Reduction Treatment Alternatives.

Least Effective		Most Effective	
Alt. B2	Alt. B1	Alt. C2/D2	Alt. C1/D1
Thins: 32%	Thins: 36%	Thins: 68%	Thins: 70%
Burns: 0%	Burns: 64%	Burns: 0%	Burns: 30%

would be much smaller and would be surrounded by thinned and slash-treated areas. The risk of a prescribed burn escaping would be reduced since there would be a safety buffer where the fuels had been reduced around the units to be burned. Burning embers from a running crown fire entering the project area could still be lofted over the fuel breaks, however the large acreage of treated areas adjacent to the fuel breaks would reduce the potential of these embers initiating crown fires. Reducing the quantity and continuity of fuels over a large area also reduces the potential of having conditions where fire intensity can build rapidly and where plume-dominance becomes possible. Under D1, the rows and piles of cut whole trees would behave similar to the slash piles and felled tree trunks in Alternative C1. The difference in the arrangement of the fuels would not significantly alter expected fire behavior.

Alternatives C2 and D2 (Moderately Effective)

Effects would be similar to those described for C1 and D1, since the same number of acres would be mechanically thinned. However, leaving a patchy mosaic of untreated areas that remain as a fuel hazard would reduce effectiveness in meeting project objectives. Not broadcast burning in unthinned steep slope stands reduces the risk of an escaped fire. Under D2, the rows and piles of cut whole trees would behave similar to the slash piles and felled tree trunks in Alternative C2. The difference in the arrangement of the fuels would not significantly alter expected fire behavior.

Option A: No Wood Removal

The immediate effects of this option would be the same as described for the thinned and slash-treated acreage in all of the action alternatives, only it is applied to the 560 acres of roadside thinning. It just adds 560 more acres where the cut tree trunks would remain on the ground and the slash would be burned. When the boles begin to break down in about 10 years, they would pose more of a fuel hazard than if they were removed. A future surface fire or maintenance burn could substantially reduce those surface fuels.

Option B: Thin Large Conifers in Canyon Bottom

This treatment option would retain 3 to 5 of the largest trees per acre within the river corridor. Cutting would not occur within the narrow riparian area or within a 15-foot buffer zone. According to the analysis conducted for this study, the active floodplain remains mostly confined to the streambank width. The existing

riparian zone is too narrow to offer a barrier to crown fire spread or spotting activity. However, reducing the conifer overstory within the river canyon bottom (i.e. including flood terraces) would reduce the threat of crown fire burning through these conifer patches along the river. A review of burn severity of both the Cerro Grande and Viveash Fires on the Santa Fe National Forest indicates much less fire severity in riparian areas dominated by deciduous trees such as aspen, as compared to drainages dominated by conifers (USDA Forest Service 2000d, 2000e). Hardwood species have higher live fuel moisture levels than conifers under similar soil moisture conditions. At the time of the Cerro Grande Fire, conifers had 70-80 percent live fuel moisture as compared with 150-180 percent in the hardwood species (e.g. aspen, oak). Several aspen stands within the Cerro Grande and Viveash Fires survived crown fire while the surrounding conifer stands were completely consumed by the flames.

Reducing conifer density in the canyon bottom would reduce the crown fire severity and encourage herbaceous vegetation. Research in Montana showed that "although fire intervals are longer in riparian areas, fire exclusion has caused dense stocking of conifers, resulting in exclusion of shrubs and deterioration of riparian vegetation" (Harrington 1999). Thus, reducing conifer stocking near the riparian area may encourage the spread of deciduous riparian vegetation, such as willows and cottonwoods, especially where soil moisture is increased. Increasing vegetative ground cover would provide a sediment filter.

Cumulative Effects

The cumulative effects analysis area for fuels and fire behavior is the entire 17,000-acre Watershed, as well as the forested areas within about a mile or two from the Watershed boundary. The assumption behind looking at an expanded area is that a wildfire beginning in these adjacent areas can easily spread into the Watershed within a 5-hour burn period. This includes approximately 15,000 to 17,000 acres in the Dalton and Macho Canyon areas east of the Watershed, 10,000 to 15,000 acres north of the Watershed parallel to Hyde Park Road, and about 10,000 acres in and around Apache Canyon south to southwest of the Watershed. This analysis area was based on fuel loads, topography, risk of fire ignition and spread, and other factors described in the section, "Forest Vegetation, Fuels and Fire Behavior."

In considering the potential cumulative effects for this analysis, we considered the historical circumstances that created the current situation. The "Forest Vegetation, Fuels and Fire Behavior" section describes the

current fuel conditions that are the result of historic land uses and climate patterns. The long-term, cumulative effect has been a change from a low-intensity, high-frequency fire regime to an infrequent, high-intensity, stand-replacing fire regime.

This cumulative effects analysis also considered the current and future growth of the wildland-urban interface area where the City boundary meets the national forest, adjacent to the south and west boundaries of the project area. Increased human presence increases the probability of intentional or unintentional fire ignitions. The more homes there are in the interface, the more difficult it is to suppress wildfires. In addition,

more trails are planned for the interface area south of the Watershed boundary, and recreational uses adjacent to the Watershed are increasing.

Thousands of other acres of high-risk, high-hazard forests within the analysis area would not be treated as part of the proposed project. This includes the wilderness as well as forests south of the Watershed boundary on the Pecos/Las Vegas District. The FARSITE model indicates that with strong winds blowing from the southwest, an intense fire in this area has the potential to throw embers up to 1.5 miles in front of the fire. This means a fire this distance away has the potential to ignite spot fires within the Watershed.

Table 16. Annual Soil Erosion (loss) Rates in the Watershed, Based on the Revised Universal Soil Loss Equation for TES Map Units on the Santa Fe National Forest. The asterisk (*) and highlighting identifies those TES units within the project treatment area. The other TES units are at higher elevations primarily within the wilderness portion of the Watershed.

TES Unit No.	TES Potential Vegetation Type, Based on Soils	Acres	Annual Soil Loss Rates in the Watershed			
			Tons per Acre	Total Tons	Acre-Feet	Total Acre-Ft.
3*	Riparian	234.1	0.13	30.43	0.0001	0.0234
6*	Riparian	87.7	0.54	47.36	0.0003	0.0263
7	Spruce-Fir	195.5	0.09	17.59	0.0001	0.0195
91	Spruce-Fir	334.3	2.41	805.66	0.0015	0.5015
328	Spruce-Fir	114.6	0.49	56.15	0.0003	0.0344
329	Spruce-Fir	1084.0	2.05	2,222.20	0.0013	1.4092
331	Spruce-Fir	95.2	0.54	51.41	0.0003	0.0286
332	Spruce-Fir	548.3	1.83	1,003.39	0.0011	0.6031
333	Spruce-Fir	1.7	5.76	9.79	0.0035	0.0060
334	Spruce-Fir	209.3	0.67	140.23	0.0004	0.0837
336	Spruce-Fir	198.2	1.12	221.98	0.0007	0.1387
337	Spruce-Fir	1772.2	1.61	2,853.24	0.0010	1.7722
340	Alpine	20.6	1.65	33.99	0.0010	0.0206
341	Alpine	28.1	4.28	120.27	0.0026	0.0731
345*	Ponderosa Pine (PP)	644.3	0.31	199.73	0.0002	0.1289
351*	PP-Fir	143.5	1.16	166.46	0.0007	0.1005
352*	PP-Fir	50.4	0.71	35.78	0.0004	0.0202
353*	PP-Fir	7065.5	0.45	3,179.48	0.0003	2.1197
358*	Piñon-Juniper (PJ)	709.3	0.71	503.60	0.0004	0.2837
359*	PP	2919.2	0.58	1,693.14	0.0004	1.1677
361*	PJ/PP	191.6	2.72	521.15	0.0017	0.3257
Total Annual Soil Loss				13,913 tons per year		9 ac-ft per year

In considering other current land uses, and foreseeable future actions, it is notable that there have been no vegetation management projects within the large, cumulative effects analysis area within the last 10 years. There are no foreseeable future forest or fuels management projects in the analysis area, except the possibility of the City proceeding with implementing part of this proposed project on City lands in advance of the Forest Service decision. If the City moves forward with implementing that project, effects would not differ from the effects described for the 560 acres of thinning and wood removal along the roads. It would not cumulatively add to the fuel reduction or fire behavior effects described. Overall, in considering all past, present and foreseeable future activities, there would be no other cumulative effects expected from the action alternatives with respect to the fuels treatments, given that there are no recent past actions or planned future actions that change the fuel loading or fire behavior.

Soil and Water Resources

A project objective associated with soil and water resources is:

Increase the amount of grasses and shrubs that stabilize the soil and filter sediments before they reach the Santa Fe River and reservoirs.

A soil and water resource issue associated with the project is:

Changes in the structure and composition of forest vegetation and soil surface characteristics may increase soil erosion and stream sedimentation. Those surface changes could also affect peak flows (floods), water quality, soil properties, and nutrient cycling. If burning slash piles generates high temperatures, it could adversely affect soil properties and vegetative productivity under the piles.

Affected Environment

Erosion and Sediment

Twenty Terrestrial Ecosystem Survey map units are found in the Watershed. Each TES map unit describes an area with similar biological and physical characteristics including slope, vegetation, climate, and soil properties (USDA Forest Service 1993). Erosion rates were calculated for each TES map unit using the

Revised Universal Soil Loss Equation (RUSLE) (Table 16). Based on TES map units, soil loss rates in the Watershed total approximately 13,912 tons per year. This indicates fairly stable soils, with acceptable soil movement rates that are well below tolerance levels for these soil types. Assuming a sediment unit weight of 75 pounds per cubic foot (lbs/ft³), this yields a total soil loss volume of 9 acre-feet (ac-ft) annually under existing conditions. A comparison of 1935-1936 conditions with current conditions indicates that the amount of bare soil has significantly decreased since the Watershed was closed and that it has moderate runoff potential under current undisturbed conditions. Accelerated erosion is evident within localized piñon-juniper and ponderosa pine areas that have little effective ground cover due to the closed or near closed canopy cover. There are two soil types in the piñon-juniper on the north side of McClure Reservoir that pose potential soil loss problems impacting site productivity if vegetation is consumed in a wildfire (TES map unit 361).

Only a small fraction of the soil loss is delivered to stream channels (Toy and Osterkamp 1995). The proportion of soil that reaches stream channels is referred to as the sediment delivery ratio. In undisturbed forestlands, the sediment delivery ratio is typically less than 5 percent of the total soil loss. Therefore, under current Watershed conditions, we estimate that only 5 percent (or 0.4 feet per year) of the total annual soil loss is transported as sediment to stream channels and the reservoirs. This negligible amount of sediment delivery is consistent with recent data gathered by the City of Santa Fe on reservoir sedimentation rates, which indicate no measurable loss of storage in McClure or Nichols Reservoirs (pers. comm., A. Lewis, City of Santa Fe, June 2000). Therefore, most sediment is redistributed within sub-watersheds, ephemeral tributaries, and the Santa Fe River floodplain, with only negligible amounts being deposited in the reservoirs.

Peak Flows

Peak discharge in the Santa Fe River in the project area was estimated using the U.S. Geological Survey stream gauge located about 0.4 miles downstream from McClure Reservoir. Peak discharge was also estimated using the flow modeling contained in the Federal Emergency Management Agency (FEMA) studies for the City of Santa Fe (FEMA 1993) and the McClure Dam spillway modification project (Woodward-Clyde 1994).

Stream gauge records date back to 1913 and the drainage area varied from 18 to 22 square miles because the gauge was relocated in 1930 (Hardaway and Thompson 1962). Peak discharge during the 84-year period of

record was 1,500 cubic feet per second (cfs), which was recorded on August 14, 1921. Peak flows exceeding 1,000 cfs occurred on August 19, 1872 and September 29 or 30, 1904. McClure Reservoir, constructed in 1929, greatly reduced subsequent peak flows at the gauge site (Table 17).

Although McClure and Nichols Reservoirs act to regulate flows, the FEMA flood insurance study for the City of Santa Fe noted, "the three reservoirs located in the Upper Watershed ... do not provide for flood water storage" (FEMA 1993). The FEMA study estimated flood flows for the Santa Fe River at the confluence of Arroyo Mascaras. In order to estimate flood flows in the river at the downstream end of the project area, linear scaling based on watershed area was applied. This resulted in the unregulated peak flow estimates in the third column of Table 16. Estimated 100-year recurrence interval peak flows at McClure and Nichols Reservoirs were interpolated to yield a flow at the gauge station of 2,190 cfs. This estimate is consistent with estimate made by drainage area scaling of the FEMA value.

Given the negligible flood storage capacity of the reservoirs, the downstream areas along the Santa Fe River floodplain are not protected from extreme runoff or flood events. The Santa Fe River is constricted in a narrow engineered channel through Santa Fe. This channel has limited capacity for conveying peak flows through the downtown area.

**Normalized Water Yield of SF Watershed
Adj. for Basin Area (Hardaway & Thompson, 1962)**

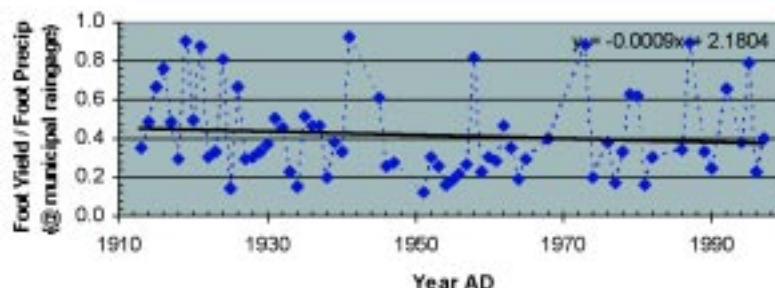


Figure 32. Annual water yield. The water yield measured at the gauge near Santa Fe was normalized by Santa Fe precipitation and the drainage area above the gauge.

Water Yield

Annual water yield from the Watershed is highly variable (Figure 32). Data used in this analysis was adjusted for the basin area as recommended by Hardaway and Thompson (1962). Water yield has declined approximately 20 percent from 1913 to 1997, although water yield trends were inconsistent from 1914 to 1958. Hauck and White (1996) evaluated water yield from the Watershed and concluded that vegetative cover and associated evapotranspiration has increased over the period of record while the water yield decreased. Studies of other watersheds have documented increased water yield following thinning or removal of tree cover (Ffolliot and Thorud 1977; Bosch and Hewlett 1982; Troendle, 1983; Alexander et al. 1985; Whitehead and Robinson 1993). It is hypoth-

Table 17. Peak Storm Flows in the Santa Fe River of Various Return Frequencies.

Return Period (years)	Historic Peak Flows Regulated by McClure Reservoir Operation, from U.S.G.S. Gauge (cfs)	Estimated Unregulated Peak Flows (cfs)	
		Peaks Estimated by Scaling from FEMA Report	Peaks Estimated by Woodward-Clyde Rainfall-Runoff Model
2	37	66	-----
5	102	-----	-----
10	218	386	-----
25	597	912	-----
50	1,277	1,439	-----
100	2,733	2,213	2,190
500	-----	4,848	-----

esized that the increase in tree cover in the Watershed over the past 80 years could be the cause of the apparent reduction in water yield.

Surface Water Quality

Surface water quality refers to the physical, chemical, and biological characteristics of surface water in reference to a particular use (DeBano et al. 1998). Changes in suspended sediments and turbidity are the most important responses that occur in surface water quality following a fire. In addition, a severe fire could release large amounts of nutrients (N-NO³) beyond the buffering capacity of the Santa Fe River, thus having detrimental consequences on water quality. Hauck and White (1996) described existing water quality as “pristine.” Concentrations of nitrate and phosphate were at or below analytical detection limits and far lower than U.S. Environmental Protection Agency water quality standards. Except for immediately following rainstorms or during spring runoff, turbidity and suspended sediment loads are extremely low, as is total dissolved solids. Surveys of macroinvertebrate populations and water chemistry samples demonstrate that the upper Santa Fe River within the Watershed fully meets New Mexico water quality standards for its designated uses, and the designated uses reflect the highest water quality classification in the state’s classification system (Tolisano 1997, State of New Mexico 2000).

Soil Nutrients

Soil nutrient status under current conditions can only be qualitatively characterized given a lack of site-specific data. Soils are probably somewhat deficient in many mineral nutrients due to the granitic- and metamorphic-derived soils (USDA Forest Service 1993), high tree densities with a characteristic lack of shrubs, forbs, and grasses, and the lack of fire over the past 100 years. Sustained productivity of forest soils depends on regular and consistent cycling of nutrients essential for plant growth.

Although abundant organic matter exists in the form of pine needles and the live biomass of trees, decomposition of biological material on the forest floor is probably quite slow given the generally dry conditions, particularly in the project area portion of the Watershed. It has been found that low- to moderate-intensity fire aids in breaking down vegetation and litter into available minerals and easily decomposed organic matter (Andreu et al. 1996; Kutiel and Inbar 1993), effectively speeding up soil nutrient cycling. Tree ring reconstructions of fire history of southwestern pine forests (Swetnam et al. 1999) indicates that low-intensity ground fires were a

dominant ecological process prior to nineteenth century Euro-American settlement of the region. This multi-century record indicated such fires occurred in 5- to 12-year cycles. Research by Covington and Sackett (1986) indicated that available nitrogen (N) was higher on ponderosa pine forested sites subjected to frequent low-intensity burning. This suggests that the lack of fire in the Watershed for the past 100 years or more has removed one of the key natural processes in nutrient cycling.

Hauck and White (1996) analyzed watershed soils for nitrogen generation characteristics and found a wide range of results depending on predominant vegetation type. They obtained several soil samples from representative vegetation associations and topographic aspects and subjected the samples to laboratory measurements of nitrification potential (Gosz 1981). One of their conclusions was that soils within the upper mixed conifer and riparian vegetation types were least sensitive in terms of generation of leachable nitrate. Thus, they could be subject to harvest or thinning with only minimal risk of losing nitrogen. Soils in the other vegetation types, particularly on north-facing slopes, were more sensitive to aggressive harvesting treatments (i.e. more likely to generate leachable nitrate). These conclusions are based on the nitrogen cycling model of Vitousek et al. (1979). Under existing heavily vegetated conditions, however, it is unlikely that soils in the Watershed are leaching significant amounts of nitrogen.

Effects on Soil and Water

Soil erosion and sediment yield for each alternative were evaluated using two methods: 1) Santa Fe National Forest TES in conjunction with RUSLE; and 2) an analogue watershed approach that uses erosion and sediment yield comparisons from other watersheds. Both of these methods use information on soil type, land slope, vegetation cover, soil litter cover, stream discharge records, sedimentation rates, watershed sediment yields, and qualitative and quantitative measures of sediment movement. Erosion and sediment yield are expressed in tons per acre per year and acre-feet.

Peak flows (flood events), expressed in cubic feet per second, were also evaluated using two methods: 1) Curve Number (CN) method; and 2) an analogue watershed approach. These methods required information on watershed area, soil runoff factors, stream discharge records, parameters relating burned area to change in peak flow; reservoir capacity, and flood pool capacity.

The analogue watershed approach was also used to evaluate surface water quality, changes in soil nutri-

ents, and changes in water yield. Water quality, expressed in terms of turbidity and total suspended solids, involved analysis following similar treatments in other watersheds with the same forest cover types as this Watershed. Water yield analysis employed a long record of water yield and climate data with stand-replacing fire, low-intensity fire, and moderate-intensity fire. In all cases, we selected analogue watersheds that were most comparable to this Watershed on the basis of slope, tree canopy density, fire incidence, and other relevant parameters.

Alternative A

No Action Without Wildfire

Erosion and Sediment. Under No Action, there would likely be small increases in erosion, sediment yield, and ephemeral stream channel incision, primarily in the piñon-juniper cover type. This increased erosion would occur as the canopy cover continues to shade-out herbaceous ground cover. Ground vegetation is an important soil stabilizer. In the moister ponderosa pine/Douglas-fir areas, increased erosion or sediment would be negligible due to the thick layer of pine needles and organic matter. This duff layer helps moisture to penetrate the ground surface, reducing erosion and runoff.

Peak flows, surface water quality, and soil nutrients would remain relatively unchanged. However, water yield would continue its gradual decline as trees continue to grow and utilize and intercept more water than the amount that recycles back to the river.

No Action With Wildfire

For this analysis, it is assumed that the Watershed would be subject to a high-severity crown fire that spreads through most of the Watershed, based on the wildland fire situation analysis ("Forest Vegetation, Fuels and Fire Behavior" section). Recent experience with the Cerro Grande and the Viveash Fires on Santa Fe National Forest in summer 2000 vividly illustrated the large acreages that can be consumed in just a few days when adverse fire conditions exist. For instance, the Viveash Fire, located in similar vegetation, soils, and topography close to the Watershed, grew from roughly 2,000 acres to 20,000 acres in a single day.

Erosion and Sediment. Numerous studies have shown that erosion, and consequent increased sediment transport, is a relatively transient phenomenon after forest fires, with the highest yields occurring in

the first year or two after the fire (DeBano et al. 1998). Severe fires increase the potential for mass soil movement and landslides in areas such as these, comprised of shallow, granitic soils and limited herbaceous vegetation (Gonsior and Gardner 1971, Megahan 1983, Clayton et al 1979). Frequently, but certainly not always, a significant portion of the total increase in sediment yield occurs as mass erosion (e.g. debris flows resulting from channel incision or extension, or dry ravel erosion). These mass erosion events that follow severe fires are due to hydrophobicity, where the fire-heated soil develops a waxy layer that repels water. Other factors that contribute to these mass erosion and runoff events include friable bedrock units and cohesionless soils, long, smooth, and regular slopes inclined more steeply than 65 percent and denuded of ground vegetation, and the lack of riparian vegetation along stream channels (Dunne and Leopold 1978, Cannon 1997, Cannon et al. 1998). In this Watershed, the thin soils and steep slopes combined with high-intensity rainstorms that typically follow the fire season indicate high susceptibility to mass erosion after a severe wildfire.

Typically, it takes 2 to 15 years for sediment yields to return to their pre-fire levels. The time until recovery generally corresponds to time required for establishment of vegetation. Hydrophobic soils take longer to recover than lightly burned soils. Sediment yield ratio is defined as the post-fire sediment yield normalized by the initial yield. Sediment ratio data for a fire in north-central Arizona (DeBano et al. 1996), computed as a function of burn severity, was applied to analysis of temporal effects of wildfire on erosion in the Watershed (Figure 33).

The "potential" sediment yield calculated from the TES/RUSLE data (USDA Forest Service, 1993) was initially used to predict sediment yield following a severe wildfire in the Watershed. TES defines potential soil loss as the rate when virtually all forest vegetation is removed based on old clearcut harvesting models. However, the TES/RUSLE calculations do not account for the effects of hydrophobic soils that form from high-intensity wildfires. Hydrophobic soils are known to greatly magnify erosion and runoff effects following severe wildfire. The Viveash and Cerro Grande Burned Area Emergency Rehabilitation (BAER) Teams observed thick hydrophobic layers throughout the severely burned areas (USDA Forest Service 2000d, 2000e). Thus, the initial sediment yield calculation using the TES/RUSLE model alone, 50 acre-feet in the first year following the fire, probably underestimates the sediment yield prediction for this wildfire scenario because it does not account for hydrophobicity.

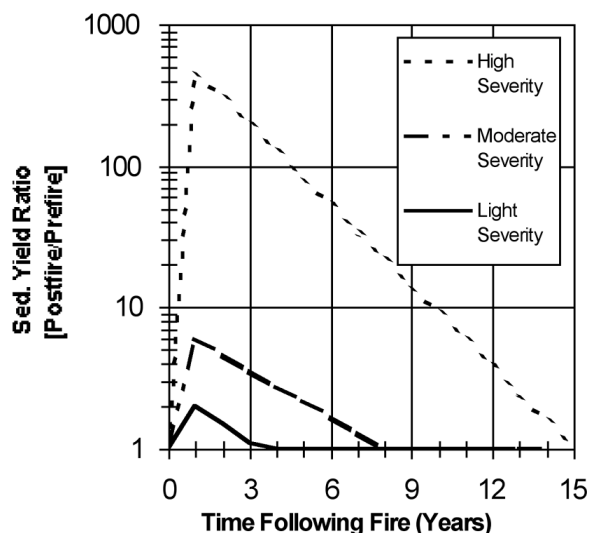


Figure 33. Projected time history of sediment yield from a ponderosa pine forested watershed following light, moderate, and high severity fires (adapted from DeBano et al. 1996).

To account for hydrophobicity effects of the burned soils, the Viveash BAER Team multiplied TES/RUSLE projected erosion rates by an “erosion rate multiplier” between 1.1 and 2.5 depending on the dominant overstory and understory vegetation. Using this “Viveash BAER- TES/RUSLE” approach, we calculated a sediment yield of 92 acre-feet the first year after a severe wildfire event and a cumulative sediment yield of 256 acre-feet by the 10th year after the fire. The 10th year cumulative total sediment yield was calculated by re-scaling the curve in Figure 33 using the Viveash BAER TES/RUSLE results developed for hydrophobic soils integrating the resulting curve over time and multiplying by a 30 percent sediment delivery ratio. Studies of fire impacts in watersheds similar to the project area indicated that about 30 percent of the total sediment yield is discharged into the streams in the first rainy season following fire (pers. comm., D. Martin, U.S. Geological Survey, June 2000). The 30 percent sediment delivery ratio is probably conservative for this Watershed area considering the steep slopes, high drainage density, short tributary channel lengths, potential for complete denudation, and extreme hydrophobicity likely to occur after a catastrophic fire. Therefore, the projected sediment yields in this analysis are probably at the low end. Table 18 shows the results of these calculations. Notice that the total tolerance soil loss rate of 55,542 tons per year is substantially higher than the current condition soil loss rate of 13,913 tons per year (Table 15), and the potential soil loss rate with severe wildfire is 271,382 tons per year.

To illustrate the impact of sedimentation on the City water supply, we can compare sediment yield volumes to reservoir volumes. Total storage volume in the two reservoirs combined is approximately 4,000 acre-feet. Even though sediment volumes include interstitial void spaces occupying on the order of 30 percent of the total volume, the total sediment volume including voids should be considered to displace available reservoir storage volume. This is because water, which would occupy the void spaces, cannot be readily extracted. Therefore, the entire sediment volume (solid plus void) would effectively replace reservoir volume. The sediment yield analysis using Viveash BAER TES/RUSLE calculations suggest significant increases in sediment delivery over current conditions and the potential for heavy accumulations in the Santa Fe River, reservoirs and riparian areas.

Sediment yield was also calculated using analogue watershed studies from conifer forests that experienced large wildfires in the western U.S. The sediment yield ratio, which is used to quantify the increase in sediment after a fire, was calculated as the post-fire sediment yield divided by the pre-fire sediment yield. Figure 34 summarizes the sediment yield ratio for numerous analogue watersheds. Note the average sediment yield ratio for sites vegetated by conifer species indicates a 216-fold increase in sediment yield the first year after the fire.

To apply the analogue watershed approach, the selected sediment yield ratio from all conifer sites was multiplied by the existing sediment yield estimate for all conifer sites. This product is then multiplied by a 30 percent sediment delivery ratio to obtain an estimated sediment delivery to the reservoirs. In addition, we multiplied the Yellowstone yield ratio by the estimated existing sedi-

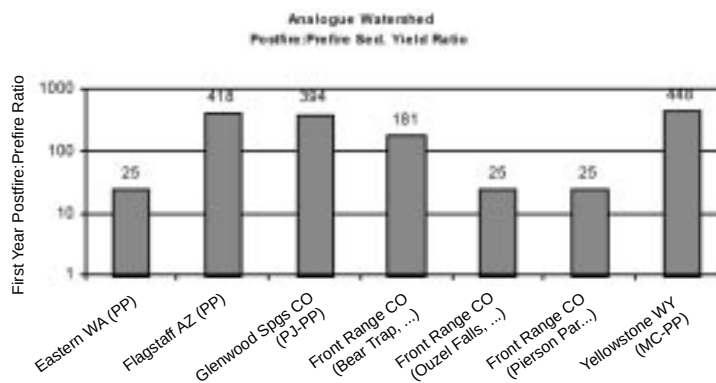


Figure 34. Sediment Yield Ratio (post-fire yield divided by pre-fire yield) for Analogue Watersheds. Cover type abbreviations are: PP=ponderosa pine; PJ=piñon-juniper; MC=mixed conifer; LP=Lodgepole pine.

Table 18. "Tolerance" and "Potential" Annual Soil Loss Rates from TES Units in the Watershed. Tolerance is the soil loss that can occur while sustaining inherent site productivity. Potential is the soil loss after removing forest vegetation, such as after severe wildfire events.

TES Map Unit	Acres of TES Map Unit in Watershed	Annual Tolerance Soil Loss		Annual Potential Soil Loss	
		Tons/Acre (Total)	Acre-Feet/Acre (Total)	Tons/Acre (Total)	Acre-Feet/Acre (Total)
3*	234.1	2.99 (699.96)	0.0018 (0.4214)	3.39 (793.60)	0.0021 (0.4916)
6*	87.7	2.99 (262.22)	0.0018 (0.1579)	4.73 (414.82)	0.0029 (0.2543)
7	195.5	2.99 (584.25)	0.0018 (0.3517)	9.06 (1,770.32)	0.0055 (1.0747)
91	334.3	2.99 (999.56)	0.0018 (0.6017)	6.92 (2,313.36)	0.0042 (1.4041)
328	114.6	2.99 (342.65)	0.0018 (0.2063)	16.73 (1,917.26)	0.0102 (1.1689)
329	1084.0	2.99 (3,241.16)	0.0018 (1.9512)	52.65 (57,072.60)	0.0322 (34.9048)
331	95.2	2.99 (284.65)	0.0018 (0.1714)	18.29 (1,741.21)	0.0112 (1.0662)
332	548.3	2.99 (1,639.42)	0.0018 (0.9869)	45.96 (25,199.87)	0.0281 (15.4072)
333	1.7	2.99 (5.08)	0.0018 (0.0031)	10.84 (18.43)	0.0066 (0.0112)
334	209.3	2.99 (625.81)	0.0018 (0.3767)	10.22 (2,139.05)	0.0063 (1.3186)
336	198.2	2.99 (592.62)	0.0018 (0.3568)	52.65 (10,435.23)	0.0322 (6.3820)
337	1772.2	2.99 (5,298.88)	0.0018 (3.1900)	53.09 (94,086.10)	0.0325 (57.5965)
340	20.6	0.98 (20.19)	0.0006 (0.0124)	7.63 (157.18)	0.0047 (0.0968)
341	28.1	0.98 (27.54)	0.0006 (0.0169)	13.74 (386.09)	0.0084 (0.2360)
345*	644.3	2.99 (1,926.46)	0.0018 (1.1597)	3.70 (2,383.91)	0.0023 (1.4819)
351*	143.5	4.02 (576.87)	0.0025 (0.3588)	14.14 (2,029.09)	0.0087 (1.2485)
352*	50.4	4.02 (202.61)	0.0025 (0.1260)	10.44 (526.18)	0.0064 (0.3226)
353*	7065.5	4.02 (28,403.31)	0.0025 (17.6638)	6.69 (47,268.20)	0.0041 (28.9686)
358*	709.3	0.98 (695.11)	0.0006 (0.4256)	4.06 (2,879.76)	0.0025 (1.7733)
359*	2919.2	2.99 (8,728.41)	0.0018 (5.2546)	5.35 (15,617.72)	0.0033 (9.6334)
361*	191.6	2.01 (385.12)	0.0012 (0.2299)	11.65 (2,232.14)	0.0071 (1.3604)
Annual Soil Loss in Watershed		(55,542) total	34 ac-ft/ac. tons/ac.	(271,382) total	166 ac-ft/ac. tons/ac.

ment yield to characterize a “worst case” scenario. This would yield 1,193 acre-feet the first year following wildfire. Other analyses conducted are contained in the project record. Using the average of the conifer study areas, sediment delivery to the reservoirs would be approximately 577 acre-feet the first year following wildfire in the Watershed.

In summary, based on analogue watershed observations, we would expect approximately 577 acre-feet or more sediment delivery in the first year following a severe wildfire event. Using the re-scaled curve over time, we estimate accumulations of at least 1,571 and 3,249 acre-feet in the 10th year after the fire. Comparing these numbers to the total reservoir capacity of 4,000 acre-feet suggests that catastrophic fire could reduce the City reservoir capacity by 50 percent or more.

Figure 35 shows sediment yield over time is from three prediction approaches: 1) the Viveash BAER TES/RUSLE; 2) mean yield ratio from conifer forest analogue watersheds; and 3) Yellowstone yield ratio. The Yellowstone yield shows the maximum or worse case scenario, since it had the highest sediment yield following wildfire than all other conifer watersheds evaluated.

Peak Flows. A catastrophic fire in the Watershed would consume vegetation and litter on the soil surface, reducing interception of precipitation and evapotranspiration by plants. It has also been shown that infiltration rates are significantly reduced after fire due to a number of factors including soil hydrophobicity, ash and charcoal clogging of soil pores, and an increase in bulk density (decrease in porosity) due to combustion of organic matter that helps maintain soil aggregate stability (DeBano et al. 1998). One net effect of these changes in soil properties is an increase in discharge or peak flows (Tiedeman et al. 1979, Baker 1990).

Downstream impacts of a catastrophic fire on peak flows (floods) in the Santa Fe River were evaluated using two approaches. Both approaches utilize a peak flow multiplier to magnify current peak flows from the Watershed. The first relies on use of the runoff Curve Number (CN) model (SCS 1973, Dunne and Leopold 1978, and Viessman et al. 1989). The CN method is widely applied to Southwestern U.S. watersheds less than 10 square miles in area to estimate peak discharges for a range of rainfall amounts, soil types, land use, and cover conditions. The other employs analogue watershed observations. To graphically illustrate the effect on peak flows, flood frequency curves for the Watershed for the post-fire conditions were developed and compared to flood frequency curves for the existing condition. Combining these comparative analyses with

the FEMA floodplain map presented in Figure 36 allows for an evaluation of the increased flood hazard.

For the runoff CN approach, we relied on CN modeling developed by the Viveash BAER team (USDA Forest Service 2000e). The 2000 Viveash Fire consumed over 40,000 acres in the Cow Creek and adjacent drainages in the Sangre de Cristo Mountains just east of the Watershed. Based on the similar vegetation types, soil conditions, underlying geology, slope, drainage patterns, and watershed aspect, a catastrophic fire in the Watershed would be expected to reflect what was observed in the Viveash Fire area. As part of the Viveash BAER analysis, the flood hazard due to increased peak flows was explicitly addressed. For this analysis, runoff curve numbers for southwestern ponderosa pine forests were derived from Jencsok (1969) and SCS (1973). Additional input data were obtained from burn severity maps. Runoff from individual sub-watersheds within the burn zone was modeled independently, and the results were summed to obtain a net response for the entire Cow Creek watershed. The BAER Team analysts examined peak flows for the 2-year/1-hour, the 25-year/1-hour, the 100-year/1-hour storms for burned conditions and the 25-year/one-hour storm for unburned conditions. Comparing the unburned to the burned condition peak flows, the CN approach predicted a 23.5-fold increase in peak flows for the entire Viveash burned area including large areas of low-severity burn. The most severely burned sub-watersheds, Elk and Middle Cow, were projected to experience 60-times and 42-times increases in peak flood flows, respectively.

Three analogue watersheds were employed to predict a

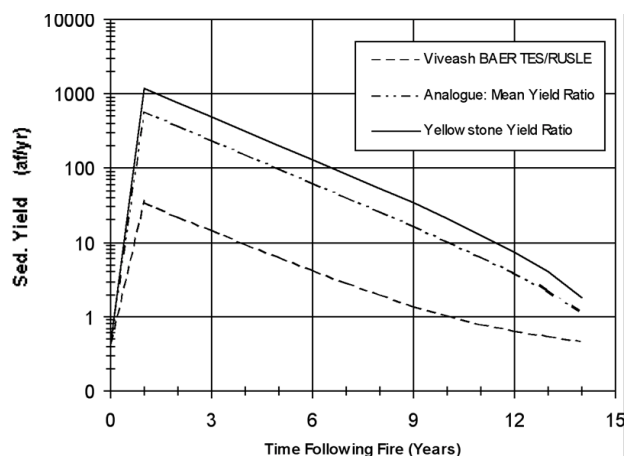


Figure 35. Predicted Time History of Sediment Yield in the Watershed Following Catastrophic Fire (Using Analogue Watersheds).



Figure 36. The 100-year and 500-year Flood Zones (Adapted from the FEMA Flood Map of the Santa Fe River).

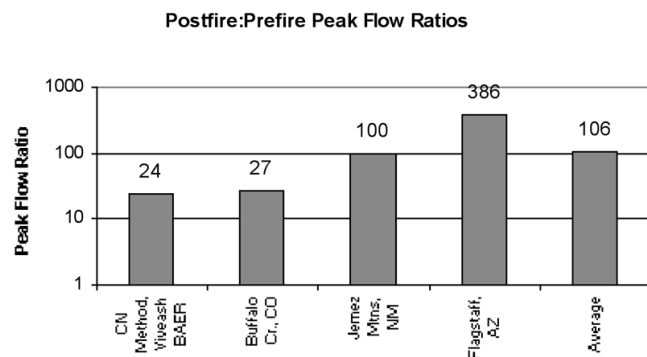


Figure 37. Post-fire:pre-fire Peak Flow Ratios for Three Analogue Watersheds and the Viveash BAER CN Method.

range of post-fire peak flows. They are all comprised of ponderosa pine and mixed-conifer forests located in the western U.S that experienced large wildfires: Jemez Mountains, New Mexico; Buffalo Creek, Colorado; and Flagstaff, Arizona. Peak flow ratios (post-fire:pre-fire) for these watersheds after wildfire indicate that peak flows can be expected to increase between 27 and 386 times over pre-fire flows (Figure 37). Utilizing these peak flow ratios, predictions for post-fire peak flows can be obtained by multiplying the estimated unregulated peak flows in the Watershed by the peak flow ratio (Table 19).

Given that perhaps the gravest concern due to increased peak flows is their impact in the downtown area of Santa Fe, peak flows in the Santa Fe River at the confluence of Arroyo Mascaras were evaluated. Arroyo Mascaras was selected as the location for predicting peak flows for two reasons: 1) the FEMA flood insurance study predicts flow at this location (FEMA 1993); and 2) this location is immediately downstream of the intensively developed downtown commercial district and would, therefore, characterize flooding from the project area through the heart of the City. To effectively estimate peak flow impacts at the Arroyo

Mascaras location, flow contributions from the Watershed must be disaggregated from those originating in the drainage basin downstream from Nichols Reservoir.

Flow contributions from the Watershed were separated from total flow at Arroyo Mascaras utilizing a basin-area scaling approach, which is incorporated by reference and contained in the project record. Peak flows for the Santa Fe River were evaluated at three locations:

- At the stream gauge between reservoirs: 18 mi² drainage area.
- At the Watershed outlet below reservoirs: 27 mi² drainage area.
- At the confluence with Arroyo Mascaras below downtown: 40 mi² drainage area.

The difference between the Arroyo Mascaras confluence value and the Watershed outlet value represents the peak flow contribution from the City area downstream from the Watershed.

Peak flow predictions following catastrophic fire used

Table 19. Santa Fe River Peak Flows Above and Below the City of Santa Fe at the Watershed Outlet and Arroyo Mascaras Confluence for Specified Return Intervals, Both Under Current Conditions and Predicted Responses Following Catastrophic Fire in the Watershed.

Condition and Location on the Santa Fe River	Peak Flow (cfs) for Return Interval (in years)					
	2	5	10	25	50	100
Existing Condition						
Santa Fe River near U.S.G.S. Gauge Station	66	226	386	912	1,439	2,213
At Watershed Outlet	98	335	572	1,355	2,137	3,286
At Confluence of Arroyo Mascaras	145	498	850	2,012	3,173	4,880
Predicted Using Viveash Fire Curve Number						
At Watershed Outlet	2,299	7,876	13,453	31,834	50,214	77,215
At Confluence of Arroyo Mascaras	2,346	8,039	13,731	32,491	51,250	78,252
Predicted Using Buffalo Creek, Colorado Watershed Pre-Fire:Post-Fire Peak Flow Ratio						
At Watershed Outlet	2,641	9,049	15,457	36,575	57,692	88,716
At Confluence of Arroyo Mascaras	2,689	9,212	15,735	37,232	58,729	92,111

fire effects multipliers and the Viveash CN modeling results, to generate flood frequency curves for the Watershed. The flood frequency curves used in the analysis and additional details regarding these calculations are incorporated by reference and contained in the project record. Table 20 compares current peak flow estimates with peak flow estimates following catastrophic fire.

Particularly notable in these results is the increased frequency of much higher flows under post-fire conditions. For instance, a major flood event with a magnitude similar to a 100-year flood would change from a 1 percent chance of occurring to about a 30 percent probability of occurring in the first year following a fire. The 100-year flood flows at the Watershed outlet increase 6 to 23 times over the existing conditions. An extremely large magnitude 500-year flood event probability changes from a 0.2 percent chance of occurring under existing conditions to a 5-20 percent chance of occurring in the first year after a catastrophic fire.

Peak flows exceeding about 3,000 cfs are predicted to result from a severe wildfire in the Watershed, and would probably inundate the entire 100-year floodplain along the river (Figure 36). Based on FEMA flood zone delineation, the 100-year flood flow would include the following areas:

- Low-lying areas along the north side of Upper Canyon Road and south of Cerro Gordo Road; Canyon Road between East Alameda and Palace Avenue;
- Nearly the entire length of East Alameda Street;
- The entire commercial district bounded by Cathedral Place on the east, Water Street on the north, Sandoval Street on the west, and West DeVargas Street on the south;
- Low-lying areas between West Alameda and Alto Street from Guadalupe Street west to St. Francis Avenue;
- West of St. Francis Avenue downstream toward the wastewater treatment plant;
- Several low-lying residential areas off of Alto Street and West Alameda; and
- Low areas adjacent to the Santa Fe River in the traditional communities of Cieneguilla and La Cienega.

With a 5-20 percent probability of occurrence after wildfire, the 500-year flood zone would extend well

beyond the 100-year flood zone and include most of the area south of San Francisco Street in downtown Santa Fe. Peak flow predictions for the Santa Fe River would be expected to be similar for the Rio Tesuque, impacting low-lying areas in the Village of Tesuque, if the stand-replacing wildfire spreads north from the Watershed and burns through a substantial portion of the upper Tesuque drainage. Similarly, if the fire spreads up the Santa Fe River canyon to the east, it could burn through the upper Pecos River drainage and result in floods along the upper Pecos River corridor. Additional indirect and cumulative effects are discussed at the end of this section as well as in the section, "Social Environment."

Water Yield. Based on observed effects in other watersheds, a beneficial increase in water yield is expected to result in the first year following a large stand-replacing fire. Furthermore, increased water yield would likely continue for several years following

Table 20. Threshold Temperatures (degrees centigrade) for Combustive Loss of Soil Properties, for Selected Insensitive, Moderately Sensitive, and Sensitive Soil Properties (adapted from DeBano et al. 1998).

Category and Soil Property	Threshold Temperature (°C)
Relatively Insensitive Soil Properties	
Manganese	1,962
Calcium	1,484
Magnesium	1,107
Clay Alteration	460 to 980
Phosphorus and Potassium	774
Moderately Sensitive Soil Properties	
Sulfur	375
Soil Structure	300
Soil Wettability	250
Nitrogen	200
Organic Matter	100
Sensitive Soil Properties	
Protein Coagulation	60
Wet Bacteria	100
Dry Bacteria	120
Plant Roots	48 to 54
Seeds	70 to 90
Small Mammals	49 to 63

the fire and would return to pre-fire yields only after a decade or more. Bosch and Hewlett (1982) analyzed data from 94 watersheds that reinforced previous conclusions by Hibbert (1967)-that water yield increases when there is significant reduction of forest cover. Increased water yields are presumed to occur as a result of combined effects of: 1) loss of vegetation cover and consequent reductions in evapotranspiration, interception, and sublimation of intercepted snowfall; and 2) decreased litter accumulations. Water repellent soils represent a compounding factor in the first year following fire.

DeBano et al. (1998) describe several instances of significantly increased annual water yield. Following a wildfire in a mixed conifer forest that consumed nearly 100 percent of the vegetation, annual streamflow increased by 100-200 percent over pre-fire yields. Larger increases in yield occurred during wetter years. Increased water yield was observed to persist for several years following fire in other watersheds as well (Helvey 1980). Following a wildfire in a ponderosa pine forest in northern Arizona, Campbell et al. (1977) observed a 3.5-fold increase in average annual stormflow. Increases over 12 percent in annual water yield and over 60 percent in discharge from individual storms were observed after a wildfire in a 497-acre watershed in the Cape Region of South Africa (Scott 1993). There was a 30 percent increase in annual stream discharge in the first year following a wildfire that occurred in an oak and chestnut forested watershed in France near the Mediterranean Sea.

Considering these observations in conjunction with the approximately 20 percent decrease in Santa Fe Watershed water yield over the past 70 years (Figure 32), annual water yields from the Watershed would be expected to increase anywhere from 25-100 percent following a catastrophic fire. These increases would be expected to return to pre-fire levels over a 10- to 20-year period following the fire as vegetation re-establishes in the Watershed.

Surface Water Quality. As discussed previously, changes in suspended sediments and turbidity are among the most important effect on surface water quality following a fire (DeBano et al. 1998). The previously described sediment yield analysis indicates there is a high potential for transport of large volumes of sediment ash and woody debris into the Santa Fe River channel and reservoirs. Fine-grained materials (i.e., silts and clays) along with ash from the fire, are likely to substantially degrade surface water quality in the Watershed in the first couple of years following a large, stand-replacing fire. Water quality would not meet state and Federal standards for at least a few years,

if not longer. Ash is known to alter the pH or acidity of the water chemistry. Ash residues have been known to create an undesirable taste in the drinking water that cannot be filtered out at the water treatment plant and can last for a long time, as was experienced in the City of Denver after the Buffalo Creek Fire.

Furthermore, it is anticipated that soil nutrients such as nitrate and phosphorous would be more readily leached following such a fire (DeBano et al. 1998; Hauck and White 1996). These nutrients would be transported into the surface water system where they would adversely affect water quality. In addition, the transport of organic material mixed with sediments would result in anaerobic decomposition of the logs, litter and other woody debris, further impairing water quality. Increased suspended sediments and ash, dissolved solids, and nutrient loading can be expected to seriously impact the City's water supply system in the Watershed that would impact the majority of the residents in Santa Fe.

Soil Nutrients. As described previously, sustained productivity in natural ecosystems depends on regular and consistent cycling of nutrients essential for plant growth (DeBano et al. 1998). Fire can alter nutrient cycling processes dramatically and the overall effect depends on fire severity. A high-severity fire, such as that expected to occur under the No Action Alternative, would be more destructive to the physical properties of the soil and to the soil nutrient cycling process compared to beneficial soil effects expected from low-intensity burning. With a high-severity fire, most of the nitrogen in the litter would probably be volatilized. Severely burned soil can become sterilized (DeBano et al. 1998). Soil nitrogen is hypothesized to become more readily leachable following aggressive removal or mortality of vegetation (Hauck and White 1996, Vitousek et al. 1979). Fire interrupts the slow decomposition processes and rapidly releases phosphorus in the form of the phosphate ion. The continued availability of phosphorus following fire depends on soil pH and the presence of soluble calcium, iron, and aluminum compounds (DeBano et al. 1998).

Table 20 lists threshold temperatures for combustive loss of soil properties. Figure 38 shows observed soil temperature profile data gathered from fires of low-, moderate-, and high-severity burns. A prediction of expected soil nutrient effects from fire can be obtained by synthesizing the information in Table 20 and Figure 38. For the high-severity fire envisioned to occur as part of the No Action Alternative, most of the "moderately sensitive" and "sensitive" soil properties are likely to be adversely affected (Table 20). This includes damage to the soil structure, wettability and protein coagulation, in

addition to loss of organic matter, nitrogen, sulfur, important bacteria, etc. Although phosphorus, potassium, calcium and magnesium would not be lost through combustion, they would likely be removed by the significantly increased runoff and erosion. Thus, the soil nutrient-cycling impacts of a severe fire on the Watershed are likely to be highly adverse. Overall, site productivity would be reduced under this alternative for many years.

Alternative B1

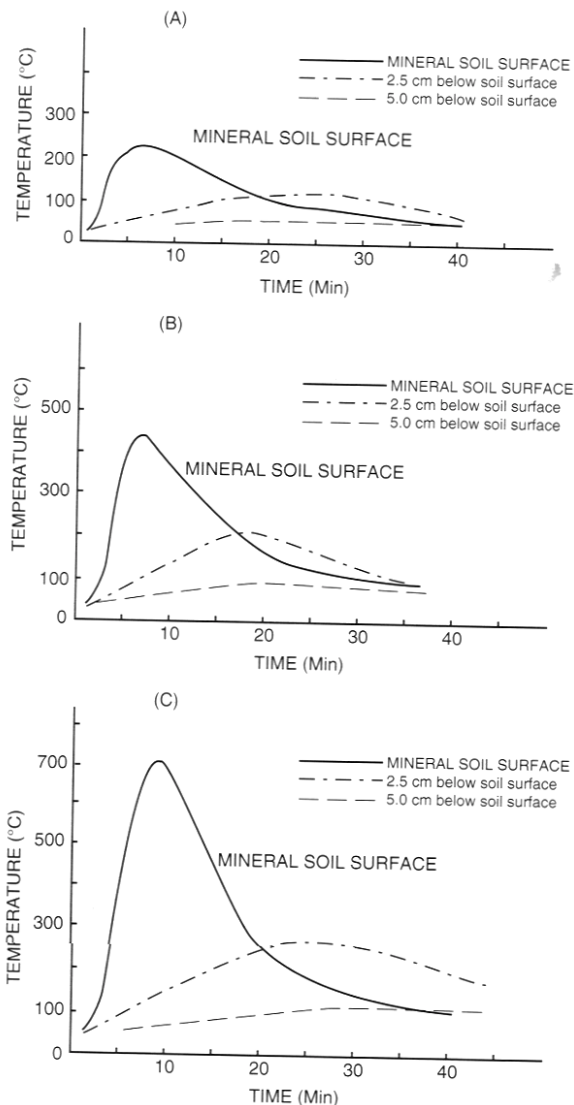


Figure 38. Soil Temperature for Light, Moderate, and High Severity Fires (adapted from DeBano et al. 1998).

Erosion and Sediment. Numerous published studies have shown that mechanical thinning operations and low-severity burns have only minor effects on sediment yield. For example, Robichaud and Waldrop (1994) investigated erosion and sediment yield effects of various slash cleanup approaches following a thinning operation. In general, they found sediment yield increases were only slightly greater than background conditions when slash was subjected to low-severity fire. Andreau et al. (1996) showed low-severity fire plots produced 50 times less sediment yield than plots subjected to high-severity burns. Soto and Diaz-Fierros (1998) observed similar differences in erosion following low-severity and high-severity burns. While some plot studies have shown substantial increases in study plot-scale slope erosion following low-severity burns, watershed-scale sediment yield increases were extremely minor (Robichaud and Waldrop 1994, Kutiel et al. 1995). DeBano et al. (1998) summarized much of the published research by noting that, in general, low-severity burns have only minor effects on sediment yield. These observations, coupled with the fact that mechanical thinning would be undertaken utilizing mitigation measures to minimize ground and soil disturbance, indicate that sediment yields in response to both thinning and prescribed burning would be relatively minor. In addition, leaving the cut tree trunks on the ground, especially perpendicular to the slope, would help reduce soil movement and runoff.

Sediment yield would be expected to increase only approximately two to four times over the existing condition in the first year or two following treatment. As ground vegetation becomes re-established and stabilizes the soil approximately 3 to 5 years after treatments are complete, erosion and sediment rates would return to background levels. Based on observations in Pacheco Canyon and other thinned and slash-treated areas on the Santa Fe National Forest, vegetative ground cover would take several years to become established. Vegetative ground cover would be expected to increase to 30-50 percent on the decomposed granite soil in this area, which is less productive than the volcanic soils of the Jemez Mountains. If monitoring indicates a need to supplement ground vegetation in treated areas, seeding with native species such as ceanothus, locust, and bunch grasses may be effective. The low-severity broadcast burning would improve growth of herbaceous vegetation by reducing the pine needle and duff accumulation and releasing nutrients into the soil that are currently tied up in the biomass.

Visits to a watershed just north of the Santa Fe Watershed where the tree canopy was reduced showed

a varied response in vegetative ground cover. Grass cover was visually estimated to be 40 percent, and shrub response was minimal where it was absent prior to thinning. Grasses are needed to hold the soil in place as well as provide a fuel source for future low-severity ground fires (Cassidy 2000).

With this alternative, only a small portion of the project area (and Watershed) would be mechanically thinned to create canopy openings and reduce the continuous dense crown cover. Thus, even after low-severity burning of seedlings, saplings and litter in the project area, there would be a moderate risk of crown fire. If a high-severity crown fire consumes the project area after all treatments are implemented, sediment yield would be significantly increased, although not nearly as much as expected for a severe fire for the No Action Alternative.

Peak Flow. Studies in the Fraser Experiment Watershed in Colorado (Alexander et al. 1985) indicate that thinning conducted with mitigation measures designed to minimize ground surface impacts lead to only minor increases in peak flood flows.

Thinning, slash treatment and broadcast burning would be anticipated to impart negligible impacts on stream flow. The purpose of the prescribed burns is to consume slash, excessive accumulations of forest litter, and thin smaller trees in “dog hair thickets.” The prescribed burns would be undertaken only when forest and climatic conditions are favorable to achieve these goals, as constrained by mitigation measures. For these reasons, DeBano et al. (1998) states “streamflow responses to prescribed burns are generally smaller in magnitude, or almost nonexistent in instances of low fire severity, in

contrast to responses to wildfire.” Gottfried and DeBano (1990) monitored stream flow in a ponderosa pine-forested watershed in northern Arizona for 6 years following a prescribed fire. Annual discharge was not significantly changed relative to pre-fire levels even though the prescribed fire affected 43 percent of the watershed and met the burn plan goals of a 70 percent reduction in fine fuels and a 40 percent reduction in heavy fuels. Also notable is the fact that damage to the residual stand of trees was minimal.

However, even after all treatments are implemented for this alternative, there would be a moderate risk of high-severity fire in the untreated areas. If a high-severity crown fire consumes the project area after all treatments are implemented, peak flows would be dramatically increased, although not nearly to the extent expected under the No Action with Wildfire Alternative.

Figure 39 shows the relative differences in runoff between the high-severity fire conditions expected under the No Action with Wildfire Alternative and a light burn reflecting conditions in the thin and prescribed burn treatments under the action alternatives. It can be discerned from Figure 39 that the effects diminish rapidly in the years following the catastrophic fire or low-severity burns. This is due primarily to the reestablishment of herbaceous vegetation by the third year after the fire. Ground vegetation would be expected to increase following thinning and low to moderate burn treatments, and the runoff would return to background levels within 3 to 5 years.

Water Yield. While localized runoff can be anticipated to occur in the short-term following thinning, the change in yield relative to annual runoff is typically quite small (Huff et al 2000). Water yield would be expected to increase only slightly under this alternative, since only 36 percent of the project area and only 13 percent of the 17,000-acre Watershed would be mechanically thinned to create openings in the overstory canopy. The broadcast burning treatment covering the majority of the project area would only reduce small understory trees generally less than six-inch diameter, and would not be expected to open the overstory canopy sufficient to measurably affect water yield. If the canopy cover is not reduced more than approximately 20 percent, changes in water yield are not expected to be detectable by measuring stream flows (Huff et al 2000). In addition, the increases in water yield would diminish as herbaceous ground vegetation increases within created openings in the forest canopy.

Surface Water Quality. Provided all listed mitigation measures (“Mitigation and Monitoring” section) are

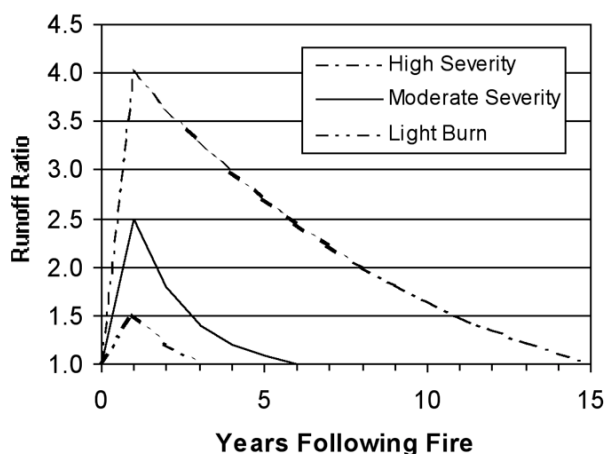


Figure 39. Average Increases in Runoff Following Fire of Varying Severities (adapted from DeBano et al. 1986).

employed in implementation of this alternative, it is anticipated that minimal impacts to surface water quality would occur. There would be no adverse effects such as increased suspended sediment loads and turbidity, since runoff and erosion would not significantly increase. As described in previous discussions of erosion, sediment yield and peak flow, there are ample studies and field observations that this alternative would lead to only minor increases in runoff and erosion. Minor erosion would occur during the first rainy season following a treatment action on steep slopes that have been newly exposed after thinning. Such effects are anticipated to diminish to pre-treatment conditions within a few years. Also, the extent and degree of disturbance would be controlled through treatment prescriptions and mitigation measures, which further diminishes the risk to stream courses. Local effects would be attenuated at the Watershed scale, so that surface water quality degradation in the Santa Fe River is expected to be negligible.

Adverse water quality impacts could occur similar to those described for the No Action Alternative, if the entire Watershed experiences a high-severity wildfire due to the limited acreage thinned to desired fuel levels under this alternative. However, treating the canyon bottom with thinning and slash disposal would result in a greater abundance of herbaceous and riparian vegetation in the river corridor that would probably attenuate some of those potential adverse water quality effects.

Soil Nutrients. The thinning treatment alone would not alter nutrient cycling, although retaining the felled down logs on the forest floor provides benefits to soil nutrient cycling processes. Slash burning generally results in higher temperatures and longer durations of soil heating compared to broadcast burning. Past experiences with slash pile burning on the Santa Fe National Forest provides evidence that slash burning would not be expected to have any long-term impacts on soil productivity or cause other lasting damage to the soil. However, slash pile burning could adversely affect soil properties under piles that burn at higher than average temperatures and for a longer than average duration. The soil directly under the burned pile may become hydrophobic, inhibiting water infiltration, and there may be losses of soil nutrients (DeBano et al 1998). Those effects could delay the growth of herbaceous vegetation on some of those small, localized sites for several years, although it would not be likely to compromise long-term site productivity for the treated area as a whole. Slash piles would cumulatively cover only 10 percent of the thinned areas ("Forest Vegetation, Fuels, and Fire Behavior" section). If slash is cut and scattered rather than piled prior to burning, these minor and temporary soil

impacts would be avoided, because the prescribed fire ignited in scattered slash would burn at lower temperatures and for shorter durations.

The broadcast burning mimics historic disturbance patterns in Southwestern ponderosa pine forests, and would increase nutrient release and production of understory vegetation. Studies on the Fort Valley Experimental Forest, Arizona, found prescribed burning created a more favorable seedbed by exposing mineral soil and increasing soil moisture, and resulted in a 22-fold increase in germination of ponderosa pine seeds compared with unburned sites (Haase 1986). With a low-severity broadcast burn, there would be increased rates of litter decomposition and nutrient availability in the soil, particularly nitrogen and phosphorus (DeBano 1991, Monleon and Cromack 1996, Ryan and Covington 1986, White 1986). Herbaceous ground cover would be expected to be higher in areas broadcast burned compared to unburned areas that had been mechanically thinned. A cyclic cumulative effect of enhanced growth of understory vegetation is the subsequent increase in the amounts of soil carbon, nitrogen, and microbial biomass carbons, which are favorable to soil productivity (Busse, M.D. et al 1996). This alternative is not likely to adversely effect nutrient cycling in the soil profile. As described by DeBano et al. (1998), fire effects on the soil profile depend on the threshold temperature reached during the broadcast burning. With implementation of the mitigation measures listed in the "Mitigation and Monitoring" section, the overall ground temperatures are anticipated to remain lower than thresholds that would cause nutrient losses (Table 20 and Figure 39). Low-severity burning would help release nutrients from the biomass on the forest floor into the soil profile, stimulating soil development and enrichment processes. Even if there were localized losses of soil nutrients or changes to the soil properties where the prescribed fire burns at higher temperatures (i.e. under the slash piles), those impacts would be attenuated at the Watershed scale so that soil impacts overall would remain negligible. Long-term soil productivity would be maintained under this alternative.

Due to the limited amount of mechanical thinning included in this alternative, it is foreseeable that a high-severity crown fire could spread through the large acreage remaining that would still have a closed overstory canopy following broadcast burning. This would allow a fire to spread, having similar impacts to those described for the No Action Alternative With Wildfire, although to a lesser extent and confined to portions of the middle and upper slopes of the canyon.

Alternative B2

Under this alternative, assuming the mitigation measures listed in the “Mitigation and Monitoring” section are followed, there would be very minor, localized and short-term increases in erosion and sediment yield, and minor changes in soil properties or soil nutrient status. There would be no measurable changes in peak flows, water yield or water quality due to the very limited total acreage treated in this alternative combined with the thin-from-below prescription that retains all of the largest trees. No large scale or long term adverse impacts would be anticipated. In the treated areas, growth of ground vegetation would be greater than existing conditions, however, ground vegetation would continue to be limited by the thick pine needle and duff layer and lack of low-severity surface fire. Long-term soil productivity would be maintained under this alternative.

Among the action alternatives, this alternative results in the highest risk of a catastrophic fire occurring in the untreated portion of the project area after treatment, due to only treating a small percent of the area (“Forest Vegetation, Fuels and Fire Behavior” section). If a large-scale high-severity crown fire consumes the entire wilderness portion of the Watershed along with the other untreated portions, sediment yield and peak flows would be only slightly less than those described for the No Action Alternative With Wildfire.

Alternatives C1, C2, D1 and D2

Effects for these alternative would be similar to those described for Alternative B1 and B2, with minor, short-term, localized erosion, runoff and sediment yield, minor, short-term (10-20 percent) increases in water yield, and no measurable effect on peak flows, water quality or soil nutrients. There would be no unacceptable adverse impacts to soil or water conditions from implementing these alternatives, based on the reasons described for Alternative B1. There would be no reduction in long-term soil productivity.

Noticeable beneficial effects from these alternatives include an increase in herbaceous ground cover that would improve soil properties and reduce erosion and runoff. This would occur mostly on the areas thinned and slash treated. For Alternatives C1 and D1, low-severity broadcast burning would improve nutrient cycling and herbaceous vegetation response. The expected increase in grasses, forbs and shrubs in the project area would enhance long-term soil productivity.

Under these alternatives, there would be a low probability of experiencing a large-scale, high-severity crown fire

within the project area after treatments are complete. Risk of catastrophic fire is lowest for Alternatives C1 and D1 because most of the 7,270-acre project area would be treated to desired fuel levels (“Forest Vegetation, Fuels and Fire Behavior” section). In terms of long-term effects, if low-severity maintenance burns are conducted in the future, soil and water conditions should remain at acceptable or desired levels, as long as a large scale, stand-replacing wildfire does not consume the 10,000 acres remaining untreated in the uppermost portion of the Watershed, most of which is wilderness. If a large-scale, high-severity crown fire consumes the entire headwaters area of the Santa Fe River, sediment yield and peak flows would be 34-37 percent of the sediment projected for the No Action with Wildfire Alternative.

Option A: No Wood Removal

Leaving the logs and treating the slash on the 560 acres of proposed roadside thinning sites would not alter the effects on soil and watershed conditions previously described for the action alternatives, since it is the same treatment being applied on most of the project area under all action alternatives. There would not be a noticeable difference in erosion rates, sediment yield, peak flows, water yield, water quality, or soil nutrients.

Option B: Thin Large Conifers in Canyon Bottom

By felling many of the conifers other than three to five of the largest trees per acre within this relatively fertile portion of the project area, herbaceous vegetation would recover quickly and cover over 50 percent of the forest floor within the treated areas. For the first year after treatment there would be a minor increase in localized erosion. However, because the treated areas are relatively flat and located at least 15 feet from the riparian zone, and the existing riparian vegetation would remain intact along the streambanks, it is anticipated that minimal sediment and ash would enter the river. The larger felled tree trunks that would remain on site as erosion barriers would further limit erosion and sediment delivery to the river.

With this option, the difference in the size of the trees cut and the number of trees cut compared to the other action alternatives would also not make a significant difference in terms of effects on peak flows, water quality, water yield, soil nutrient status. Effects would be similar to those described for the other action alternatives.

Cumulative Effects

Erosion and Sediment Yield

The treatments proposed would have little, if any, cumulative effects when considering effects from other non-project activities in or around the project area that contribute to erosion and sediment in the Santa Fe River. Other past, present and foreseeable future actions were considered that could incrementally add to the sediment load in the Santa Fe River, including land development downstream from the project area. Past improvements to the service road in the Watershed appears to be effectively reducing road related sediment contributions to a minimal level. Downstream from the project area, some river reclamation activities have reduced sedimentation to the Santa Fe River, although there are several non-point sources of sedimentation and water pollution to this river system. The minor sediment delivery expected from the action alternatives, when added to these other sediment contributions, would not result in a significantly larger sediment yield in the Santa Fe River.

The No Action Alternative With Wildfire would result in the largest cumulative increase in sediment yield. The sedimentation effects would primarily be realized in the reservoirs, although sedimentation impacts could be carried in flood events through the City of Santa Fe before the active floodplain would dissipate sediment impacts downstream. Other runoff into the downstream reaches of the Santa Fe River would add to this impact. The potential impacts within the project area itself are far reaching from both the environmental health aspect as well as the City of Santa Fe and Santa Fe County community perspectives. From an environmental health perspective, severe sedimentation in the riparian zone can lead to long-term declines in aquatic and riparian habitats. Single events of severe sedimentation in the riparian zone can conceivably wipe out most, if not all, macro-invertebrates living in the Santa Fe River, and seriously decimate the trout population. It may take several years for regeneration of streamside grasses, forbs, shrubs, and riparian trees.

From the human community perspective, severe sedimentation events may exert large adverse indirect effects on the water treatment plant and water supply for the City of Santa Fe. Large suspended sediment loads and ash, and anaerobic decomposition of organic debris would cumulatively increase in the reservoirs, affecting the water supply for a long period of time. These impacts would likely result in the need for alterations to the treatment plant's water purification

processes, which would be time consuming and costly. Even after the water regains drinking water purification standards, the taste of the drinking water would be undesirable for a long period of time.

The water supply can be adversely affected due to sedimentation, including lost reservoir capacity. A reliable surface water supply depends on having an adequate surface water storage capacity to sustain supplies during dry periods and droughts. If the reservoirs lose capacity due to sediment build-up as expected under Alternative A With Wildfire, they would probably need to be dredged. The dredging operation would reduce water quality for a short time, would be very expensive, and would also result in associated truck traffic impacts (described in the "Social Environment" section). Serious water supply problems were experienced during the summers of 1999 and 2000 (e.g. declared Stage 2 and Stage 3 emergencies) and potential future water shortages in Santa Fe are critical concerns. The city currently depends on 40 percent of the water supply coming from the Watershed. Significant losses in the reservoir capacity would adversely affect water supply to City residents, especially when combined with the lack of sufficient water supply to meet current and future demand. There is no alternative water source currently operational. The City of Santa Fe is currently working with regional governments to investigate development of a regional sustainable water supply system that would include using the reservoirs in the Watershed as part of an overall conjunctive use management strategy.

It is certainly possible, if not likely, that a catastrophic fire in the Watershed could spread into adjacent watersheds, such as the Rio Tesuque or Upper Pecos watersheds. If that occurred, severe sedimentation problems and increased flood potential in those watersheds are likely to follow.

Peak Flow

Another key issue is large increases in peak flows in the Santa Fe River as a result of the No Action Alternative With Wildfire. There are no other land use activities that would significantly alter peak flows in this Watershed. It is expected that following a catastrophic fire in the Watershed, flooding in low-lying areas along the river would increase. Other adverse indirect and cumulative effects of the No Action with Wildfire alternative include: increased potential for over-topping the dams, or incurring damage to the spillway (see the "Facilities" section); greatly increased chance of flooding in the City, causing severe property damage,

including personal property, historic structures (the 100-year and 500-year floodplains include some of the oldest structures in the U.S), museums, art galleries, city utilities and water supply wells. Flooding in downstream communities would also threaten traditional agriculture, which is already at risk due to residential sprawl. As previously mentioned, there would also be a high risk of flooding in Rio Tesuque or upper Pecos watersheds.

Peak flows from a catastrophic fire could affect the Santa Fe River downstream for many miles. The magnitude of the flows would dissipate somewhat as they move downstream toward Cochiti Reservoir. However, the significantly increased peak flows expected following a wildfire for the No Action Alternative With Wildfire would be expected to have devastating effects all the way down to the Village of La Cienega. Other past, present and foreseeable future actions that could incrementally add to peak flows in the Santa Fe River include paving and land development activities.

The action alternatives would only result in very minor and short-term increases in peak flows, even when added to other contributions to peak flows in the Santa Fe River. Ongoing Santa Fe River restoration projects could reduce the impact that peak flows have on channel morphology.

Water Yield

The treatment alternatives would not increase average water yield beyond 15 percent the first year after treatment, and declining in subsequent years as herbaceous vegetation is established.

Alternative A with Wildfire would lead to the largest water yield increases (i.e. on the order of 50-100 percent in the first few years following a fire), due to the major reduction in tree cover anticipated. However, the detrimental effects of severe sedimentation and loss of water quality would offset this beneficial water yield effect. If there were cumulative, long-term increases in annual water yield, beneficial effects would include: keeping the Santa Fe River “wet”, maintaining regular in stream flows within the City; and enhancing recharge of the unconfined aquifer connected to the Santa Fe River. The magnitude of the increased yield would dissipate downstream toward Cochiti Reservoir. Other past, present and foreseeable future actions were considered that could incrementally add to water yield in the Santa Fe River. The primary action expected to slightly increase water yield downstream from the project area is continued land development.

Surface Water Quality

The action alternatives are not expected to adversely impact water quality and would not have an incrementally additive effect on the water quality problems experienced in downtown Santa Fe and below the City limits. Downstream sources of pollution would not affect water quality in the Watershed. There are no other past, present or foreseeable future land uses contributing to water quality degradation in the Watershed. Current water quality is very good.

Alternative A with Wildfire would have severe adverse effects to surface water quality, and those effects would be carried downstream for many miles during peak flows to combine with other source of non-point source of pollution downstream from the project area. The distance of downstream impacts is dependent on the type of water quality changes and the biochemical buffering capacity of the stream. Other past, present and foreseeable future actions were considered that could incrementally add to water quality problems downstream in the Santa Fe River. Those actions include, but are not limited to, changes in grazing practices and land development activities.

The indirect and cumulative effects resulting from a severe fire in the Watershed include not meeting water quality standards for a high quality cold water fisheries stream designation, increases in total suspended and dissolved solids, and increases in nutrient loading. Increased nutrient loading into the river can also cause an increase in algae blooms in the reservoirs, and degradation of water quality can significantly affect operations at the water treatment plant. Aggressive watershed restoration activities following a catastrophic fire would help reduce the recovery time and perhaps avoid some of these adverse cumulative effects.

Soil Nutrients

The action alternatives are not expected to adversely impact soil nutrient status and, therefore, would not have any cumulative effects.

Alternative A with Wildfire would have several adverse indirect and cumulative effects, although aggressive watershed restoration efforts may help attenuate these effects. A high-severity fire interrupts the soil nutrient cycle, destroying some components of the soil nutrient cycle and rapidly releasing other nutrients by volatilizing them. Soil nutrients can also be removed from the site with increased runoff and erosion. The adverse water quality effects discussed above are an indirect effect of adversely impacted soil nutrient cycling. The

rapidly released nutrients are washed into surface water bodies due to the greatly increased runoff. The Watershed soils would be left in a nutrient deficient state. Coupling this with seed mortality in severely burned areas would likely hamper forest regeneration. Site productivity would also be impacted on severely burned soils. Cumulative effects would not likely extend beyond the area directly affected.

Other past, present and foreseeable future actions considered that could incrementally add to soil nutrient impacts include the past elimination of frequent, low-severity fires that helped recycle nutrients, promoted growth of herbaceous vegetation and maintained soil productivity. In addition, historic extraction of large trees and other land uses prior to closure of the Watershed left the canyon bottom almost devoid of pine trees and subject to increased soil erosion. There are no other current or foreseeable future activities in the Watershed that impact soil nutrient status other than the continued lack of surface disturbances such as low-severity fire.

Aquatic Habitat and Biota

An issue related to aquatic habitat and biota is:

Thinning conifers in the canyon bottom near the riparian zone may result in a short-term reduction in shading over the river that may increase water temperature and adversely affect aquatic habitat and fish.

Affected Environment

The only perennial aquatic habitat in the project area is the Santa Fe River, including the two manmade impoundments on the river: McClure and Nichols Reservoirs. Headwaters of the Santa Fe River are at about 11,600 feet elevation at Santa Fe Lake. The stream flows about 10 miles to the inflow to McClure Reservoir. There is about another 3 miles of stream

channel between McClure Dam and the upper end of Nichols Reservoir.

Aquatic Habitat

Approximately 10 miles of the Santa Fe River-from Santa Fe Lake downstream through the wilderness to McClure Reservoir-is unregulated by dams. The segments of the Santa Fe River from the Pecos Wilderness to McClure Reservoir and from McClure Dam to Nichols Reservoir have similar geomorphological characteristics (Table 21). Both segments are classified as B4 stream types, which are fairly stable channels (Rosgen 1996:5-72). Coarse woody debris (i.e. down logs) plays an important role in providing deep pool habitat and cover for fish in B4 stream types (Rosgen 1996:5-72).

Classification of stream channels using the Rosgen system relies on accurate identification of bankfull stage. Bankfull cross-section area was 14.43 square feet at the Pecos Wilderness boundary site and 11.18 square feet at the site above Nichols Reservoir. Watershed area for these sites is about 12 to 18 square miles. These bankfull cross-section areas agree reasonably well with regional curves developed for New Mexico (Moody et al. 2000), indicating that estimation of bankfull stage was accurate.

Aquatic habitat of the Santa Fe River above McClure Reservoir is in excellent condition. The streambanks are stable and well vegetated. Woody riparian vegetation provides shading and coarse woody debris in the channel is abundant, providing cover and pool habitat. The segment of the Santa Fe River between McClure Dam and Nichols Reservoir is subject to regulated flows. Releases from McClure Dam are irregular and flow in the river channel ceases periodically, particularly during dry years. Cessation of releases from McClure Dam results in contraction of aquatic habitat to pools and beaver ponds. Despite the highly regulated flow regime, physical habitat in this portion of the river is in excellent condition due to vigorous riparian vegetation (Figure 40), numerous beaver dams (Figure

Table 21. Delineative Geomorphological Characteristics for Classification Using the Rosgen System (Rosgen 1994; Rosgen 1996) of Two Segments of the Santa Fe River.

Site	Delineative Criteria					Stream Type
	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Slope	Channel Material	
Wilderness Boundary	1.87	15.62	1.09	2.68%	Gravel	B4
Above Nichols Reservoir	1.50	12.88	1.24	2.12%	Gravel	B4

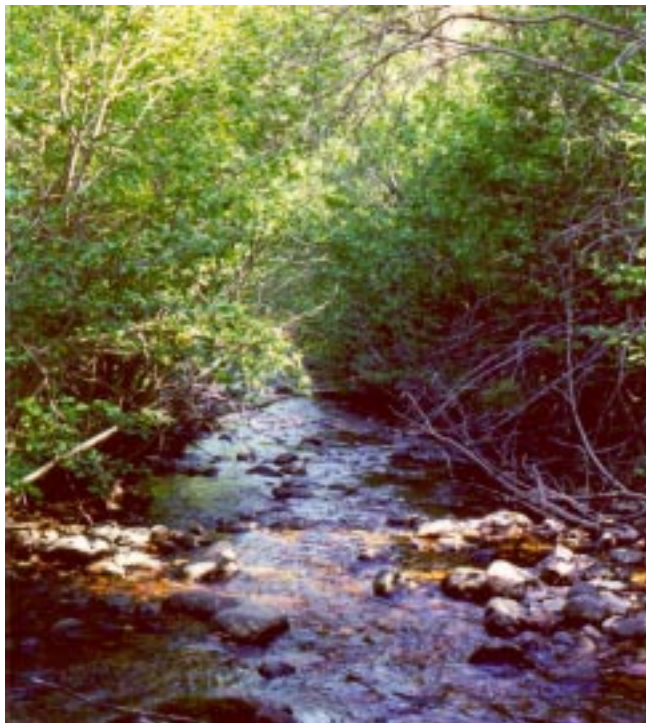


Figure 40. Woody riparian vegetation along the Santa Fe River.

41), and an abundance of coarse woody debris in the channel (Figure 42). The existing population of beavers and their habitat are discussed in the “Riparian Ecosystem and Jurisdictional Wetlands” section.

Fish Community

No historic fish collections are recorded in the Fish Database of the New Mexico Department of Game and Fish. Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) are reported to occur in Santa Fe Lake (U.S. Forest Service 1998). However, the lake is not listed by Sublette et al. (1990) as harboring a population of this native trout. No data are available to characterize the fish communities in McClure and Nichols Reservoirs. It is likely that the two impoundments harbor fish communities similar in species composition to the Santa Fe River.

Fish sampling in the Santa Fe River was conducted at two sites:



Figure 41. Beaver dams on the Santa Fe River.

the Pecos Wilderness boundary and above Nichols Reservoir. Rainbow trout (*Oncorhynchus mykiss*) was the only fish species found. Density of rainbow trout was similar at the two sites (Table 22). However, the average length of trout was slightly higher and the maximum length (10.94 inches) was greater at the Pecos Wilderness site than at the Nichols site.

The relationship between fish length and weight was similar between the two sites. Structure of the rainbow trout population at the Pecos Wilderness boundary indicated successful reproduction and an abundance of trout in the 6- to 7-inch length class. The trout population above Nichols Reservoir was dominated by smaller fish, in the 3 to 4-inch length class (Figure 43).

Management Indicator Species

There is a single aquatic management indicator species for the Santa Fe National Forest: the Rio Grande

Table 22. Trout Density and Mean Length and Weight of Trout at Two Sites where Fish Sampling was Conducted on the Santa Fe River in the Project Area.

Site	Trout Density (no./100 sec)	Mean Length (Range) inches	Standard Deviation	Mean Weight (Range) ounces	Standard Deviation
Pecos Wilderness Boundary	12.9	6.3 in (2.8 to 10.9)	1.75	1.6 oz (0.11 to 6.0)	1.12
Above Nichols Reservoir	12.0	5.4 in (3.1 to 8.6)	1.74	1.1 oz (0.2 to 2.9)	0.96



Figure 42. Large woody debris in the channel of the Santa Fe River.

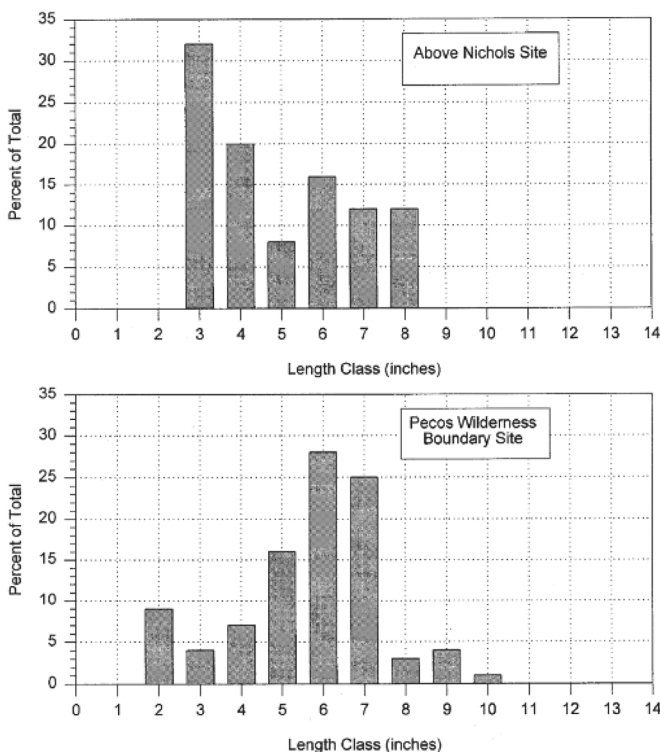


Figure 43. Length-frequency histograms of trout in the project area.

cutthroat trout (*Oncorhynchus clarki virginalis*), which is reported to occur in Santa Fe Lake. It is uncertain if this population represents a pure strain or if Rio Grande cutthroat trout occur in the headwaters of the Santa Fe River. The historic range of the Rio Grande cutthroat is not definitely known although it likely encompassed all waters presently capable of supporting trout in the Rio Grande drainage, including the Chama, Jemez, and Rio San José drainages along with cold water habitats in the Pecos and Canadian River drainages. Populations of this subspecies in New Mexico currently inhabit isolated headwaters of four drainage basins. Of these, the Rio Grande drainage has the most populations with 23 in the Sangre de Cristo Mountains, 13 in the Jemez Mountains, 4 in the San Juan Mountains, and 1 in the Black Range. In three other drainages, 21 streams have populations of Rio Grande cutthroat: Pecos (9); Canadian, including the Mora (11); and a single population in the headwaters of the Tularosa basin (Sublette et al. 1990). Cutthroat trout prefer clear, cold water streams and lakes. Eggs are laid in a gravel nest built in flowing water. Rio Grande cutthroat trout are discussed further in the section, “Special Status Species.”

Effects on Aquatic Habitat and Biota

Alternative A

No Action Without Wildfire

In the absence of disturbance from a wildfire, the aquatic habitats would remain in a state similar to the existing condition. Water management operations at McClure Reservoir would continue to limit the amount of aquatic habitat below that reservoir and the existing rainbow trout fishery and aquatic macroinvertebrate community would continue to be impacted by flow regulation.

No Action With Wildfire

The effects of catastrophic wildfires on fisheries can range from minor losses of individual fish to extirpation of entire populations as well as dramatic changes in the condition of aquatic habitats. Effects of large, stand-replacing fires on aquatic habitat include alteration of the hydrologic regime, radical changes in sediment input and transport, and elevation of water temperatures from loss of riparian cover (Swanson 1981, Minshall et al. 1990, Bozek and Young 1994). Increases in the volume of precipitation runoff and sediment input often occur following large, intense

wildfires (Gresswell 1999). These effects vary with size and severity of the fire and landscape features such as soil characteristics and slope gradient (Swanson 1981, Swanson et al. 1988). Coarse woody debris may increase in the stream channel following large, stand-replacing fires, which may in turn increase the amount of pool habitat.

Elimination of fish populations as the result of large, stand-replacing wildfire is documented in the Southwest (Propst et al. 1992, Rinne 1996) and other regions of the country (Gresswell 1999). Such events typically occur where fish populations are isolated from sources of recolonization following recovery of a stream. Direct mortality of fish may result during a fire from toxic effects of ash and combustion gases (Spencer and Hauer 1991). It is unlikely that all of the fish in the Santa Fe River within the Watershed would be extirpated from a single, large fire event because stream length and habitat diversity are high. These factors would facilitate persistence of refuge populations that could then recolonize the stream. However, in the event that the existing rainbow trout population was extirpated, an opportunity to establish a population of pure Rio Grande cutthroat trout in the Santa Fe River would arise.

Density and diversity of aquatic macroinvertebrates can be reduced substantially following large, stand-replacing fire (Novak 1988, Rinne 1996). Stand-replacing fires in the watersheds of Dude, Ellison, and Bonita Creeks in Arizona resulted in density reductions ranging from 98-100 percent and loss of up to 75 percent of the species compared to pre-fire conditions (Rinne 1996). A stand-replacing wildfire in the Watershed would likely have similar effects on the benthic macroinvertebrate community.

A stand-replacing fire in the headwaters of the Santa Fe River, in the vicinity of Santa Fe Lake, could extirpate the population of Rio Grande cutthroat trout that is purported to occur there. Habitat may remain unsuitable for several years following such a fire. However, a population could be reestablished in the stream following habitat recovery.

All Action Alternatives

For all action alternatives, the treatments would result in very minor increases in sediment delivery to the Santa Fe River ("Soil and Water Resources" section). These slight increases in predicted sediment yield likely would not have any measurable effect on size or viability of trout populations in the project area. Similarly, populations of aquatic invertebrate are not likely to be

substantially affected. Rio Grande cutthroat trout, a management indicator species, would also not be subject to substantial direct or indirect impacts by any treatment alternative.

If a large crown fire occurs in the area despite the fuel reductions treatments, the impacts to aquatic habitat and fisheries would be similar to those described for the No Action With Wildfire Alternative, although the severity and spatial extent of the impacts would be reduced based on the relative effectiveness of the fuel reduction treatments ("Forest Vegetation, Fuels and Fire Behavior" section). Alternatives B2 followed by B1 were determined to be the least effective in preventing a catastrophic fire.

Option A: No Wood Removal

Leaving the logs on site and treating the slash on site within the 560 acres of roadside treatments would not result in any impacts to aquatic habitat or biota.

Option B: Thin Large Conifers in Canyon Bottom

Felling additional conifers and larger-size conifers on about 11 sites (totaling 100 acres) along the canyon bottom just outside of the narrow riparian zone could result in reduced canopy cover and stream shading in localized reaches of the Santa Fe River. Reduction of canopy cover can increase water temperatures, which in turn may reduce suitability of these areas as trout habitat (Patton 1973, Meehan et al. 1977). However, reduction of conifer canopy cover in these scattered patches of coniferous forest would not be likely to have a measurable effect on aquatic habitat conditions. There would be no measurable detrimental effects on the trout population of the Santa Fe River due to the small areas that would be affected by this option. Beneficial effects from this option may be anticipated as some densely forested areas are opened up and replaced with a mix of deciduous riparian plants (in moist sites) and herbaceous vegetation (on drier sites). The increase in ground vegetation would help stabilize soils and reduce sediment yield into the stream channel, which would cumulatively contribute to maintaining or improving aquatic habitat conditions.

Cumulative Effects

Road and reservoir maintenance activities would continue to add minor amounts of sediment into the Santa Fe River in the project area. Culvert installations completed in the recent past would probably be effective in reducing sediment loading to the stream. Future

improvements to the road such as adding a gravel surface may have similar beneficial effects.

Unauthorized fishing in the project area may continue to occur although human trespass activity is thought to be decreasing due to the increased presence of security officers and other government employees. If the City proceeds with their proposed manual thinning of small trees on City lands in the project area, the insignificant sediment contribution from implementing that project would not likely have any impacts. Considered altogether, the minor activities in the area that could contribute incremental amounts of sediment to aquatic habitat in the project area would not significantly add to the effects of the treatments. Therefore, there would be no measurable cumulative effects to aquatic habitat.

Riparian Ecosystem and Jurisdictional Wetlands

Riparian habitats are ecotones (i.e. areas of transition) between upland and aquatic ecosystems that are influenced by lateral water flow from adjacent stream channels (Brown et al. 1979). Riparian vegetation is that which occurs at or adjacent to drainage channels or their floodplains and which differs in species composition from that of immediately surrounding vegetation (Lowe 1961, Dick-Peddie 1993). Riparian environments are dynamic systems that are characterized by frequent disturbance. Periodic and abrupt disturbances create a heterogeneous riparian landscape that includes plant associations representing a variety of successional stages (Steele 1984, Szaro

1989). The principal mechanism of disturbance in riparian ecosystems is flooding. Channel avulsions, sediment deposition, and scour result in patches of the riparian landscape that support early successional species (Malanson 1993). However, other disturbance mechanisms such as fire, grazing, and windthrow may also be important.

Jurisdictional wetlands are habitats regulated under section 404 of the Clean Water Act. Sites are subject to the jurisdiction of section 404 when three criteria are met: 1) vegetation is dominated by hydrophytic species; 2) hydric soils are present; and 3) a regime of wetland hydrology is operative at the site (U.S. Army Corps of Engineers 1987).

Issues related to riparian habitat and jurisdictional wetlands are:

Thinning and burning may promote the spread of invasive plant species such as Siberian elm and Russian olive which currently occur in the canyon bottom below Nichols Reservoir. Invasive, non-native plants can out-compete native species and take over a site. This can result in a decline in habitat quality.

Prescribed burning in the Santa Fe River canyon bottom and along ephemeral drainages may result in killing cottonwood seedlings as they are not resistant to fire.

Treatment activities near the riparian zone may disturb species that use the area, such as the existing beaver population.

Table 23. National Wetland Inventory Community Types Found in the Project Area.

NWI Map Code	Definition
PSS1A	Palustrine broad-leaved deciduous shrub-scrub, temporarily flooded.
PFO1A	Palustrine broad-leaved deciduous forest, temporarily flooded.
PFO/SS1A	Palustrine broad-leaved deciduous forest and shrub-scrub, temporarily flooded.
R3OWH	Upper-perennial riverine, open water, permanently flooded.
R4SBA	Intermittent riverine streambed, temporarily flooded.

Affected Environment

Riparian Ecosystem

Riparian Vegetation Community Types

Large-scale mapping of the project area using 1:58,000-scale color infrared aerial photography delineated five riparian or wetland vegetation community types in the Watershed (Figure 44). Vegetation of these five types consists of deciduous forest and deciduous shrub-scrub (Table 23). This large-scale mapping does not identify the existing narrow bands of deciduous riparian plant species that are restricted to the banks of Santa Fe River in areas with adjacent conifer-dominated overstory trees. These areas are typically dominated by thinleaf alder (*Alnus tenuifolia*) and are

classified as the *Alnus tenuifolia* or *Alnus tenuifolia*-mixed deciduous community types by Szaro (1989).

Palustrine shrub-scrub (PSS1A on Figure 44) vegetation in the project area is characterized by relatively dense stands of bluestem willow (*Salix irrorata*) and coyote willow (*S. exigua*), with lesser numbers of thinleaf alder (*Alnus tenuifolia*) and narrowleaf cottonwood (*Populus angustifolia*). This vegetation community is mapped as occurring only along the Santa Fe River immediately upstream from Nichols Reservoir (Figure 44). The willow scrub community does not correspond well with the vegetation classification system developed by Dick-Peddie (1993). In that system, there are no *Salix exigua*-*Salix irrorata* willow associations. However, this willow shrub-scrub vegetation does correspond well with the *Salix irrorata* community type of Szaro (1989). The shrub-scrub willow association likely represents a successional stage to the forested narrowleaf cottonwood-bluestem willow association.

Palustrine forest (PFO1A on Figure 44) vegetation in the project area is characterized by an overstory of narrowleaf cottonwood or quaking aspen (*P. tremuloides*). Stands dominated by narrowleaf typically have an understory with scattered willow stands and patches of thinleaf alder usually occurring along the streambank. Aspen-dominated stands typically have an understory of

herbaceous species. Palustrine forest vegetation is mapped at two locations along the Santa Fe River between the reservoirs and along the Santa Fe River upstream from McClure Reservoir (Figure 44). Isolated patches of palustrine broad-leaved deciduous forest are also found in a tributary of Agua Sarca Creek on private land in T. 17 N., R. 10 E., Section 27 NE 1/4, and in two ephemeral tributaries to the Santa Fe River in T. 17 N., R. 11 E. Section 19, east of McClure Reservoir (Figure 44). Palustrine forest composition changes from aspen-dominated stands upstream from McClure Reservoir to stands dominated by narrowleaf cottonwood in the segment of the river between McClure and Nichols Reservoirs (Table 24). This change in dominant deciduous riparian tree species corresponds to the change in upland forest vegetation from mixed conifer above McClure Reservoir to ponderosa pine below the reservoir. Narrowleaf cottonwood-dominated palustrine forest in the project area corresponds to the *Populus angustifolia*/*Salix irrorata*/mixed grass-forb association of the Narrowleaf Cottonwood Series in the vegetation classification scheme developed by Dick-Peddie (1993) and the *Populus angustifolia* community type of Szaro (1989). The aspen-dominated riparian forest habitats correspond to the *Populus tremuloides*/mixed shrub/mixed grass-forb association of the Aspen Series (Dick-Peddie 1993). The aspen-dominated riparian habitats most closely resemble the *Acer grandidentatum*-*Abies concolor* community type of Szaro (1989), indicating that these aspen stands are successional to stands with overstory cover dominated by white fir in the absence of any disturbance.

Palustrine forest/shrub-scrub vegetation occurs in the project area as a diverse mosaic of dense willow stands interspersed with stands of narrowleaf cottonwood. It is mapped as occurring along the Santa Fe River between the upper end of Nichols Reservoir and the confluence of Agua Sarca Creek. This vegetation type is obviously successional to forested narrowleaf cottonwood-dominated habitat described above.

The upper-perennial riverine, permanently flooded open water community type occurs

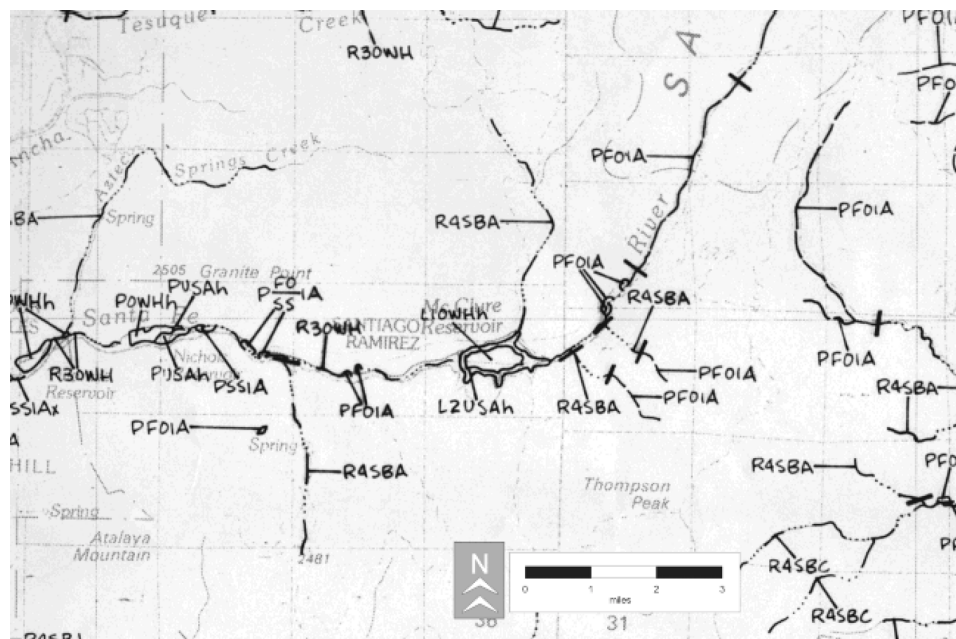


Figure 44. Riparian and wetland communities in the project area (by the National Wetlands Inventory, U.S. Fish and Wildlife Service, from 1:58,000 color infrared aerial photography taken in 1982).

Table 24. Density of Riparian Tree and Shrub Species in Bottomland Forest in the Project Area (excerpted from Tolisano 1998).

Segment of the Santa Fe River	Quaking Aspen no./acre	Narrowleaf Cottonwood no./acre	Thinleaf Alder no./acre	Bluestem or Coyote Willow no./acre
Wilderness boundary to McClure Reservoir	420	86	445	161
McClure Dam to Nichols Reservoir	0	586	200	509

as beaver dam impoundments in the project area (R3OWH on Figure 44). Palustrine broad-leaved deciduous forest and shrub-scrub communities, described above, occur around the beaver ponds. The interpretation of 1982 aerial photography indicated only one occurrence of this community type, located on the Santa Fe River upstream from the confluence of Agua Sarca Creek in T. 17 N., R. 10 E., Section 23.

Riverine streambed (R4SBA on Figure 44) vegetation consists of narrow bands of deciduous species, including bluestem willow, narrowleaf cottonwood, thinleaf alder, and quaking aspen. This community type is mapped in ephemeral tributaries to the Santa Fe River, including Aztec Springs Creek, Agua Sarca Creek, and three unnamed tributaries. These stands are classified as either *Populus angustifolia* / *Salix irrorata* / mixed grass-forb or *Populus tremuloides* / mixed shrub / mixed grass-forb associations (Dick-Peddie 1993), depending on the dominant overstory species.

Riparian Site Characteristics

Riparian sites are defined by the occurrence of plant species that are limited to such habitats which are called obligate riparian plant species (Dick-Peddie 1993). Obligate plant species and semiriparian species, such as aspen, are typically used in classification of riparian vegetation (Dick-Peddie 1993). Obligate riparian species in the project area include bluestem willow, coyote willow, and thinleaf alder. Narrowleaf cottonwood is a riparian species,

but in the project area it may also be found growing along the road or other areas where there has been disturbance of the soil.

The distribution of riparian vegetation in the project area coincides with a soil-moisture gradient associated with surface water drainages. This gradient is typically related to distance from the stream channel. Stream hydrograph plays a central role in the development and maintenance of riparian vegetation through controlling soil moisture levels, sediment deposition on the floodplain, and depth and duration of inundation of the floodplain (Nilsson 1982, Petts 1984, Williams and Wolman 1984). Over time, riparian vegetation would establish a new dynamic equilibrium in response to altered flow and water-level regimes with changes in plant species composition, density, and structure (Nilsson 1982).

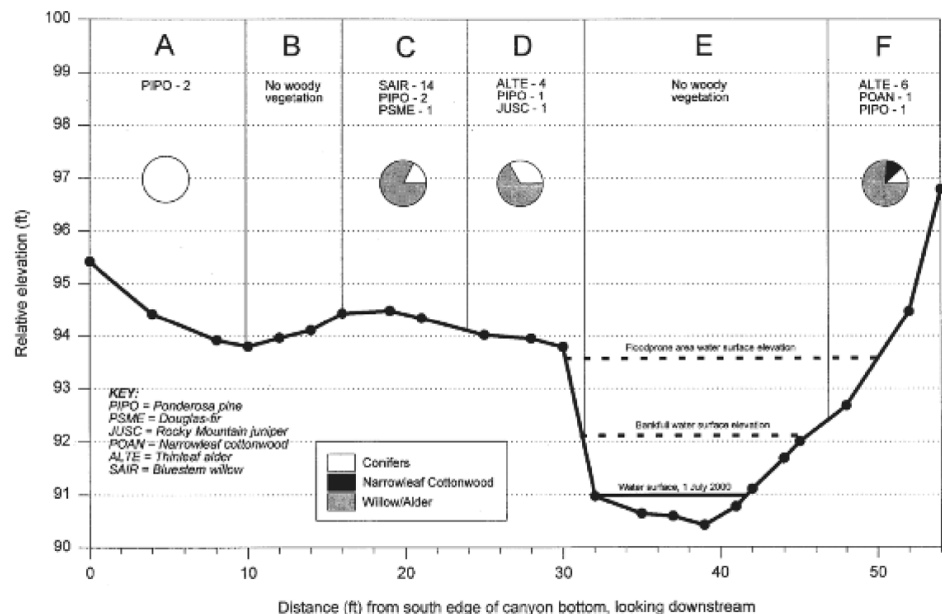


Figure 45. Floodplain cross section in a segment of the Santa Fe River with a narrow floodplain. Numbers next to species codes refer to the number of each species within a 16.4-foot-wide transect.

Flow regulation can decrease riparian plant species cover through induced soil moisture stress or elimination of flow conditions required for seedling establishment (Harris et al. 1985). This effect is evident in locations of the Santa Fe River below McClure Reservoir where the floodplain is narrow and the channel is entrenched (Figure 45). In these areas affected by dams and reservoirs, conifer establishment has occurred on the floodplain to the top of the streambank and seedlings of narrowleaf cottonwood are rare. Thus, these sites have become drier and more suitable for conifer establishment. Overbank flows and high soil moisture conditions necessary for establishment of riparian species no longer exist below McClure dam. The floodplain has essentially become abandoned and now comprises a terrace. The floodprone area water surface elevation in Figure 45 approximates a 50-year recurrence interval flow (Rosgen 1996). A 50-year recurrence interval flow has a 2 percent chance of occurring in any given year and provides an index of the area of the floodplain that is susceptible to inundation on a fairly frequent basis. The bankfull water surface elevation in Figure 45 represents the active channel of the Santa Fe River.

However, flow regulation can also result in increased riparian plant species cover through reduced destructive effects of flooding and increased soil moisture (Harris et al. 1985). This effect is evident in portions of the Santa Fe River below McClure Reservoir where the floodplain is relatively wide and numerous beaver dams, either abandoned or active, create ponded areas and spread surface water over a large area (Figure 46). The elimination of peak flows by the impoundment of flood waters behind McClure Reservoir has allowed numerous abandoned beaver dams to remain in place, which otherwise would have been destroyed by high flows. These abandoned dams, along with active dams and coarse woody debris that has fallen into the channel, create large areas of high soil moisture or inundation. Note that the width of floodplain area dominated by riparian vegetation is about 130 feet in Figure 46,

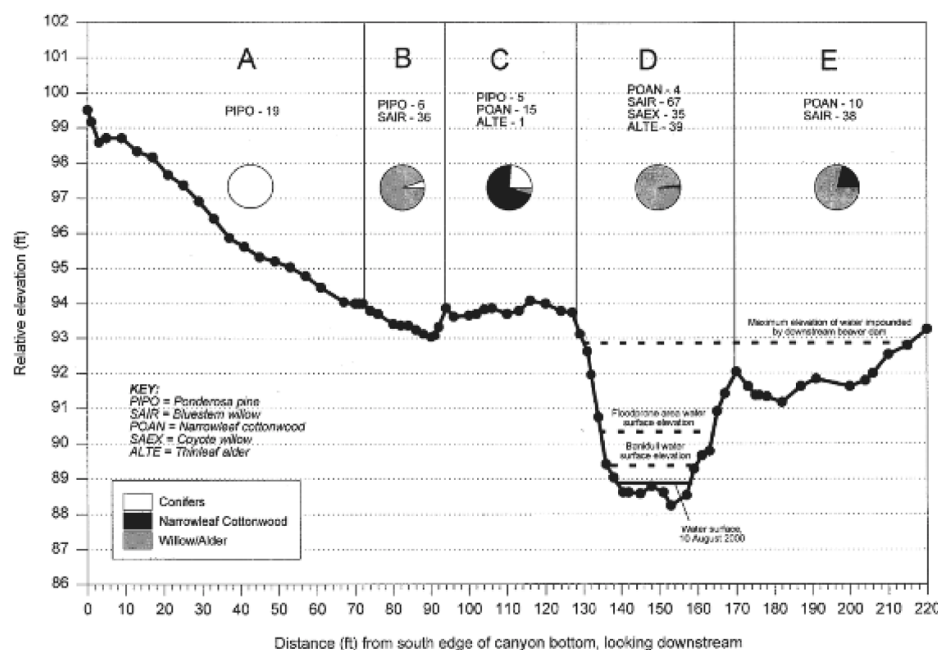


Figure 46. Floodplain cross section in a segment of the Santa Fe River with a wide floodplain. Numbers next to species codes refer to the number of each species within a 16.4-foot-wide transect.

compared to a riparian width of only about 40 feet in Figure 45. When water is released into the Santa Fe River from McClure Reservoir, a beaver dam immediately downstream from the transect location creates an extensive backwater that raises the water surface substantially higher than the floodprone area water surface elevation (Figure 46). Data was collected from this transect on August 10, 2000, when there was no release of water from McClure Dam and the Santa Fe River between the reservoirs consisted of a series of isolated pools.

The floodplain of the Santa Fe River above McClure Reservoir, where flow is not regulated, is generally quite narrow, which is common in the faster-flowing stream reaches near the headwaters. Riparian vegetation in this portion of the Santa Fe River consists of a narrow, dense band of thinleaf alder along the streambank and a conifer- or aspen-dominated forest on the floodplain (Figure 47). As noted earlier, aspen-dominated riparian stands are successional to a white-fir dominated riparian community (Szaro 1989). Obligate riparian plant species along the Santa Fe River above McClure Reservoir are generally restricted to the floodprone area (Figure 47). Beaver dams and debris dams in this portion of the river may act as channel grade controls. The small backwater areas created in these upper

stream reaches results in a localized lateral expansion of the riparian zone due to increased area with high soil moisture. However, these features are not as persistent as those below McClure Dam and are frequently removed by high flows.

Development and Status of Riparian Habitats in the Project Area

Early in the 20th century, riparian habitats in the Watershed were denuded (Snow 1881). The Watershed was grazed extensively by sheep and goats around the turn of the century (Snow 1881, Sabo 1980) and a majority of the tree cover was removed for firewood and lumber (Sabo 1980). Riparian vegetation has recovered from these historic impacts to the current condition. Thus, the floodplain stands of narrowleaf cottonwood, willow thickets, beaver ponds and wetlands, and alder stands along the streambanks have developed mainly in the last 50 to 60 years. The existing riparian habitats in the project area are an important and relatively uncommon habitat feature on a landscape scale and they contribute significantly to habitat diversity.

In an ecological sense, the existing riparian habitats in the Watershed have been judged to be functioning properly (Tolisano 1998). Riparian habitats in the project area have high plant species diversity and are structurally complex. Regeneration of narrowleaf cot-

tonwood is evident where there is overbank flooding or inundation from backwaters created by beaver dams and large woody debris. The former case is evident at the confluence of Agua Sarca Creek and the Santa Fe River, where runoff flows from the ephemeral tributary have deposited sediment on the floodplain, and seedlings and saplings of narrowleaf cottonwood are quite dense. Areas of high narrowleaf cottonwood seedling and sapling density also occur on depositional features in backwater areas. Small areas between the reservoirs where the floodplain is narrow and beaver dams or debris dams are absent have abandoned floodplain sites that are dominated by conifers. Upstream from McClure Reservoir, much of the riparian habitat has very high densities of white fir seedlings and saplings due to the lack of disturbance.

Jurisdictional Wetlands

Jurisdictional wetlands are restricted to narrow vegetated areas within the bankfull channel of the Santa Fe River and to backwater areas behind beaver dams and debris dams where fine sediments have deposited and hydrophytic vegetation has become established. Soils in these wetland areas are dark (Munsell 7.5 YR 2.5/1), have a high proportion of organic matter, and are inundated or saturated within 6 inches of the surface. Vegetation in these areas typically consists of mosses, thinleaf alder, bluestem willow, occasional narrowleaf cottonwood trees, wire rush (*Juncus balticus*), brome (*Bromus* sp.), cutleaf coneflower (*Rudbeckia laciniata*), and other herbaceous species. These wetlands contribute significantly to habitat diversity on a landscape scale.

Wildlife Associated with Wetland and Riparian Habitats

There are 166 vertebrate species that are known to occur in montane riparian habitat in Santa Fe County. This includes 3 amphibian, 7 reptile, 124 bird, and 32 mammal species. Potential species richness in montane riparian habitat in the project area is higher than any terrestrial habitat (see the "Terrestrial Habitat and Associated Wildlife" section). Bird species richness is particularly high in montane riparian habitat. The greatest number of bird species in any terrestrial habitat of the area is 73 in ponderosa pine. However, montane riparian habitat may support up to 124 species of birds.

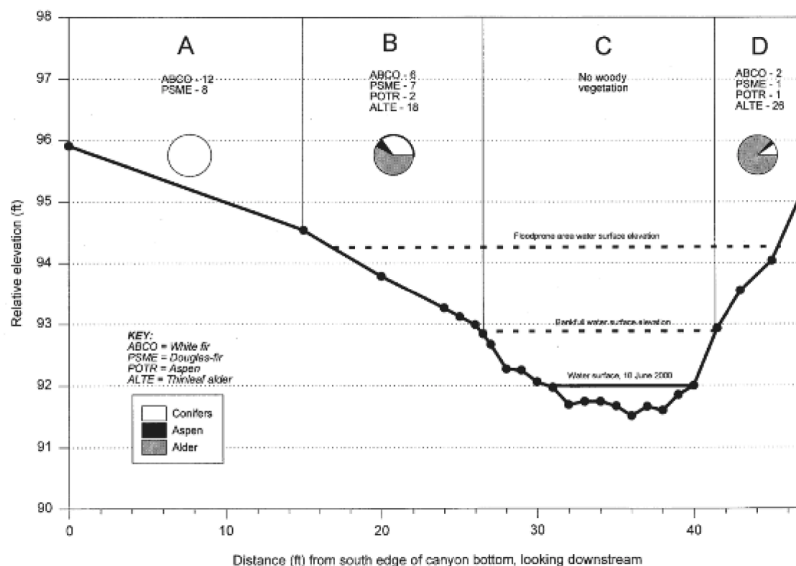


Figure 47. Floodplain cross section in a segment of the Santa Fe River upstream from McClure Reservoir. Numbers next to species codes refer to the number of each species within a 16.4-foot-wide transect.

Of these 124 bird species, 40 percent (49 species) nest in cavities in live or dead trees, or nest in large trees which are defined as trees over 50 feet tall or trees greater than 20-inch diameter (Table 25). Trees that meet these criteria are primarily mature narrowleaf cottonwoods, which are uncommon, and ponderosa pine growing in the canyon bottom. Upstream from McClure Reservoir, Douglas-fir and white fir in the canyon bottom may meet these size criteria. Six of the bird species in Table 26 nest in cavities of large trees.

Beaver are a keystone species in the riparian ecosystem of the Watershed. A keystone species is defined as “one that makes an unusually strong contribution to community structure or processes” (Meffe and Carroll 1994:129). Beavers modify stream habitat and create water impoundments that affect nutrient cycling, streamflow, sediment transport, and channel morphology (Naiman et al. 1986). There is extensive mortality of conifer trees in areas inundated by beaver ponds, which has created snag habitat and provided large woody debris to the stream channel and riparian forest floor. Wetlands created by beaver ponds in the project area provide excellent habitat for species such as northern leopard frog, wandering garter snake, New Mexico garter snake, and water shrew.

Effects on Riparian Ecosystem and Jurisdictional Wetlands

Some of the terrestrial management indicator species may occur in riparian habitats. However, to avoid duplication, terrestrial management indicator species are discussed in the “Terrestrial Habitat and Associated Wildlife” section.

Alternative A

No Action without Wildfire

Without wildfire in the Watershed, riparian aspen stands in the Watershed would continue to be gradually eliminated and replaced by white fir. This would result in gradual, incremental loss of riparian habitat diversity in the project area. This change in species composition would also reduce vegetative resistance to mortality by fire. Flow regulation below McClure Dam would continue to limit floodplain width and growth of riparian vegetation. Downstream from McClure Reservoir, seedling density of ponderosa pine on abandoned floodplain sites would continue to increase. The resultant shading and competition for soil moisture by conifer trees would eventually lead to a decline in the diverse herbaceous communities that currently occupy these sites.

Beneficial habitat modification by beaver would continue in much the same state as the existing condition, resulting in formation of new seedbeds for riparian species and maintenance of backwater and wetland habitats. Accumulation of surface fuels in the riparian ecosystem would continue.

No Action with Wildfire

The effect of large, stand-replacing wildfire on riparian vegetation is dependent on site conditions such as fuel loading, water table, structure and composition of vegetation, litter depth, and climate (Culver 1998). Aspen-dominated riparian stands are reported to burn only when a dense conifer component, such as white fir seedlings, is present (DeByle et al. 1987), which is a common situation within the project area. High-severity fire in these stands would likely result in total stand replacement with aspen sprouts and increased structural diversity of aspen in the project area. This scenario is probable for the riparian habitats upstream from McClure Reservoir that have high densities of white fir seedlings and saplings.

Combustion of litter and ground fuels may provide a seedbed for invasive, non-native species, particularly Siberian elm (*Ulmus pumila*), the wind-born seeds of which can disperse over large distances. Once established, Siberian elm can be very difficult to control (Carter 1997).

Riparian sites in the ponderosa pine forest are reported to have burned at a frequency similar to upland pine forest (Arno and Peterson 1983, McCune 1983). Historically, fires in these riparian areas are generally thought to have burned at a low to moderate severity and in a patchy manner (Arno 1986). However, current conditions of high fuel loads and, in some areas, relatively high densities of conifer trees may create conditions suitable for high-severity fire to burn through some riparian habitats. Narrowleaf cottonwood will sprout from the rootcrown after low to moderate-severity fire, but hot fires will kill individual trees (Schier and Campbell 1976). Seedlings and saplings of narrowleaf cottonwood are susceptible to fire (Culver 1998). Establishment of narrowleaf cottonwood following fire may be quite dense if soil moisture is high enough to maintain seedlings. Coyote willow and other shrub willow species respond to fire in a similar manner (Rowe and Scotter 1973).

The Viveash Fire of 2000 burned approximately 29,000 acres. Approximately 200 acres of riparian habitat were located within the burned area. Of these riparian acres, 7 percent burned with high-severity, 1 percent at moderate-severity, and the remaining 92 percent was either

Table 25. Bird Species that Occur in Montane Riparian Habitat in Santa Fe County and That Nest in Cavities in Live or Dead Trees or That Nest in Large Trees (i.e. trees over 50 feet tall or greater than 20 inches diameter). Source: BISONM 1/2000).

Common Name	Scientific Name	Nest Site		
		Cavity	Large Tree	Cavity in Large Tree
Turkey Vulture	<i>Cathartes aura</i>	X	-	-
Sharp-shinned Hawk	<i>Accipiter striatus velox</i>	-	X	-
Cooper's Hawk	<i>Accipiter cooperii</i>	-	X	-
Northern Goshawk	<i>Accipiter gentilis</i>	-	X	-
American Kestrel	<i>Falco sparverius sparverius</i>	X	X	X
Band-tailed Pigeon	<i>Columba fasciata fasciata</i>	-	X	-
Mourning Dove	<i>Zenaida macroura</i>	-	X	-
Flammulated Owl	<i>Otus flammeolus</i>	X	-	-
Western Screech Owl	<i>Otus kennicottii</i>	X	-	-
Great-horned Owl	<i>Bubo virginianus</i>	X	-	-
Northern Pygmy Owl	<i>Glaucidium gnoma californicum</i>	X	X	X
Mexican Spotted Owl	<i>Strix occidentalis lucida</i>	X	-	-
Black Swift	<i>Cypseloides niger borealis</i>	X	-	-
Belted Kingfisher	<i>Ceryle alcyon</i>	X	-	-
Lewis's Woodpecker	<i>Melanerpes lewis</i>	X	-	-
Williamson's Sapsucker	<i>Sphyrapicus thyroideus nataliae</i>	X	-	-
Ladder-backed Woodpecker	<i>Picoides scalaris</i>	X	-	-
Downy Woodpecker	<i>Picoides pubescens leucurus</i>	X	-	-
Hairy Woodpecker	<i>Picoides villosus</i>	X	-	-
Three-toed Woodpecker	<i>Picoides tridactylus dorsalis</i>	X	-	-
Northern Flicker	<i>Colaptes auratus</i>	X	-	-
Olive-sided Flycatcher	<i>Contopus cooperi</i>	-	X	-
Ash-throated Flycatcher	<i>Myiarchus cinerascens cinerascens</i>	X	-	-
Pinyon Jay	<i>Gymnorhinus cyanocephalus</i>	-	X	-
Tree Swallow	<i>Tachycineta bicolor</i>	X	X	X
Violet-green Swallow	<i>Tachycineta thalassina lepida</i>	X	X	X
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	X	X	X
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>	-	X	-
Black-capped Chickadee	<i>Poecile atricapillus</i>	X	-	-
Mountain Chickadee	<i>Poecile gambeli gambeli</i>	X	-	-
Juniper Titmouse	<i>Baeolophus ridgwayi</i>	X	-	-
Red-breasted Nuthatch	<i>Sitta canadensis</i>	X	-	-
White-breasted Nuthatch	<i>Sitta carolinensis nelsoni</i>	X	-	-
Pygmy Nuthatch	<i>Sitta pygmaea melanotis</i>	X	-	-
Brown Creeper	<i>Certhia americana</i>	X	X	X
Bewick's Wren	<i>Thryomanes bewickii</i>	X	-	-
House Wren	<i>Troglodytes aedon parkmannii</i>	X	-	-
Golden-crowned Kinglet	<i>Regulus satrapa</i>	-	X	-
Ruby-crowned Kinglet	<i>Regulus calendula calendula</i>	-	X	-
Blue-gray Gnatcatcher	<i>Poliophtila caerulea amoenissima</i>	-	X	-
Western Bluebird	<i>Sialia mexicana bairdi</i>	X	-	-
Mountain Bluebird	<i>Sialia currucoides</i>	X	-	-
European Starling	<i>Sturnus vulgaris</i>	X	-	-
Yellow Warbler	<i>Dendroica petechia</i>	-	X	-
Yellow-rumped Warbler	<i>Dendroica coronata</i>	-	X	-
Black-throated Gray Warbler	<i>Dendroica nigrescens</i>	-	X	-
Grace's Warbler	<i>Dendroica graciae graciae</i>	-	X	-
Baltimore Oriole	<i>Icterus galbula</i>	-	X	-
Bullock's Oriole	<i>Icterus bullockii</i>	-	X	-
Total Number of Species		32	23	6

unburned or was subject only to low-severity fire (USDA Forest Service 2000e). Growth of herbaceous vegetation on riparian sites was reported within a month after burning and woody vegetation in severely burned areas exhibited sprouting (USDA Forest Service 2000e). Many of the woody riparian species were not completely burned. From these results, it seems likely that where a crown fire burns through riparian-dominated vegetation, it would not result in total destruction of all of the riparian vegetation and that recovery would be fairly rapid. In contrast, evidence from the Viveash and Cerro Grande Fires indicates that conifer-dominated portions of riparian zones typically burn at a higher severity and destroy the vegetation in those areas. Therefore, portions along the Santa Fe River riparian zone dominated by deciduous plant species may burn with less severity than in conifer dominated patches.

Effects on riparian-dependent wildlife would vary with season. Nesting birds would likely be the most adversely affected group if a crown fire occurred during the spring or summer. Eggs and nestlings would suffer high mortality if occupied nest trees burned (Kapler 2000). Post-fledgling birds and mammals generally are capable of avoiding fire and mortality resulting from a fire is not likely to substantially affect populations of riparian birds or mammals.

Riparian-dependent reptile and amphibian species are found in moist to very wet areas which are likely to burn with low severity or not at all. A large fire in the Watershed probably would not compromise the viability of populations of these species. However, major debris and mudflows may fill beaver dams with sediment. Rainfall events and resulting peak flows may result in breaching of beaver dams. The beaver population would be adversely impacted by these events but should be able to recover in the long term.

All Action Alternatives

Selective thinning and slash disposal would not be conducted in the riparian or wetland ecosystems, but would occur within the drier portions of the canyon bottom area above the river and primarily along the service road. Wet meadows and beaver habitats are completely excluded from the treatment areas. Therefore, the treatments would not directly affect riparian or wetland habitats. Indirect effects may include short-term localized disturbance of wildlife in riparian and wetland habitats adjacent to upland treatment areas. Such temporary disturbance would not likely result in any measurable effects on persistence of beaver populations or any other riparian-associated wildlife species. Thinning and slash disposal would usually be con-

ducted in late summer, fall and winter. Thus, nesting birds in riparian and wetland habitats would not be affected by noise disturbance from thinning and slash disposal on adjacent upland areas.

None of the alternatives propose to burn riparian vegetation. Under Alternatives B1, C1 and D1 where low-to moderate-intensity broadcast burns are conducted, one would expect a beneficial reduction of surface fuels and litter, improved nutrient availability, increased production of herbaceous vegetation, and induced regeneration of woody riparian species. The likelihood of a severe crown fire resulting from the broadcast burning near the riparian area would be extremely low due to conditions of high humidity, low air temperature, low wind speed and other factors that would be components of the prescription for broadcast burning.

Overall, compared to the No Action Alternative where a serious crown fire would be anticipated, implementation of treatment alternatives would reduce the severity and spatial extent of a crown fire, although to varying degrees. The alternatives determined to be most effective in reducing this crown fire risk (C1 and D1, followed by C2 and D2) would have the most beneficial effects, by reducing the probability of crown fire impacts to riparian habitats of the Watershed.

Option A: No Wood Removal

Leaving the logs and treating the slash on the 560 acres along roads would not result in any additional impacts on riparian or wetland resources for any of the alternatives.

Option B: Thin Large Conifers in Canyon Bottom

Approximately 11 scattered patches of conifer trees totaling about 100 acres would be thinned along the flatter canyon bottom areas adjacent to the Santa Fe River. Thinning would not occur within the riparian areas, which would be delineated based on the occurrence of willows or alders and would include a 15-foot-wide buffer around such areas. The larger conifer trees subject to felling under this option provide a relatively uncommon habitat component for wildlife in the project area. Felling these larger trees, leaving three to five per acre, would reduce the amount of large standing tree habitat available for species that require this component, such as the bird species described in Table 26. However, it is expected that many of the larger trees felled would be left in place (as they are too far from the road to be manually removed), which would increase the number of large down logs in this area. Large down

logs are an important wildlife habitat component, and are also lacking within the canyon bottom. Research by Harrington (1999) indicated that removing conifers that had become established in a riparian zone helped restore riparian habitat to a more sustainable condition. Overall, no unacceptable adverse effects to the riparian or wetland habitats or species would be expected from this option.

Cumulative Effects

If the City proceeds with their thinning project along the roads on City lands in the project area, it would add to the duration of the disturbance effects described for the action alternatives. If thinning operations are conducted during the nesting season for birds (i.e. spring through summer), reductions in nesting success of a variety of species could result. These disturbances could add to the other minor disturbances from ongoing road and reservoir maintenance activities, road improvement work, data collection, public field tours, unauthorized recreational activities, security patrols, and others. Overall, cumulative disturbance effects to riparian species would be minimal and short-term and would not affect population viability for any species. There are no other habitat-altering projects proposed for the foreseeable future within the project area.

Terrestrial Habitat and Associated Wildlife

Affected Environment

Terrestrial habitat in the Watershed is described based on vegetation associations defined by dominant plant species and vegetation inventory data described in the “Forest Vegetation, Fuels, and Fire Behavior” section. Vegetation associations provide a consistent basis for describing broad habitat types that occur in the project area. From this information, inferences can be made about expected wildlife species richness, based on habitats with which wildlife species are associated.

This section does not discuss terrestrial wildlife species that are listed as proposed, threatened, endangered or other special status species. Those species and their habitats are included in the subsequent “Special Status Species” section.

Issues related to terrestrial habitat and associated wildlife are:

Thinning and burning may result in changes to forest structure and species composition that may affect the quality of terrestrial habitat and associated wildlife species. For example, unintentional burning of snags, or felling of snags that pose worker safety concerns, may reduce nesting or roosting habitat. As another example, a reduction in tree density and canopy closure in ephemeral tributaries to the Santa Fe River may reduce the quality of these wildlife corridors for some species. Habitat changes may also affect population viability for Forest Plan management indicator species.

Terrestrial Habitats

Five vegetation associations, as mapped by the New Mexico Gap Analysis Project, are found in the Santa Fe Municipal Watershed. These vegetation associations are: Rocky Mountain-Great Basin closed conifer woodland (i.e. piñon-juniper woodland), Rocky Mountain lower montane conifer forest (i.e. ponderosa pine forest), Rocky Mountain upper montane conifer forest (i.e. mixed conifer forest), subalpine broadleaf forest (i.e. aspen forest), and subalpine conifer forest (i.e. spruce-fir forest). The project area is comprised of the first two associations along with a minor aspen component. Figure 3 in Chapter 1 shows a map of forest vegetation types in the project area.

Piñon-Juniper and Oak Woodlands

The Rocky Mountain-Great Basin closed conifer woodland, or piñon-juniper woodland, is dominated by rounded-crown, low stature conifer trees that typically create canopy cover of 40 percent or more. Piñon is the dominant tree with respect to canopy cover. Juniper is a common tree in this woodland vegetation association. Important species in the understory vegetation includes species such as gray oak (*Quercus grisea*), skunkbush, blue grama (*Bouteloua gracilis*), and mountain muhly (*Muhlenbergia montanus*). This vegetation association corresponds to the Colorado Pinyon - One-Seed Juniper Series of Dick-Peddie (1993) and is commonly referred to as piñon-juniper woodland. In the eastern portion of the project area is an old wildfire burn area dominated by shrub-stature Gambel oak growing in association with other shrubs such as

wavyleaf oak, mountain mahogany, and skunkbush. These areas correspond to the Colorado Pinyon - Oak - Juniper Series of Dick-Peddie (1993).

The Piñon-juniper woodlands range from moderately-closed canopy stands on south- and southwest-facing slopes to dense, closed canopy stands on cooler, moister, north- and northeast-facing slopes. Shrub-oak woodland occurs on rocky, south-facing slopes along the northwest side of the Santa Fe River above McClure Reservoir and along south- and southwest-facing slopes east of the river above McClure (Figure 3). Piñon-juniper woodland in the project area is contiguous with large expanses of similar woodland habitat to the north, south, and west. Thus, the piñon-juniper woodland vegetation in the project area is not a unique component of the regional landscape, nor does it provide habitat features that are not found in the adjacent woodland habitats.

Ponderosa Pine Forest

The Rocky Mountain lower montane conifer forest, or ponderosa pine forest, consists of open to closed canopy stands dominated by ponderosa pine. Understory vegetation varies considerably with degree of canopy closure and aspect. Important species in understory vegetation, where it is present, include buckbrush (*Ceanothus fendleri*), Gambel oak, wavyleaf oak, mountain mahogany, New Mexico locust (*Robinia neomexicana*), kinnikinnick (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), wood rose (*Rosa woodsii*), snowberry (*Symphoricarpos oreophila*), mutton bluegrass (*Poa fendleri*), Arizona fescue (*Festuca arizonica*), mountain muhly, screwleaf muhly (*Muhlenbergia virescens*), blue grama (*Bouteloua gracilis*), and pine dropseed (*Blepharoneuron tricholepis*). This forest association corresponds to the lower montane coniferous forest of Dick-Peddie (1993).

Ponderosa pine forest is the dominant vegetation association in the project area. Much of the ponderosa pine forest lacks understory grasses, forbs and shrubs due to high tree density and canopy closure. The oak component of the ponderosa pine forest consists of widely scattered clumps of low-stature Gambel oak brush, typically along ridgetops and upper slopes. Large areas of ponderosa pine forest consist of these homogeneous stands of mostly small diameter, closed-spaced trees. Refer to the "Forest Vegetation, Fuels, and Fire Behavior" section for further description of the high tree densities and composition of the ponderosa pine forest in this area. The dense, homogeneous age class and vertical structure of most of the ponderosa pine forest stands in the project area diminish its quality as wildlife habitat.

Ponderosa pine forest in the project area is contiguous with large expanses of similar forest habitat to the north and south. On a large-scale perspective, these ponderosa pine forests all share similar characteristics in terms of age class structure, tree density, and structural diversity. The ponderosa pine forest vegetation in the project area, therefore, is not a unique component of the regional landscape.

Mixed Conifer Forest

Rocky Mountain upper montane conifer forest, or mixed conifer forest, consists of generally closed-canopy forest dominated by Douglas-fir, white fir, and blue spruce (*Picea pungens*). Ponderosa pine and limber pine (*Pinus flexilis*) are also found in mixed conifer forest on drier sites. As with ponderosa pine forest, undergrowth is highly variable. Where understory vegetation is present, species diversity can be very high. Important understory plant species include Rocky Mountain maple (*Acer glabrum*), Gambel oak, kinnikinnick, snowberry, creeping mahonia (*Berberis repens*), Arizona fescue, fringed brome (*Bromus ciliatus*), mountain and screwleaf muhly, meadowrue (*Thalictrum fendleri*), strawberry (*Fragaria americana*), geranium (*Geranium richardsonii*), and yarrow (*Achillea millefolium*). The mixed conifer forest described here corresponds to the upper montane coniferous forest of Dick-Peddie (1993), particularly the White Fir - Douglas-fir - Ponderosa Pine Series.

Mixed conifer forest occurs in the higher elevation forests in the wilderness, outside the project area. Small patches of mixed conifer forest occur on north-facing slopes in some of the tributary canyon bottoms within the project area

Aspen

The subalpine broadleaf forest, or aspen forest, consists of a closed canopy forest dominated by quaking aspen. Aspen forests are often long-term successional communities to mesic to wet mixed conifer forest and spruce-fir forest. Aspen forests typically have understory species characteristic of the surrounding conifer forest (Dick-Peddie 1993). Aspen forest occurs as small stands of localized clones in the lower elevation, drier mixed conifer sites dominated by white fir, Douglas-fir, and ponderosa pine. In upper elevation, moister mixed conifer sites dominated by blue spruce, white fir, and Douglas-fir and in the spruce-fir forest, aspen stands can potentially cover larger, contiguous patches of the landscape (Dick-Peddie 1993).

Within the Pecos Wilderness, aspen occurs as relict trees in late-successional conifer stands dominated by Engelmann spruce (*Picea engelmanni*) and other conifers, including Douglas-fir (Cassidy 1998). In the project area, most aspen stands consist of narrow strips along canyon bottoms, where sites are cool and moist relative to the surrounding warm and dry ponderosa pine forest. These small, linear strips of aspen forest contribute significantly to habitat diversity at the landscape level in ponderosa pine and dry mixed conifer forests.

Spruce-Fir Forest

The subalpine conifer forest, or spruce-fir forest, is characterized by a closed canopy dominated by Engelmann spruce and fewer numbers of subalpine fir (*Abies lasiocarpa*), often with Douglas-fir and white fir as associated, successional species. Important understory species include mosses, myrtle huckleberry (*Vaccinium myrtillus*), currant (*Ribes montigenum*), bearberry honeysuckle (*Lonicera involucrata*), thimbleberry (*Rubus parviflorus*), forest fleabane (*Erigeron eximius*), spike trisetum (*Trisetum spicatum*), and fringed brome. This vegetation association corresponds to the subalpine coniferous forest of Dick-Peddie (1993) and is commonly referred to as spruce-fir forest.

Spruce-fir forest occurs on cold, wet sites generally above about 9,000 feet elevation. This forest type is found only in the northeastern third of the Watershed, in the Pecos Wilderness. Spruce-fir forest in the project area is characterized by multi-storied stands that are typically about 150 years old or older. The spruce-fir forest in the Watershed is relatively homogeneous, which is characteristic of this forest type because succession occurs with stand-replacing fires. Small relict aspen stands are apparent in the spruce-fir forest, as evidenced by scattered, old trees and aspen downfall on the forest floor. Most aspen stands in the spruce-fir forest in the Watershed have or are in the process of converting to conifer-dominated stands due to the lack of fire disturbance in at least the last 100 years (Cassidy 1998).

Terrestrial Wildlife

This section discusses wildlife habitat and species that may occur in any of the five vegetation associations described for the entire Watershed, including areas outside the project treatment area. The ponderosa pine, piñon-juniper and aspen vegetation associations are emphasized as they could be directly affected by treatment activities in the project area.

Table 26. Number of Vertebrate Species in Each of the Five Vegetation Associations Found in the Watershed (BISONM database, 1/2000).

Vegetation Association	Number of Species (Percent of Total)				Total
	Amphibians	Reptiles	Birds	Mammals	
Piñon-Juniper Woodland	4 (3%)	29 (21%)	72 (52%)	34 (24%)	139
Ponderosa Pine Forest	2 (2%)	9 (8%)	77 (65%)	30 (25%)	118
Mixed Conifer Forest	1 (1%)	5 (5%)	63 (64%)	30 (30%)	99
Aspen 1 Forest	2 (1%)	52 (3%)	26 (64%)	81 (32%)	
Spruce-Fir Forest	1 (1%)	2 (3%)	54 (65%)	26 (31%)	83

* Species tallies for each vegetation association were obtained by querying the database for species that make important use of each vegetation association in any season and that also are known to occur in Santa Fe County. For example, to obtain the number of mammal species in piñon-juniper woodland, the following query was used: select spp with occur.county = '049' and with cat = '05' and with gap matches "'3121-1X'-10'".

A list of terrestrial wildlife species associated with each of the five vegetation associations was compiled using the Biota Information System of New Mexico database (BISONM version 1/2000). Species tallies for each vegetation association were obtained by querying the database for species that make important use of the specific vegetation association and are known to occur in Santa Fe County. Specific queries are detailed in the project record. Use of a vegetation association is considered important if a species actually lives in the vegetation type during at least one season.

Total wildlife species richness is highest in piñon-juniper woodland

and ponderosa pine vegetation associations (Table 26). Amphibian and reptile species richness is highest in the warmer habitats of the piñon-juniper woodland and ponderosa pine forest. The number of species of these two groups declines with increasing elevation. Bird species richness reaches a peak in the ponderosa pine forest vegetation association. The number of mammal species in each vegetation association exhibits a pattern similar to herptiles, where the total number of species decreases with increasing elevation (Table 26).

Table 27. Bird Species That Use Ponderosa Pine Stands Dominated by 5- to 12-inch Diameter Trees with 40-100 Percent Canopy Closure

Sharp-shinned Hawk (<i>Accipiter striatus velox</i>)
White-breasted Nuthatch (<i>Sitta carolinensis nelsoni</i>)
Cooper's Hawk (<i>Accipiter cooperii</i>)
Pygmy Nuthatch (<i>Sitta pygmaea melanotis</i>)
Blue Grouse (<i>Dendragapus obscurus obscurus</i>)
Brown Creeper (<i>Certhia americana</i>)
Broad-tailed Hummingbird (<i>Selasphorus p. platycercus</i>)
Bewick's Wren (<i>Thryomanes bewickii</i>)
Rufous Hummingbird (<i>Selasphorus rufus</i>)
House Wren (<i>Troglodytes aedon parkmannii</i>)
Olive-sided Flycatcher (<i>Contopus cooperi</i>)
Ruby-crowned Kinglet (<i>Regulus calendula calendula</i>)
Western Wood Pewee (<i>Contopus sordidulus</i>)
Bohemian Waxwing (<i>Bombycilla garrulus pallidiceps</i>)
Dusky Flycatcher (<i>Empidonax oberholseri</i>)
Cedar Waxwing (<i>Bombycilla cedrorum</i>)
Cassin's Vireo (<i>Vireo cassinii</i>)
Virginia's Warbler (<i>Vermivora virginiae</i>)
Plumbeous Vireo (<i>Vireo plumbeus</i>)
Yellow-rumped Warbler (<i>Dendroica coronata</i>)
Solitary Vireo (<i>Vireo solitarius</i>)
Townsend's Warbler (<i>Dendroica townsendi</i>)
Warbling Vireo (<i>Vireo gilvus swainsonii</i>)
Black-throated Green Warbler (<i>Dendroica virens virens</i>)
Mountain Chickadee (<i>Poecile gambeli gambeli</i>)
Grace's Warbler (<i>Dendroica graciae graciae</i>)
Juniper Titmouse (<i>Baeolophus ridgwayi</i>)
Macgillivray's Warbler (<i>Oporornis tolmiei</i>)
Bushtit (<i>Psaltiriparus minimus</i>)
Western Tanager (<i>Piranga ludoviciana</i>)
Red-breasted Nuthatch (<i>Sitta canadensis</i>)

Piñon-juniper woodland habitat supports 48 vertebrate wildlife species that are not found in ponderosa pine, mixed conifer, aspen, or spruce-fir habitats. Ponderosa pine supports four species not found in any of the other vegetation associations and three species are unique to spruce-fir forest.

Factors Currently Influencing Wildlife Species Richness

The number of species that actually occur in a vegetation association is largely a function of the age size structure of the forest and the interspersed patches that differ in species composition, tree density, and size-class distribution (Hunter 1990). Of these factors, diversity of different aged stands in a forest plays a critical role (Hunter 1990). Wildlife species richness in the ponderosa pine forest of the project area is limited by the relatively uniform conditions that include a high density of small diameter trees, closed canopy, lack of large trees, and scarcity of understory vegetation. Of the 77 bird species known to make important use of ponderosa pine forest, only 31 (40 percent) use stands with most trees in the 5- to 12-inch diameter class and a canopy closure of 40-100 percent, which represent typical conditions of ponderosa pine forest in the project area (Table 27). Similarly, only 5 of the 30 mammal species (17 percent) that occur in ponderosa pine forest use young, small-diameter forest structure stands with closed canopy (Table 28). Thus, the current condition of ponderosa pine forest limits the diversity of vertebrate wildlife species that could potentially occur there.

The interspersed disturbance-related vegetation associations, such as oak and aspen, and of different-aged stands within a vegetation association are low in the project area. Although relatively small in area, aspen and narrowleaf cottonwood dominated stands in canyon bottoms in the project area contribute significantly to habitat diversity and heterogeneity. Aside from riparian habitats with a narrowleaf cottonwood overstory, aspen and oak stands provide the only deciduous forest habitat in the project area.

The understory vegetation in aspen stands is typically more productive, dense, and more diverse than in adjacent conifer forest (Reynolds 1969, Kranz and Linder 1973, Severson 1982). Aspen stands characteristically support a richer invertebrate fauna than surrounding conifer forest (Glenn-Lewin 1977), which provides an abundant, diverse food base for insectivorous species. Additionally, numerous species use the bark, buds, and foliage of aspen as a food source. Young aspen stands (less than ca. 8 years old) provide valuable browse, particularly during fall and winter (Patton and Jones

Table 28. Mammal Species that Use Ponderosa Pine Stands Dominated by 5- to 12-inch Diameter Trees with 71-100 Percent Canopy Closure.

Dusky Shrew (<i>Sorex monticolus</i>)
Ringtail (<i>Bassariscus astutus</i>)
Golden-mantled Ground Squirrel (<i>Spermophilus lateralis</i>)
Elk (<i>Cervus elaphus nelsoni</i>)
Black Bear (<i>Ursus americanus amblyceps</i>)

1977, Tew 1970). Despite the fact that aspen stands cover a very small area of the Watershed, 56 percent (81 of 145) of the wildlife species found in ponderosa pine, mixed-conifer, or spruce-fir habitat make important use of aspen habitat at least during part of the year. Mule deer and elk browse on aspen bark, leaves, buds, twigs, and sprouts. Cottontail rabbit, pocket gophers, squirrels, mice, voles, porcupine, and beaver also feed extensively on aspen (DeByle 1985). In the Watershed, aspen stands provide potential habitat for up to 63 species of birds. Mesic aspen sites typically support higher bird species diversity than drier aspen sites and sapling to pole-size stands provide good winter cover for birds (DeByle 1985). Early seral stands of aspen also provide hiding cover for deer and elk.

Another important habitat component in the project area is oak woodlands or scrub. In Arizona, the occurrence of oaks was found to be an important variable affecting bird distribution in ponderosa pine forest (Rosenstock 1998). Seventeen of the 193 vertebrate wildlife species (8 percent) that may occur in the project area are associated with or feed on oak. Oak foliage provides browse for deer and elk and may be particularly important in winter and spring (Brown 1958, Reynolds et al. 1970). Acorns produced by Gambel oak are consumed by a variety of mammals and birds (Reynolds et al. 1970). Young or uneven-aged stands of Gambel oak with patches of open, grassy areas provide good cover for elk and mule deer (Kunzler and Harper 1980). Mountain mahogany (*Cercocarpus montanus*) is an important browse plant for wildlife that is commonly found in oak stands in the project area (Lamb 1971).

Snags and down logs provide important habitat for wildlife (Maser and Trappe 1984, Smith 2000). Snags are particularly important for cavity-nesting birds (Cunningham et al. 1980, Newton 1994). The proportion of wildlife species that use snags ranges from 27

percent in mixed conifer forest to 35 percent in spruce-fir forest (Table 29). Based on limited stand examination data, snag density in the ponderosa pine forest in the project area is about one per acre but may be highly variable. Down logs are an important element in habitat for small mammals (Goodwin and Hungerford 1979). The proportion of species that use down logs ranges from 15 percent in piñon-juniper woodland to 35 percent in spruce-fir forest (Table 30). Down logs are particularly important for several species of small mammals including mice, shrews, voles, and weasels. Large down logs (i.e. 1,000 hour fuels) occur in the project area at a density of 13 to 15 tons per acre.

Management Indicator Species

Terrestrial management indicator species for the Santa Fe National Forest are Merriam's turkey (*Meleagris gallopavo merriami*), mourning dove (*Zenaidura macroura*), Mexican spotted owl (*Strix occidentalis lucida*), hairy woodpecker (*Picoides villosus*), pinyon jay (*Gymnorhinus cyanocephalus*), elk (*Cervus elaphus nelsoni*), and Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*). Mexican spotted owl is Federally listed as threatened and is discussed in the "Special Status Species" section. Of the remaining six species, Merriam's wild turkey, hairy woodpecker, pinyon jay, and elk may occur or have suitable habitat in the project area.

Merriam's wild turkey occurs in mountainous habitats. Ponderosa pine is the most frequently used roost tree and also provides a source of mast. Ponderosa pine is an essential component of habitat for Merriam's wild turkey, as is close proximity to surface water. Piñon nuts are also an important food source (American Ornithologists' Union 1957). Turkeys mate in March and April and females lay 9 to 12 eggs in shallow depressions in grass and pine needles. Nests are located at the base of a tree, typically next to a down log. Poults hatch in about 28 days. Winter roost trees are typically large ponderosa pine trees with horizontal branches. These winter roost trees are used year after year. Turkeys have been sited in the project area in ponderosa pine forest within about one-third mile of the Santa Fe River.

Mourning dove is uncommon from spring through fall in the vicinity of the project area (National Audubon Society 1990). This dove occurs in open forest habitats and forest edges and avoids dense forests. Breeding occurs in the summer months. Nests are constructed in trees, shrubs, or on the ground, and clutch size is typically two eggs. Eggs hatch in about 2 weeks. Mourning doves feed primarily on seeds of grasses and forbs and typically forage in open areas with low-

Table 29. Species Associated with Snag Habitat in the Santa Fe Municipal Watershed.

Species	Piñon-Juniper	Pine	Mixed Conifer	Aspen	Spruce-Fir
Eastern Fence Lizard (<i>Sceloporus undulatus</i>)	X	X	-	-	-
Northern Tree Lizard (<i>Urosaurus ornatus</i>)	X	-	-	-	-
Great Plains Skink (<i>Eumeces obsoletus</i>)	X	-	-	-	-
Desert Striped Whipsnake (<i>Masticophis taeniatus taeniatus</i>)	X			-	-
Turkey Vulture (<i>Cathartes aura</i>)	X	X	X	X	X
Northern Goshawk (<i>Accipiter gentilis</i>)	-	X	X	X	X
American Kestrel (<i>Falco sparverius sparverius</i>)	X	X	-	-	-
American Peregrine Falcon (<i>Falco peregrinus anatum</i>)	X	X	X	X	X
Band-tailed Pigeon (<i>Columba fasciata fasciata</i>)	X	X	X		-
Flammulated Owl (<i>Otus flammeolus</i>)	-	X	X	-	X
Western Screech Owl (<i>Otus kennicottii</i>)	X	-	-	-	-
Great-horned Owl (<i>Bubo virginianus</i>)	X	X	X	-	X
Northern Pygmy Owl (<i>Glaucidium gnoma californicum</i>)	X	X	-	-	X
Mexican Spotted Owl (<i>Strix occidentalis lucida</i>)	X	X	X	-	X
Boreal Owl (<i>Aegolius funereus</i>)	-	-	-	-	X
Lewis's Woodpecker (<i>Melanerpes lewis</i>)	X	X	X	-	-
Williamson's Sapsucker (<i>Sphyrapicus thyroideus nataliae</i>)	X	X	X	X	X
Ladder-backed Woodpecker (<i>Picoides scalaris</i>)	X	-	-	-	-
Downy Woodpecker (<i>Picoides pubescens leucurus</i>)	-	X	X	X	X
Hairy Woodpecker (<i>Picoides villosus</i>)	X	X	X	X	X
Three-toed Woodpecker (<i>Picoides tridactylus dorsalis</i>)	-	-	X	X	X
Northern Flicker (<i>Colaptes auratus</i>)	X	X	X	X	X
Olive-sided Flycatcher (<i>Contopus cooperi</i>)	-	X	X	X	X
Ash-throated Flycatcher (<i>Myiarchus cinerascens cinerascens</i>)	X	-	-	-	-
Tree Swallow (<i>Tachycineta bicolor</i>)	-	-	X	X	X
Violet-green Swallow (<i>Tachycineta thalassina lepida</i>)	-	X	X	X	X
Black-capped Chickadee (<i>Poecile atricapillus</i>)	X	X	X	-	-
Mountain Chickadee (<i>Poecile gambeli gambeli</i>)	X	X	X	X	X
Juniper Titmouse (<i>Baeolophus ridgwayi</i>)	X	X	-	-	-
Red-breasted Nuthatch (<i>Sitta canadensis</i>)	-	X	X	X	X
White-breasted Nuthatch (<i>Sitta carolinensis nelsoni</i>)	X	X	X	X	X
Pygmy Nuthatch (<i>Sitta pygmaea melanotis</i>)	-	X	X	X	X
Brown Creeper (<i>Certhia americana</i>)	X	X	X	X	X
Bewick's Wren (<i>Thryomanes bewickii</i>)	X	X	-	-	-
House Wren (<i>Troglodytes aedon parkmannii</i>)	-	X	X	X	X
Western Bluebird (<i>Sialia mexicana bairdi</i>)	X	X	-	-	-
Mountain Bluebird (<i>Sialia currucoides</i>)	X	X	X	X	X
Long-legged Myotis Bat (<i>Myotis volans interior</i>)	X	X	X	X	X
Fringed Myotis Bat (<i>Myotis thysanodes thysanodes</i>)	X	X	X	X	X

Table 29. Species Associated with Snag Habitat in the Santa Fe Municipal Watershed (Continued).

Species	Piñon-Juniper	Pine	Mixed Conifer	Aspen	Spruce-Fir
Southwestern Myotis Bat (<i>Myotis auriculus apache</i>)	X	X	X	-	-
Big Brown Bat (<i>Eptesicus fuscus pallidus</i>)	X	X	X	X	X
Pallid Bat (<i>Antrozous pallidus pallidus</i>)	X	X	-	-	-
Colorado Chipmunk (<i>Tamias quadrivittatus</i>)	X	X	X	-	-
Deer Mouse (<i>Peromyscus maniculatus</i>)	-	X	X	X	X
Brush Mouse (<i>Peromyscus boylii rowleyi</i>)	X	-	-	-	-
Pinyon Mouse (<i>Peromyscus truei truei</i>)	X	-	-	-	-
Northern Rock Mouse (<i>Peromyscus nasutus</i>)	X	X	-	-	-
White-throated Wood Rat (<i>Neotoma albigula</i>)	X	-	-	-	-
Bushy-tailed Wood Rat (<i>Neotoma cinerea</i>)	X	X	-	-	X
Southern Red-backed Vole (<i>Clethrionomys gapperi</i>)	-	-	X	X	X
Common Gray Fox (<i>Urocyon cinereoargenteus scottii</i>)	X	X	-	-	-
Black Bear (<i>Ursus americanus amblyceps</i>)	X	X	X	-	X
Ringtail (<i>Bassariscus astutus</i>)	X	X	X	X	-
American Marten (<i>Martes americana origenes</i>)	-	-	-	-	X
Mountain Lion (<i>Felis concolor</i>)	X	X	X	X	X
Bobcat (<i>Lynx rufus baileyi</i>) X	X	X	X	X	
Total Number of Species Using Snags	42	42	35	28	33
Percent of Total	30%	30%	27%	34%	35%

growing vegetation (Tomlinson et al. 1994). Suitable habitat for mourning dove is limited in the project area by high tree density and lack of open areas for foraging.

Hairy woodpeckers are an uncommon bird from summer through fall in the vicinity of the project area (National Audubon Society 1990). They occur from low elevation riparian habitats in desert grassland up into spruce-fir forest. The species nests in cavities of live or dead trees, with aspen being a commonly used tree species. Breeding occurs from May through July. Clutch size averages 4 eggs and incubation lasts about 12 days. Hairy woodpeckers forage mainly on insects taken from dead or diseased trees, but they will also consume fruits, grains, and nuts. Suitable habitat for hairy woodpecker is found in the project area and the species has been sited in the vicinity of the Watershed.

Pinyon jay occurs throughout the year in Santa Fe County (Hubbard 1978). This jay uses habitats ranging in elevation from Chihuahuan desert scrub to

ponderosa pine forest. Pinyon jays nest in April and May and build nests in piñon or ponderosa pine. Clutch size ranges from 3 to 6 eggs and the incubation period is 16 to 17 days (Bailey and Niedrach 1965). Pinyon jays are omnivorous. Suitable habitat for pinyon jay is found in the project area.

Elk are found in mountain meadows and mountain coniferous forests in summer. In winter, they move to lower elevations. Grass composes about 85 percent of the diet of elk and they forage primarily in montane grassland (Findley et al. 1975). About 65 percent of elk observed during a study on the east slope of the Jemez Mountains used shrub- and grass-dominated habitat and piñon-juniper woodland. Elk used mixed conifer forests least, with only 5 percent of all elk observed in this vegetation type (Biggs et al. 1997). Mating typically occurs in September and October and calving occurs in late May and early June. Elk often use the same calving areas year after year. Very few elk have been seen using the project area.

Table 30. Species Associated with Down Logs in the Watershed.

Species	Piñon-Juniper	Pine	Mixed Conifer	Aspen	Spruce-Fir
Tiger Salamander (<i>Ambystoma tigrinum</i>)	X	X	X	X	
Eastern Fence Lizard (<i>Sceloporus undulatus</i>)	X	X	-	-	-
Great Plains Skink (<i>Eumeces obsoletus</i>)	X	-	-	-	-
Milk Snake (<i>Lampropeltis triangulum</i>)	X	X	-	-	-
Smooth Green Snake (<i>Liochlorophis vernalis blanchardi</i>)	-	X	X	-	-
Turkey Vulture (<i>Cathartes aura</i>)	X	X	X	X	X
Blue Grouse (<i>Dendragapus obscurus obscurus</i>)	-	X	X	X	X
Mexican Spotted Owl (<i>Strix occidentalis lucida</i>)	X	X	X	-	X
Black-capped Chickadee (<i>Poecile atricapillus</i>)	X	X	X	-	-
Bewick's Wren (<i>Thryomanes bewickii</i>)	X	X	-	-	-
House Wren (<i>Troglodytes aedon parkmannii</i>)	-	X	X	X	X
Townsend's Solitaire (<i>Myadestes townsendi townsendi</i>)	X	X	X	X	X
Masked Shrew (<i>Sorex cinereus cinereus</i>)	-	-	-	-	X
Dusky Shrew (<i>Sorex monticolus</i>)	-	X	X	X	X
Nuttall's Cottontail Rabbit (<i>Sylvilagus nuttallii pinetis</i>)	-	X	X	X	X
Least Chipmunk (<i>Tamias minimus</i>)	X	X	X	X	X
Colorado Chipmunk (<i>Tamias quadrivittatus</i>)	X	X	X	-	-
Golden-mantled Ground Squirrel (<i>Spermophilus lateralis</i>)	-	X	X	-	-
Deer Mouse (<i>Peromyscus maniculatus</i>)	-	X	X	X	X
Brush Mouse (<i>Peromyscus boylii rowleyi</i>)	X	-	-	-	-
Pinyon Mouse (<i>Peromyscus truei truei</i>)	X	-	-	-	-
Southern Red-backed Vole (<i>Clethrionomys gapperi</i>)	-	-	X	X	X
Long-tailed Vole (<i>Microtus longicaudus</i>)	-	-	X	X	X
Common Porcupine (<i>Erethizon dorsatum</i>)	X	X	X	X	X
Common Gray Fox (<i>Urocyon cinereoargenteus scottii</i>)	X	X	-	-	-
Black Bear (<i>Ursus americanus amblyceps</i>)	X	X	X	X	X
Ringtail (<i>Bassariscus astutus</i>)	X	X	X	-	-
American Marten (<i>Martes americana origenes</i>)	-	-	-	-	X
Ermine Weasel (<i>Mustela erminea muricus</i>)	-	-	X	X	X
Long-tailed Weasel (<i>Mustela frenata</i>)	X	X	X	X	X
Striped Skunk (<i>Mephitis mephitis</i>)	X	X	X	X	X
Mountain Lion (<i>Felis concolor</i>)	X	X	X	X	X
Bobcat (<i>Lynx rufus baileyi</i>)	X	X	X	X	X
Total Number of Species Using Coarse Woody Debris	21	25	28	18	21
Percent of Total	15%	21%	24%	22%	25%

Rocky Mountain bighorn sheep were extirpated from New Mexico in 1903. However, the species was reintroduced and currently it is found along the crest of the Sangre de Cristo Mountains as far south as Pecos Baldy, the Truchas Peaks, and Santa Fe Baldy (Frey and Yates 1996). Bighorns inhabit rugged cliffs and crags or other extremely rocky areas adjacent to suitable feeding sites, which include grass as well as browse plants (Findley et al. 1975). Suitable habitat for bighorn sheep does not occur in the project area.

Effects on Terrestrial Habitat and Associated Wildlife

Alternative A

No Action Without Wildfire

In the absence of disturbance, the high tree density dominated by small diameter trees and high canopy closure in ponderosa pine forest would remain relatively unchanged due to extremely slow growth of existing trees resulting from intense competition. Similarly, understory vegetation diversity and biomass would remain unchanged from existing conditions in the absence of disturbance. Therefore, wildlife species richness in ponderosa pine forest would remain low compared to a forest with more diversity in size classes of trees and spatial array of different-aged stands. Aspen would continue to be replaced by conifer species and would decline in extent in the project area, further reducing diversity of habitats. White fir seedlings and saplings in the understory of ponderosa pine-Douglas-fir and aspen sites would remain at high densities and would continue to inhibit understory vegetation by shading.

No Action With Wildfire

The effects of a large, stand-replacing crown fire include creation of large, continuous patches of total tree mortality with combustion of organic matter in the soil. Mortality of relatively immobile species, such as amphibians, reptiles, and small mammals would be anticipated, with maximum mortality occurring during the breeding or nesting season (Erwin and Stasiak 1979). Wood rats, which build a nest on the surface composed of dry, combustible materials, are particularly vulnerable to fire (Simons 1991). Large mammals may suffer mortality during large, fast-moving crown fires but mortality rates from such events are typically quite low (Smith 2000).

The Cerro Grande Fire burned a total of just over 42,000 acres, of which over 16,000 acres (38 percent) was a stand-replacement burn. An understory burn is defined as less than 25 percent tree loss, a mosaic burn is 25-80 percent tree mortality, and a stand-replacement burn is over 80 percent tree mortality (von Bonin et al. 2000). The La Mesa Fire of 1977 burned through stands with similar tree density and canopy closure as forest in the Watershed (Lissoway 1994) although the soil types and productivity were different than the project area. After the La Mesa Fire, an area that had not burned since 1893 had complete loss of overstory canopy and over 90 percent bare soil (Foxy 1994). Sixteen years after the La Mesa Fire, the site still had 62 percent bare soil, and vegetation consisted of 20 percent grasses, about 14 percent forbs, and ponderosa pine seedling density of 539 per acre. Areas of complete canopy loss showed a linear increase in understory vegetation cover with time following the fire (Foxy 1994).

Establishment of a mature ponderosa pine forest on sites with complete tree loss would require 180 to 200 years on most sites in the Watershed. Stand-replacing fire in moist to wet mixed conifer and spruce-fir stands in the upper Watershed area would likely result in establishment of large patches of aspen. Some stands in the moist to wet mixed conifer and spruce-fir forests would likely be subject only to understory or mosaic burns, which would result in a diversity of forest types and age classes in these higher elevation habitats. This scenario is likely in the event of a crown fire burning through the Watershed.

In areas of the La Mesa Fire where forest cover was lost, bird species richness and diversity increased within 4 years after fire (Johnson and Wauer 1994). Population sizes of bird species declined temporarily following stand-replacing fire. Compared to pre-fire conditions, populations of seed-eating birds and raptors were higher at sites where over 80 percent of the forest cover was lost following the La Mesa Fire (Johnson and Wauer 1994). Insectivorous birds that search surface areas, as opposed to birds that drill into timber for insect prey, decreased at sites following the La Mesa Fire and had not recovered to pre-fire density after 16 years (Johnson and Wauer 1994). This was likely the result of marked depression in arthropod populations following the fire (Pippin and Nichols 1994). Snags and downed logs increased after the La Mesa Fire because fire-killed trees were not removed. The increase in snags and down logs following the La Mesa Fire resulted in increased bird species diversity and abundance compared to pre-fire conditions (Moeur and Guthrie 1984). Comparable responses of birds to fire have been

reported from other locations (Dodd 1988, Hutto 1995). Avifauna response to a stand-destroying crown fire in the Watershed would likely be similar.

Removal of forest vegetation and replacement by grass and forb dominated communities resulted in a dramatic increase in elk population size at Bandelier National Monument within 3 years following the La Mesa Fire (Allen 1994). The amount of winter range for elk would likely increase substantially in the Watershed following a stand-destroying crown fire. This may, in turn, draw more elk into the Watershed and eventually result in a larger population size. Some species of small mammals, including ground squirrels, deer mice, and pocket gophers, typically increase following stand-replacing fire while other species such as shrews, voles, rabbits, and squirrels decline in abundance following stand-replacing fire (Ream 1981). However, some areas would be subject only to understory or mosaic burns and would continue to provide habitat for these species.

Management Indicator Species

A stand-replacing fire in the Watershed would likely benefit hairy woodpecker, as large numbers of dead trees would provide foraging and nesting habitat for the species. Elk would also benefit from such a fire, which would open up large areas of dense forest and create suitable habitat. The effect of such a fire on Merriam's wild turkey and pinyon jay would likely be neutral or negative, depending on the amount of forest and woodland habitat that retain some tree cover. Based on the effects of the Cerro Grande Fire (von Bonin et al. 2000), sufficient area with less than 80 percent tree mortality would remain to provide suitable habitat for these species. Therefore, while a crown fire in the Watershed would have negative short-term impacts to habitat used by these species, it would not likely diminish population viability of these species or measurably reduce their populations on the Santa Fe National Forest over the long-term.

All Action Alternatives

Effects of Thinning and Slash Disposal

Animal species native to fire-adapted pine communities typically persist in habitat shaped by fire, and the prescribed thinning combined with low-intensity burning treatments are generally beneficial to plants and animals native to these ecosystems (Lyon et al 1981, and [online] 1999 fs.fed.us/database/feis). Scientific research consistently finds that prescribed underburning in ponderosa pine stands enhances habi-

tat for birds, including goshawks, owls, woodpeckers, and migratory birds, as well as large and small mammals common to ponderosa pine forest communities (Crane et al 1999, and [online] 1999 fs.fed.us/database/feis).

The selective thinning operation is designed to create a mosaic of stands with different size classes interspersed across the treatment areas. Therefore, forest structure would become more diverse than current structural conditions. A demonstration project in the Watershed based on similar criteria altered a stand with about 360 trees per acre and 63 percent canopy cover to 83 trees per acre and 29 percent canopy cover.

Selective thinning is likely to improve the coverage and diversity of understory vegetation, particularly in areas where canopy cover is substantially diminished, such as in Alternatives C1, C2, D1 and D2. Tree density is the primary factor controlling understory vegetation production in ponderosa pine forests (Teclé et al. 1991). The relationship between tree basal area and understory vegetation production is typically inverse curvilinear, where understory production decreases with increasing basal area. Increases in understory vegetation occurred on the Aspen Ridge Timber Sale when stands were reduced to a density of less than 75 to 100 trees per acre (Cassady 2000). Increasing understory herbage production is recognized as an important benefit to wildlife (Teclé et al. 1991). The increase in herbaceous vegetation should result in an increase in the abundance of rodents and other small mammals, which are prey species for raptors and other wildlife.

One minor negative effect would be the noise disturbance that would occur during thinning operations, which would likely result in avoidance of work areas by wildlife. This effect would be temporary and wildlife would move back into suitable habitat in treated areas following cessation of noise disturbance. Disturbance from felling of trees, moving logs, piling or chipping of slash, and increased vehicle traffic on the access road may also result in mortality of relatively immobile species. However, such mortality is not expected to be substantial and would not diminish the viability or persistence of affected populations.

Burning of slash piles under all alternatives could generate relatively high temperatures in the soil, which could result in establishment of unpalatable weedy species (Ffolliot and Guertin 1988, Teclé et al. 1991). However, mitigation measures designed to keep piles small and burn when there is snow on the ground should reduce the potential for this effect.

The number of down logs would be substantially increased as a result of the thinning treatments, because the vast majority of the trees felled would not be removed from the Watershed. Down logs provide cool, moist microclimates for reestablishment of grasses and other plants, aid in nutrient cycling and add to habitat diversity. Numerous species would benefit from the increase in down logs, including mice, shrews, voles, and weasels (Table 31).

Selective thinning may reduce cover in densely wooded drainage bottoms that often serve as corridors for wildlife movement. This effect would be mitigated by allowing for forest patches with higher tree density and canopy cover to be interspersed with patches thinned to a lower tree density and lower canopy cover, as proposed. Wildlife may be temporarily displaced from these corridors during thinning activities. However, by leaving an average of approximately 50 to 100 of the largest trees per acre as prescribed outside of the fuel break areas, leaving aspen and hardwood species, and following other mitigation measures listed in the "Mitigation and Monitoring" section, wildlife using these corridors should not be adversely affected.

Treated forest areas would have higher structural diversity than the existing forest, as some forest patches would not be treated and selectively thinned areas would not be treated uniformly. Selective thinning from below would result in stands dominated by a higher percentage of trees over 16-inch diameter. The remaining dominant trees would also be expected to increase in size as a result of the reduced competition from other trees (Biondi and Dallmeier 1998).

The predominance of approximately 80-year-old, 5- to 12-inch diameter trees, which has the characteristics of a young forest, would be changed to stands dominated by 12- to 24-inch diameter trees, characteristic of a more mature stand. Mature and old growth ponderosa pine forest habitats are lacking in the Southwest due in part to long-term exclusion of low-intensity fire and the resulting domination by high-density stands, which suppress the development of mature habitat characteristics (Fiedler et al 1997, Gruell et al 1982, Arno and Harrington 1999). The treatments prescribed would result in a shift toward a more mature and eventual old growth ponderosa pine forest, which would beneficially affect many terrestrial wildlife species and potentially increase wildlife species richness. For example, of the 77 bird species that make important use of ponderosa pine forest, 7 are found in stands dominated by 12- to 24-inch diameter trees that are not found in stands dominated by smaller trees. These species are flammulated owl,

Mexican spotted owl, Lewis's woodpecker, downy woodpecker, hairy woodpecker, violet-green swallow, and red crossbill.

Selective thinning of conifers in aspen stands would result in reduced canopy cover and increased sunlight reaching the forest floor, which would increase aspen sprouting and regeneration (Doucet 1989). Alternatives B1, C1 and D1, which include broadcast burning, would further increase aspen regeneration compared to the other alternatives. Aspen regeneration would be particularly dense in areas where openings in the canopy are created by thinning or broadcast burning. The resulting increase in aspen would improve overall habitat diversity by providing a more diverse size structure and variation in aspen density. Such a change in aspen stand characteristics would likely result in increased species richness in aspen stands that are currently converting to conifer-dominated stands.

Effects of Broadcast Burning - Alternatives B1, C1, D1

Use of low-intensity prescribed broadcast burning is known to have many beneficial effects on wildlife habitat, generally due to increased patchiness, forage abundance, plant diversity, and nutritional content and digestibility of plants (Crane et al 1999, Lyon et al 1982, Meneely and Schemnitz 1981, Stark and Steele 1977, USDA Forest Service 2000, and online references at fs.fed.us/database/feis). The burns included in these three alternatives would consume primarily litter, woody debris on the ground, tree seedlings and small saplings. Production of understory vegetation increases following prescribed burning (Harris and Covington 1983, Oswald and Covington 1984, Andariese and Covington 1986). Increased understory production is primarily due to reduced depths of litter and duff and reduction in overstory canopy cover. Additionally, burning in ponderosa pine forest results in increased availability of soil nitrogen, phosphorus and moisture (Covington and Sackett 1988, White 1986). In the project area, removal or marked reductions in the existing high density of conifer seedlings and saplings would allow more sunlight to reach the forest floor, which would benefit herbaceous vegetation. Short-term (i.e. within 2 years following the fire) increases in nutrient content of herbaceous plants may occur following prescribed burning that generates soil surface temperatures of 550°F to 600°F (Severson and Medina 1983, Severson and Rinne 1988). Sprouting and regeneration in oak and mountain mahogany stands would occur with prescribed fire, which improve their quality as a food source and cover habitat for wildlife (Reynolds et al. 1970, Pase and Lindenmuth 1971).

Prescribed broadcast burning is not likely to result in substantial mortality of large aspen, and would promote aspen regeneration (Brown and DeByle 1987). Moderate-severity fire would result in dense sprouting, while low-severity fire would result in patchy sprouting and formation of uneven-age stands (Bartos and Mueggler 1981). Prescribed burns would likely kill some of the intermediate trees that have heavy fuel loadings underneath them, which would increase the number of snags in the project area. The low-heat intensity of the prescribed broadcast burns would not consume the numerous down logs left as a result of the thinning and slash burning treatments.

There would be a moderate risk for a large crown fire to occur after treatment for Alternatives B1 and B2, which were determined to be the least effective in reducing crown fire risk. Other action alternatives would be more effective in reducing the risk of catastrophic wildfire ("Forest Vegetation, Fuels and Fire Behavior" section). If a large crown fire should occur after project implementation, effects to wildlife habitat would be similar to those described for the No Action with Wildfire Alternative. However, fewer acres would likely have stand-replacing burns and a majority of the acreage would be subject to understory or mosaic burns. Such a fire would likely be contained or suppressed at a smaller size than under the No Action Alternative.

Management Indicator Species

Habitat for Merriam's wild turkey, elk, hairy woodpecker, and pinyon jay would likely improve or remain unchanged due to increased understory vegetation, maintenance of large ponderosa pine, selective removal of smaller conifers, and maintenance of snags. Increases in understory vegetation would not be as great under Alternative B2 due to the limited acreage thinned and the lack of broadcast burning. Lack of broadcast burning under Alternatives B2, C2 and D2 would result in continuation of thick litter and duff and nutrient limitations that would inhibit increases in understory vegetation compared to Alternatives B1, C1 and D1. For all action alternatives, populations of these species would not be expected to decline and viability would not likely be diminished.

Option A: No Wood Removal

The effects of this option would be similar to the action alternatives that remove the wood, Alternative B1, except that noise disturbance to wildlife from a chipper and from heavy vehicle traffic associated with hauling wood would not occur.

Option B: Thin Large Conifers in Canyon Bottom

This option affects only 100 acres, scattered over 11 different sites, which is a relatively minor portion of the 17,000-acre Watershed and surrounding terrestrial habitats. Effects of this option were described in the previous section on riparian ecosystems. This option would be likely to not adversely impact terrestrial wildlife populations that use the Watershed. It would reduce a portion of the large tree habitat component in the project area, while beneficially increasing herbaceous vegetation in the canyon bottom below the service road.

Cumulative Effects

The geographic area for cumulative effects analysis for terrestrial wildlife was determined based on the spatial extent of effects of proposed treatments (i.e. selective thinning and broadcast burning) on wildlife habitat. These treatment effects are limited to areas within the Watershed that are primarily ponderosa pine cover type. This is also the spatial scale at which treatment effects could be significant. Past, present, and reasonably foreseeable future actions proposed outside of the Watershed were thus not considered as being potentially influenced by action alternatives with respect to effects on wildlife and its habitat. These actions include development projects at the Santa Fe Ski Basin, Black Canyon Campground, and Hyde Park Road residential areas.

Ongoing security patrols, routine water system maintenance around the dams, visitor tours, and occasional trespassing recreationists cause a low level of disturbance in the Watershed, principally along the access road and the Santa Fe River. These levels of disturbance are minor for terrestrial wildlife and its habitat. Disturbances from proposed treatments, combined with these past and ongoing disturbance levels, would result in minor cumulative disturbance effects on wildlife. These cumulative disturbance levels would be limited in time and space so that the effect on wildlife in the Watershed would be unsubstantial.

Future actions, including scientific monitoring of resource response to treatments, and associated activity, would result in low levels of disturbance to wildlife. These disturbance levels, in concert with proposed treatments, would result in minor cumulative effects on wildlife. There are no other known future development actions proposed within the Watershed at this time that would result in any ground disturbance or modification of vegetation.

Special Status Species

An issue related to special status species is:

Thinning and burning may result in changes to forest structure, species composition, and percent canopy closure that may affect the quality of habitat for threatened, endangered, sensitive species that may occur or have suitable habitat in the project area.

Affected Environment

Federal Proposed, Threatened or Endangered Species

Table 31 lists the Federal proposed, threatened or endangered species known to occur in Santa Fe County. The Federal Endangered Species Act of 1973; 12-28-73, Public Law 93-205 87 Stat. 884 as amended protects these species. The list of species is published as Title 50 Code of Federal Regulations 17.11 and 17.12.

The Federally listed species in Table 31 are not known to occur in the project area, which is dominated by dense piñon-juniper, ponderosa pine, and ponderosa pine/Douglas-fir cover types. A minor amount of potential habitat for Mexican spotted owl and southwestern willow flycatcher occur in or near the project area.

Black-footed ferrets need areas where prairie dog towns 80 acres or larger are present (32 Federal Register 4001 1967). The dependency of the ferret on the prairie dog is so great that the reduction in numbers of ferrets is directly related to the reduction in prairie dogs (Hoffmeister 1986). No prairie dog towns or black-footed ferrets are present in the Watershed.

Bald eagle is a winter resident along the Rio Grande and Rio Chama down to Cochiti Reservoir (New Mexico Department of Game and Fish 1988). The eagles leave New Mexico in March to breed further north. They are not known to use the Watershed nor likely to use the Watershed.

Mountain plover is a bird that uses semi-arid plains, grasslands and plateaus (Peterson 1990). These habitats do not occur in the Watershed.

Mexican spotted owl uses mixed conifer forests for roosting and nesting. No mixed conifer forest occurs within the project area, although there is mixed conifer forest in higher elevation forests outside the project area, and small patches of mixed conifer in some drainage bottoms within the project area. Stand exam data and additional field reconnaissance by professional foresters confirmed that the ponderosa pine/Douglas-fir stands on the moist north and northeast slopes do not meet the definition of mixed conifer forest (restricted habitat) as defined in the Recovery Plan for the Mexican spotted owl (USDI Fish and Wildlife Service 1995). None of those stands have enough dominant and co-dominant fir trees to be classified as mixed conifer stands, and ponderosa pine is the dominant mature species in those stands. Co-dominant trees are a mix of pine and Douglas-fir. The dense white fir seedlings and saplings in the understory of the ponderosa pine/Douglas-fir stands are the result of fire exclusion. The small patches of mixed conifer at the bottom of some of the side drainages could be defined as "restricted habitat" and should be managed in accordance with restricted habitat guidelines in the Recovery Plan. Within these relatively small drainage bottom patches, trees greater than 9-inch diameter would not be felled, in order to be consistent with the Recovery Plan and Forest Plan. Otherwise, all activi-

Table 31. Federal Proposed, Threatened or Endangered Species Known to Occur in Santa Fe County.

Common Name	Scientific Name	Status
Black footed ferret	<i>Mustela nigripes</i>	Endangered
Bald eagle	<i>Haliaeetus leucocephalus</i>	Threatened
Mountain plover	<i>Charadrius montanus</i>	Proposed threatened
Mexican spotted owl	<i>Strix occidentalis luteus</i>	Threatened, Proposed critical habitat
Southwestern willow flycatcher	<i>Empidonax extimus trailii</i>	Endangered
Whooping crane	<i>Grus americana</i>	Experimental, non-essential
Rio Grande silvery minnow	<i>Hybognathus amarus</i>	Endangered, extirpated in the county

ties proposed under the action alternatives are allowed under the Recovery Plan and the Santa Fe Forest Plan. There are no active nest or roost areas (i.e. protected activity centers) for the Mexican spotted owl within or adjacent to the Watershed. No spotted owls were found or heard in the 2 years of spotted owl survey in the Watershed during 1996 and 1997 or the additional survey conducted in June 2000. Most of the habitat is comprised of small and medium-sized trees without many large mature trees, which is not favorable habitat.

Southwestern willow flycatcher is a bird with potential habitat that occurs in small patches in the narrow riparian vegetation corridor along the Santa Fe River between Nichols and McClure Reservoirs. Above McClure Reservoir the river moves too swiftly and contains insufficient riparian vegetation to be considered suitable for the willow flycatcher. The flycatcher nests and feeds in dense riparian vegetation approximately 5 to 8 yards high, often with high percentage of canopy cover. Generally in New Mexico, nesting habitat consists of dense coyote willow (*Salix exigua*) patches with sparse overstory of Fremont cottonwood (*Populus fremontii*) (Endangered Species Information [Online] August 2000). In New Mexico, breeding flycatchers occur in eight drainages with records from the Rio Grande, Chama, Zuni, Coyote Creek, Gila, Rio Nutria, Bluewater Creek and San Juan drainages (Hubbard 1987, Cooper 1996, Maynard 1995). No flycatchers have been located in the project area or Watershed. The closest location is an unconfirmed report from a birdwatcher prior to 1993 on private land at Monastery Lake. No flycatchers have been located to date in surveys at Monastery Lake (pers. comm., S. Williams, New Mexico Department of Game and Fish, September 2000). The southwest corner of New Mexico has the highest population of this species along the Gila River (Endangered Species Information [Online] August 2000).

Whooping crane is a migratory bird in New Mexico where it is known to winter at Bosque del Apache Wildlife Reserve. The whooping cranes in New Mexico are few in number and are being introduced artificially through a cross-fostering experiment with Sandhill cranes that breed in Idaho and spend the winter in the Bosque del Apache National Wildlife Refuge. The experiment has been terminated. These few whooping cranes are not reproducing and would eventually die off. The whooping crane does not occur in or use any habitat in the project area or Watershed.

Rio Grande silvery minnow, a small fish species, is extirpated from Santa Fe County (USDI Fish and Wildlife Service 2000). It is not present or likely to occur in the Watershed.

Federal Species of Concern

Federal species of concern are from the U.S. Fish and Wildlife Service. These species are presented for information and tracking purposes in Table 32. These species are not protected under the Federal Endangered Species Act. Some bird species are protected under the Migratory Bird Protection Act. Other species vary in protection under state laws or regulations.

Fringed myotis bat is found in the zone of ponderosa pine down into the grasslands (Findley et al 1975). Breeding colonies have been found in Isleta cave and Embudo Cave in the Sandia Mountains (New Mexico Department of Game and Fish [Online] August 2000). They have also been found to roost in 23- to 33-inch diameter ponderosa pine snags. They are not known to occur in the project area but have a wide range and the potential to occur in the project area.

Occult little brown bat occurs in cool temperate and boreal zones across North America. The species is absent from the Great Plains and warm temperature zones, except at sites with permanent water in the Southwest. Known summer roosts of this species in New Mexico are in buildings (Findley 1975). Large snags are probably used by the species. They are not known to occur and would have a low probability of occurrence in the project area.

Pale Townsend's big-eared bat is a species that is extremely sensitive to human disturbance and vandalism of roost caves by recreationists, and has a low reproductive rate (Finch 1992). This bat roosts in caves and is not likely to occur in the project area.

Spotted bat has potential habitat and a probability of using the area. Roost sites are believed to be rock crevices. Research on bats done in Frijoles Canyon in Bandelier National Monument did not locate any spotted bats (pers. comm., J. Lissoway, National Park Service, 1989) even though the area has a high density of rock crevices and holes in a strata of tuff. The species occurs very locally from central California, southern British Columbia, central Montana, and the Big Bend region of Texas southward through north-central Mexico to Queretaro (Hall 1981, Fenton et al. 1987). This bat has been found in New Mexico from the vicinity of the Rio Grande Valley westward, occurring most regularly in the Jemez, San Mateo and Mogollon Mountains and on Mt. Taylor (Fenton et al. 1987). These are presumably key habitat areas (New Mexico Department of Game and Fish 1988). It has been located through its echo-location calls in several areas on the Santa Fe National Forest (Cryan 1993).

New Mexican jumping mouse is distributed in New Mexico in areas with permanent water and long grass. Work by Morrison 1992 verified the persistence of this species in areas where it had previously been documented. Concern about it was caused by loss of natural riparian habitat. The species was trapped and identified in the Jemez and Sacramento Mountains, Rio Grande Valley and lower Rio Chama Valley. It was also discovered to use narrow zones along irrigation ditches within the Bosque del Apache National Wildlife Refuge. It is not known to occur and would have a low probability of occurrence in the project area.

American peregrine falcon is not known to use the project area. No nest locations or sightings have been reported from there. Potential nesting habitat is very limited because rock cliffs in the area do not have deep sheltered ledges to support nests. Known and historical nest locations elsewhere on the forest have been surveyed for occupancy and nesting success.

Arctic peregrine falcon is listed because it is a species of similarity of appearance to the American peregrine falcon. It migrates through the west but does not nest until it reaches Alaska or the arctic. Arctic peregrines are only migratory in the region. They do not occur in the project area or Watershed.

Baird's sparrow is a bird not found within the project area, as it uses habitats of prairies and weedy fields (National Geographic Society 1987) not found in the Watershed. It is found in summer in tall grass prairies (Griggs 1997).

Ferruginous hawk inhabits dry open country (National Geographic Society 1987) such as prairies and savannahs (Griggs 1997). Hence, it would not occur within the Watershed.

Loggerhead shrike is another predatory bird that hunts in open or brushy areas (Griggs 1997) not found in the Watershed. This species is fairly common over much of its range (National Geographic Society 1987).

Northern goshawk could have potential habitat in the project area, however, it has not been located nor heard in the project area or Watershed, and no nests have been located. The northern goshawk is rare to uncommon in the southwest (Hubbard 1978). Due to potential

Table 32. Federal Species of Concern Known to Occur in Santa Fe County.

Common Name	Scientific Name
Fringed myotis bat	<i>Myotis thysanodes</i>
Occult little brown bat	<i>Myotis lucifugus occultus</i>
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii</i> syn. <i>Plecotus townsendii</i> <i>pallescens</i>
Spotted bat	<i>Euderma maculatum</i>
New Mexican jumping mouse	<i>Zapus hudsonius luteus</i>
American peregrine falcon	<i>Falco peregrinus anatum</i>
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>
Baird's sparrow	<i>Ammodramus bairdii</i>
Ferruginous hawk	<i>Buteo regalis</i>
Loggerhead shrike	<i>Lanius ludovicianus</i>
Northern goshawk	<i>Accipiter gentilis</i>
White faced ibis	<i>Plegadis chihi</i>
Yellow-billed cuckoo	<i>Coccyzus americanus</i>
Flathead chub fish	<i>Platygobio gracilis</i>
Rio Grande sucker fish	<i>Catostomus plebeius</i>
Texas horned lizard	<i>Phrynosoma cornutum</i>
Chiricahau dock plant	<i>Rumex orthoneurus</i>
Santa Fe cholla plant	<i>Opuntia viridiflora</i>

impact of timber management on this species, it is a Forest Service Southwestern Region sensitive species. It is known to use mature stands or groups of larger trees for nesting. The elevation range in the Jemez Mountains is 7,540-8,250 feet (Kennedy 1984). In the Jemez Mountains the northern goshawk occurs in all major mountain ranges and sub-alpine forest associations except piñon-juniper. A home range averages 5 mi² (Kennedy 1984). Goshawks are usually aggressively defensive of their nests and are easily disrupted by human disturbance during the breeding season causing exposure of the eggs or chicks to the elements or predators.

White-faced ibis are migratory marsh birds through Santa Fe County but are not found in the project area. They are fairly numerous in localized freshwater marshes in the West (Griggs 1997).

Yellow-billed cuckoo uses dense gallery cottonwood bosque and orchards along the Rio Grande and does not occur in the project area or Watershed.

Flathead chub is a fish that does not occur in the Santa Fe River.

Rio Grande sucker is a fish that occurs in the Rio Grande drainage and is not found in the Santa Fe River.

Texas horned lizard inhabits arid plains and semi-arid open country with sparse plant growth, bunch grass, cactus, juniper, acacia and mesquite (Stebbins 1985). Hence, this species would not be found in the Watershed.

Chiricahau dock is a plant found at high elevations in the Pecos Wilderness near Pecos Baldy Lake. It would not likely occur in the project area.

Santa Fe cholla, an isolated sub-specie of cactus, has been found within the City of Santa Fe, NM (University of New Mexico 1984). Its flowers have a distinct color difference from the common cholla in the area. It is not known to occur or likely to occur in the Watershed.

Forest Service Southwestern Region Sensitive Species

The Forest Service Southwestern Region sensitive species are considered for information and tracking purposes but do not have legal requirements under the Endangered Species Act. Table 33 was compiled from the most recent Forest Service Southwestern Region Sensitive species list July 21, 1999, corrected February 23, 2000 to reflect those species found on the Santa Fe National Forest.

New Mexico jumping mouse, American peregrine falcon, northern goshawk, and Chiricahua dock plant were previously described under Federal Species of Concern.

The other sensitive species listed in Table 34 do not occur and are not likely to occur within the project area because they do not have habitats in this area. The exception may be the Rio Grande cutthroat trout, which does not occur in the Santa Fe River within the project area but has potential habitat in this river. Rio Grande cutthroat trout were not found in the project area using electro-shock methods (Pittenger 2000); only rainbow trout were present. Goat peak pika is a small mammal endemic only to the Jemez Mountains (New Mexico Department of Game and Fish [Online] Aug 2000). Swift fox is a plains and grassland species (New Mexico Department of Game and Fish [Online] Aug 2000). Jemez Mountains salamander occurs only in the Jemez

Table 33. Forest Service Southwestern Region Sensitive Species for the Santa Fe National Forest.

Common Name	Scientific Name
Goat peak pika	<i>Ochotona princeps nigrescens</i>
New Mexican jumping mouse	<i>Zapus hudsonius luteus</i>
Swift fox	<i>Vulpes velox</i>
American peregrine falcon	<i>Falco peregrinus anatum</i>
Northern goshawk	<i>Accipiter gentilis</i>
Jemez Mountains salamander	<i>Plethodon neomexicanus</i>
Rio Grande cutthroat trout	<i>Onchorynchus clarki virginalis</i>
Blue-black silverspot butterfly	<i>Speyeria nokomis nokomis</i>
Hairless fleabane plant	<i>Erigeron subglaber</i>
Chiricahau dock plant	<i>Rumex orthoneurus</i>
Arizona willow plant	<i>Salix arizonica</i>

Mountains (New Mexico Department of Game and Fish [Online] Aug 2000). Blue-black silverspot butterfly is associated with seeps and springs, and it is apparently no longer found in the Sangre de Cristo Mountains (New Mexico Department of Game and Fish [Online] Aug 2000). The hairless fleabane plant, also known as Pecos fleabane, occurs in San Miguel County on montane ridges between 10,000 and 11,000 feet (University of New Mexico 1984). Arizona willow is another high elevation riparian plant found growing in full sunlight in the Pecos Wilderness near Pecos Baldy Lake and would not be found at elevations in the project area.

New Mexico State Endangered, Threatened, and Sensitive Species

New Mexico State endangered and threatened species are protected under the New Mexico Conservation Act; NM Chapter 17 Statutes Annotated 1973, 17-2 Part 3. The list of threatened, endangered and restricted species is published as Title 19 of New Mexico Administrative Code, Chapter 33, Part 1 (19NMAC33.1). State sensitive species is an informal category, which carries no legal requirements. Table 34 excludes duplications from all previous Federal and Forest Service lists. Habitat types queried for Santa Fe County from the BISON-M database are: aspen, Douglas-fir/white fir, mixed conifer, ponderosa pine, piñon/juniper, montane and riparian cottonwood/alder/willow types. The two bats and the vole species highlighted in Table 33 are the only species on this list that have potential habitat in the project area.

Yuma myotis bat abundance in New Mexico seems to be in desert, grassland, and woodland, and the riparian communities of these zones, from 4,000-7,000 feet in elevation (New Mexico Department of Game and Fish [Online] August 2000). Railroad bridges and buildings are common kinds of summer retreats for the species (New Mexico Department of Game and Fish [Online] August 2000). In Arizona, all records are from piñon-juniper woodland and lower elevation vegetation with permanent water courses (Frey 1995). The species is highly colonial and roosts in bridges, buildings, cliff crevices, caves, and mines (New Mexico Department of Game and Fish [Online] August 2000). This makes the species vulnerable to acts of vandalism.

Long-legged myotis bat is primarily an inhabitant of forested areas, where it prefers high, open woods and mountainous terrain in the Trans-Pecos. There are no winter records from the area, so this species is probably only a summer resident (Schmidley 1977). Roosts have been located in ponderosa pine and mixed conifer habitat types (Green 1994). They are also found in sycamore, cottonwood, rabbit brush and riparian habitats (Cook 1986). Nursery colonies have been located in mines (one in a geothermally heated mine) and beneath the exfoliating bark of aging ponderosa pine snags (Tuttle 1996).

Heather vole is known only from the Sangre de Cristo Mountains and San Juan Mountains mostly at high altitudes (Findley et al 1975). They were found most

common in spruce and lodgepole forests with ground cover of vaccinium sp., such as frequently occur on glacial moraines (Fitzgerald et al. 1994).

Effects on Special Status Species

Alternative A

No Action Without Wildfire

There would be no change to the current wildlife and plant species and habitats as described in the "Affected Environment" section. Special status species habitats would continue to decline in quality as forest vegetative conditions continue to deteriorate. Herbaceous vegetation would continue to be minimal and decline further due to the lack of sunlight reaching the forest floor. Thus, there would be a continued decline in forage availability for a variety of wildlife and invertebrate species. Foraging habitat for special status species would remain low in the ponderosa pine vegetation type. Although cover in the form of large down woody material is present, habitat for small mammals would also remain low as would food-producing plants. The lack of understory plants would continue to reduce prey availability for predatory birds such as northern goshawk and spotted owl. The loss of diversity in wildlife and plant habitat would continue as the stands of small trees become denser, limiting the growth of understory vegetation and larger diameter trees.

Table 34. New Mexico (state) Endangered, Threatened and Sensitive Species Known to Occur in Santa Fe County.

Small-footed western myotis	<i>Myotis ciliolabrum melanorhinus</i>	sensitive
Yuma myotis bat	<i>Myotis yumanensis yumanensis</i>	sensitive
Long-legged myotis bat	<i>Myotis volans interior</i>	sensitive
Yellow-bellied marmot	<i>Marmota flaviventris</i>	sensitive
Gunnison's prairie dog	<i>Cynomys gunnisoni</i>	sensitive
Red fox	<i>Vulpes vulpes</i>	sensitive
Ringtail	<i>Bassaricus astutus</i>	sensitive
Heather vole	<i>Phenacomys intermedius intermedius</i>	sensitive
American marten	<i>Martes americana origenes</i>	threatened
Western spotted skunk	<i>Spilogale gracilis</i>	sensitive
White-tailed ptarmigan bird	<i>Lagopus leucurus altipetens</i>	endangered
Boreal owl	<i>Aegolius funereus</i>	threatened
Black swift bird	<i>Cypseloides niger borealis</i>	sensitive
Gray vireo bird	<i>Vireo vicinior</i>	threatened

No Action With Wildfire

A large, high-severity wildfire would destroy the larger trees that provide habitat components important to many species of songbirds, bats and small mammals. Destruction of the mature forest in the wilderness portion of the Watershed would negatively impact potential spotted owl habitat. Such a wildfire would greatly increase sediment, turbidity and other impacts to the Santa Fe River, which would have long-term negative impacts to Rio Grande cutthroat trout habitat.

In the higher elevations of the Watershed within the wilderness, which provide some potential spotted owl habitat, the large crown fire would destroy mature forest characteristics such as cooler temperatures. Wildfires would also injure or kill wildlife unable to escape. Wildlife caught in a large crown fire die of suffocation from lack of oxygen being consumed by the fire, lung failure from searing heat, or become trapped in the flames on all sides. The loss of vegetation and ground cover from a wildfire could sterilize soil and promote soil erosion, thereby further degrading or destroying wildlife and plant habitats for many years after such an event. Should a large wildfire occur, mortality to less mobile species of wildlife would be expected from the fire and smoke inhalation.

Large, high-severity crown fires destroy the nesting habitat for northern goshawk and other hawk species, and all passerine species and bat species dependent on live trees in which to nest or roost respectively. Crown fire during nesting season would result in loss of eggs or young in the nest. Success in finding new nest sites would depend on the season and availability of habitat elsewhere. However, after a wildfire, acres of standing dead trees provide a food source for insect-eating species and nest trees for cavity nesting species.

Alternatives B1, C1, and D1

Mexican Spotted Owl

There would be essentially no difference in the effects among these three alternatives. The only minor difference would be under Alternative B1, where the lack of thinning on the majority of the area would leave a more continuous overstory canopy cover on the middle and upper slopes. This would continue to limit the amount of understory vegetation response and subsequent abundance of prey species for the spotted owl. Overall, thinning and broadcast burning operations in the project area for all three alternatives would have no effect on the Mexican spotted owl or the minor amount of potential spotted owl habitat in the project area. The forest types in the project area are not considered habitat used by the owl for nesting or roosting. All trees over 16-inch diameter would be retained throughout the area (except under Option B where trees may be felled up to 24-inch diameter on 100 acres). Thus, all the large, mature trees on the landscape would be maintained, and their growth would be enhanced by reduction of tree competition. Forest structure would shift from that resembling a young forest to that of a more mature forest. Noise and disturbance would not be expected to have an effect on

the owl because actions are within habitat types not used for nesting or roosting. Prescribed burning especially in the ponderosa pine type would be beneficial as a means of decreasing fire risk to adjacent restricted habitats (USDI Fish and Wildlife Service 1995). The burning would improve forage of brush and herbaceous plants, resulting in increased habitat for prey species. Existing logs 12-inch diameter or greater would be retained, and the additional logs resulting from thinning would cumulatively increase habitat for prey species such as voles and mice.

Thinning and broadcast burning together would beneficially reduce the risk of large-scale catastrophic fire impacts. Noise and disturbance would not likely affect the owl as actions are well away from any protected activity centers (e.g. nest sites) outside the project area. Monitoring of habitat characteristics would occur in sample areas, including measurements of fuel levels, snag basal area and live tree basal area (described in Appendix B).

Southwestern Willow Flycatcher

Proposed activities would have no effect on the potential southwestern willow flycatcher (flycatcher) habitat because they would occur outside the riparian vegetation zone. Thus, thinning and burning are not expected to damage or destroy the established deciduous vegetation in the riparian zone. Thinning conifer trees within the canyon bottom near the river would be expected to be beneficial to potential flycatcher habitat. The reduction of conifer canopy would allow additional sunlight to reach the zone where willow, cottonwood and alder are habitat components. Riparian species along the upper Santa Fe River are limited by competition and shading from conifers and restricted water flows. If broadcast burning is conducted in the canyon bottom adjacent to the riparian zone, it could have a slight beneficial effect to flycatcher habitat. Burning increases shrub and herbaceous ground cover. The increased vegetation could increase the amount of available insects that flycatchers feed on. The food of willow flycatchers is dominantly insects, these usually taken during aerial forays (New Mexico Department of Game and Fish 1988).

Northern Goshawk

Thinning and burning would not be expected to impact potential habitat of the northern goshawk (USDA Forest Service 1991). Effects of thinning from below and prescribed burning are beneficial to prey species of the

goshawk as well as creating a diversity of habitats (USDA Forest Service 1991). Under Alternative B1, the habitat diversity over the landscape would not be as noticeable as under Alternative C1 and D1 because of the limited amount of thinning involved in Alternative B1, and the low-severity burning would not create large or frequent openings in the canopy. Noise and disturbance would be temporary effects to birds potentially entering the area during the nesting season. The effect could cause temporary displacement to adjacent areas while the disturbance persists. Retaining the existing clumps of large trees as prescribed would provide potential nest habitat. Thinning of smaller trees favors the structure of the forest used by the goshawk for nesting, and moves habitat toward mature forest conditions (USDA Forest Service 1991).

Rio Grande Cutthroat Trout

Thinning and burning are not expected to impact potential habitat of the Rio Grande cutthroat trout. Prescribed burning close to the riparian zone could create a slight temporary increase in water turbidity but reduce the risk of severe wildfire. This species was previously discussed in the "Aquatic Habitat and Biota" section.

Alternatives B2, C2 and D2

These alternatives would have no direct or indirect effects on the Mexican spotted owl, which does not occur or have suitable nesting or roosting habitat in the project area. By excluding broadcast burning, these alternatives would limit production of forage vegetation for prey species for the spotted owl, northern goshawk and other raptors. Effects to southwestern willow flycatcher and Rio Grande cutthroat trout habitat would be the same as described for Alternatives B1, C1 and D1, other than the effects of broadcast burning.

Unlike Alternatives C2 and D2, Alternative B2 treats relatively few acres and results in a moderate risk of a large crown fire. If a severe crown fire in the large contiguous untreated areas occurs, it could spread into drainage bottom patches of mixed conifer (restricted habitat) and result in a loss of this habitat.

Option A: No Wood Removal

There would be no noticeable difference in effects to special status species with this option, which treats the 560 acres of roadside corridors the same as the rest of the project area by leaving the felled tree trunks on site and burning the slash.

Option B: Thin Large Conifers in Canyon Bottom

This option is not likely to adversely affect the Mexican spotted owl and would have no effect to other special status species. This action would only be done outside of mixed conifer restricted habitat and on slopes less than 40 percent. Also, all trees 24-inch diameter or larger would be retained. By leaving the felled logs 12-inch diameter or larger, this alternative would increase the amount of large down woody material for use by prey species.

Cumulative Effects

None of the alternatives would be expected to have cumulative impacts on special status species. Other present or potential future activities considered in the project area include actions such as planting of native plants, seeding of disturbed areas, conducting public tours, collecting data for monitoring, and maintaining the road and reservoirs. We also considered the possibility of the City implementing thinning and hauling of wood products less than 6-inch diameter from City-owned lands in the project area. Times and locations would vary for these activities, although reservoir maintenance, water testing, and road maintenance are done fairly routinely. In addition, if the City were to release a large amount of additional water into the river and floodplain between McClure to Nichols Reservoir after the conifers are felled in the canyon bottom near the river, it would be a cumulative benefit to the existing riparian species. The release of water could enhance the re-establishment of riparian plants and riparian dependent species where sufficient sunlight reaches the forest floor. However, that water release action is very speculative, as it has not been scheduled or planned, and it is uncertain whether enough water could be released to re-wet the floodplain on a regular basis. Based on there being little or no direct or indirect effects expected from the treatment alternatives, and the few present and foreseeable future actions in the Watershed, no cumulative impacts to special status species would be anticipated.

Air Quality/Smoke

An issue related to air quality is:

Prescribed burning, especially broadcast burning, produces smoke that can accumulate in residential areas or other areas where people work, live, or recreate. This can impact their health, especially for people with respiratory problems, and can impair visibility along roads, in the wilderness or in scenic vistas.

Affected Environment

The Watershed is located within the Upper Rio Grande Basin Airshed. All airsheds in New Mexico are based on watershed boundaries developed by the New Mexico Water Quality Control Commission. Although the Upper Rio Grande Basin covers many counties, the Watershed lies completely within Santa Fe County.

Air Quality Standards and Current and Desired Conditions

The Clean Air Act, which was amended in 1990 and in 1999, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The NAAQS were established to set limits to protect public health, including the health of “sensitive” populations such as asthmatics, children, and the elderly, as well as to protect against decreased visibility, damage to animals, crops, vegetation, and buildings. The Environmental Protection Agency (EPA) set NAAQS for six principal pollutants referred to as “criteria” pollutants (Table 35). These pollutants are lead, sulfur dioxide, nitrogen dioxide, ozone, particulate matter less than 10 microns in diameter (PM-10), and carbon monoxide. In 1997 the EPA issued a standard for 2.5 micron-size particulate matter (PM-2.5), however it is part of a legal challenge that has not yet been resolved in court.

As defined by the Clean Air Act, a non-attainment area is a community or area that does not meet or attain the standards for any of the six criteria pollutants. The entire potentially affected area within and surrounding the Watershed currently meets air quality standards for the six criteria pollutants (<http://www.epa.gov/oar>). The area within and surrounding the Watershed typically has excellent air quality conditions. The only non-attainment areas in New Mexico are in Dona Ana County on the southern New Mexico border, for ozone and PM-10, and Grant County near Silver City for SO₂. The General Plan for the City of Santa Fe notes occa-

sional air quality degradation in Santa Fe due to smoke from wood burning stoves, smokestack emissions, dust from roads, motor vehicle emissions, and industrial development.

The desired condition or goal for the air resource in the Watershed area is to continue to meet air quality standards and protect air quality related values in the Class I Wilderness areas. The applicable desired conditions (goals) and standards/guidelines identified in the Forest Plan are:

- Maintain high quality visual conditions (page 128).
- Protect Air Quality Related Values in Class I Wilderness areas. Visibility is the Air Quality Related Value most likely to be impacted by this proposed project (page 18).
- Prepare Smoke Management Plans for prescribed burns (page 75).

The primary pollutants produced during combustion of organic material—such as would be found in smoke from a wildfire—include carbon dioxide (CO₂), particulate matter (PM-10), nitrogen oxides (NO_x), and hydrocarbons. Lead, ozone and SO₂ could be by-products but in insignificant amounts. Wood smoke consists of dispersed airborne solids and liquid particles (particulates), which can remain suspended in the atmosphere from a few seconds to several months. Table 36 presents a summary of emission factors for some of these constituents. There are no emission factors for some of the other by-products.

Of the six NAAQS criteria pollutants, it is PM-10 and PM-2.5 that are of greatest health concern. Carbon monoxide is another major product of wildfire smoke, but as a gas, it is quickly diluted in the atmosphere. Carbon monoxide can be of concern to firefighters and those conducting prescribed burns who are working quite close to the source of the smoke.

Particulate matter has the potential to impair human health and visibility. PM-10 causes eye, nose, and throat irritation. Because of its relatively larger size, it remains in the upper respiratory tract. PM 2.5, due to its smaller size, travels to the lungs and can cause more serious health impairments such as chronic respiratory disease, emphysema, or lung cancer.

Volatile organic compounds are also produced, but these are not considered criteria pollutants by EPA. The combustion of organic material also produces organic hydrocarbons that can affect human health. The two most important classes of compounds associated with organic hydrocarbons are polynuclear aromatic hydro-

carbons and aldehydes. Some of these substances (e.g. benzo-c-phenanthrene and formaldehyde) are carcinogens. Emissions containing these substances solely from fire pose a negligible risk of cancer for the general public because generally they are produced in very small amounts (Sandberg and Dost 1993).

In addition to health concerns associated with particulates and other emissions, high levels of particulate matter can impair visibility. Significant visibility impairment can lead to highway accidents or problems with landing planes at airports. Some air quality researchers believe that prescribed burns such as those included in this proposal, should be exempt from visibility standards because these kinds of low-intensity fires would occur in natural forested ecosystems (Haddow et al 1998).

Regional haze problems can develop from the cumulative effects of particulate matter, which can travel great distances. Regional haze can sometimes result from multiple burn days and/or multiple owners utilizing the air shed over too short a period of time. The cumulative particulate load may be the result of prescribed burning, smoke from wood burning stoves, and other urban and industrial sources. The causes of regional haze are difficult to identify.

Table 35. Criteria Pollutants Allowable Increments and Averaging Times (ug/m³ = micrograms per cubic meter of air; ppm = parts per million)

Pollutant	Federal Standard	State Standard
Carbon Monoxide (CO)		
8-hour average	10 mg/m ³	8.7 ppm
1-hour average	40 mg/m ³	13.1 ppm
Nitrogen Dioxide (NO₂)		
24-hour average	-	0.10 ppm
Annual arithmetic mean**	100 ug/m ³	0.05 ppm
Ozone (O₃)		
1-hour average***	235 ug/m ³	-
8-hour average (DRAFT)	157 ug/m ³	-
Lead (Pb)		
Quarterly average	1.5 ug/m ³	-
Particulate PM-10		
Annual arithmetic mean**	50 ug/m ³	-
24-hour average	150 ug/m ³	-
Particulate PM-2.5 (DRAFT)*		
Annual arithmetic mean**	15 ug/m ³	-
24-hour average	65 ug/m ³	-
Sulfur Dioxide (SO₂)		
Annual arithmetic mean**	80 ug/m ³	0.02 ppm
24-hour average	365 ug/m ³	0.10 ppm
3-hour average	1300 ug/m ³	-
Total Suspended Particulate		
24-hour average	-	150 ug/m ³
7-day average	-	110 ug/m ³
30-day average	-	90 ug/m ³
Annual geometric mean**	-	60 ug/m ³

Units of measure are parts per million (ppm) per milligrams per cubic meter of air (mg/m³), and micrograms per cubic meter of air at 25° C (ug/m³).

* The PM-2.5 standards have not been finalized.

** This is the Annual Arithmetic Mean for the averaging period.

*** The ozone 1-hour standard applies only to non-attainment areas as of July 1997, to allow for a smooth, transition to the 8-hour standard.

Effects on Air Quality

Effects Analysis Methodology

This analysis considered the dominant physiographic features that influence air patterns in the project area: the steep slopes in the Santa Fe River canyon and complex mountainous terrain surrounding the canyon. This topography creates wind flows and temperature and moisture patterns that influence the spread of fire and smoke. Our analysis also assumes that the lower level winds in the Watershed and its side drainages, which typically have cool airflows in the early mornings and late evenings, would channel the air in a downward direction toward the canyon bottom and City of Santa Fe. We assumed upper level winds (at or above 32 ft.), blow predominately from the south-southwest with speeds ranging from 20 to over 60 miles per hour at times. During the day, these upper level winds usually spread fire and smoke in a north to northeasterly direction, as was seen during the Cerro Grande Fire and other large fires in northern New Mexico.

In conducting the effects analysis, we identified “sensitive receptors”-resources within the potentially affected area that may be sensitive to smoke impacts. Sensitive receptors can be people with respiratory problems or specific places, views, hospitals, airports, schools, highways, or businesses. We identified and considered the following specific sensitive receptors:

- The City and County of Santa Fe and communities within 16 miles of the project area, including: St Vincent’s Hospital and other medical care centers in the Santa Fe area, Santa Fe Airport and Santa Fe schools.
- The Hyde Park Road/Scenic Byway corridor from Santa Fe to the Ski Basin, including Aspen Vista Trail, Tesuque Peak, and other scenic views.
- Businesses and tourism in the Santa Fe area.
- Chimayó and communities 16 to 31 miles north-northwest of the project area.
- Las Vegas and communities 31 to 47 miles east-southeast of the project area.
- Taos and communities 47 to 62 miles north of the project area.
- Pecos and Wheeler Peak (Class I) Wilderness areas: wilderness areas are of concern because the Clean Air Act specifically protects visibility in Class I areas (wilderness areas designated prior to

Table 36. Emission Factors for Certain Wildfire By-products.

Combustion Product	Emission factor (pounds of emission per ton of fuel consumed)
Carbon Dioxide (CO ₂)	2,000 to 3,500
Carbon Monoxide (CO)	20 to 500
Water Vapor (H ₂ O)	500 to 1,500
Particulate matter (PM)	20 to 180
Wildfire average PM-10	30
Wildfire average PM-2.5	27
Hydrocarbons	10 to 40
Nitrogen Oxides (NO _x)	1 to 9

1977). In New Mexico, all land not designated Class I is considered Class II, requiring less stringent protection of visibility.

- Interstate 25 and U.S. 84/285, the main north/south highways near the Watershed. The primary concern for these highways is the potential for smoke to impair motorist’s visibility.
- Highway 63 from Pecos to Cowles, including residents of Cowles and the upper Pecos River canyon.
- Village of Tesuque.

FOFEM Model Runs

The First Order Fire Effects Model was run as one screening-level tool for comparing the smoke emissions from the No Action with Wildfire alternative against the action alternatives. FOFEM is primarily designed to estimate fire behavior and other fire effects. FOFEM outputs (Table 37) for particulate emissions are in pounds rather than micrograms per cubic meter of air. There is no conversion factor to compare FOFEM outputs to Federal air quality standards. We considered using the Simple Approach Smoke Estimation Model (SASEM), which is used in the southeastern U.S. However, SASEM is not designed for areas with complex or mountainous terrain, or for conifer forest vegetation, or for wood smoke that has “smoldering” time. It is designed for sage and grasslands vegetation types with emission factors based on palmetto-gall berry stands in Florida, and cannot estimate smoke impacts for sensitive receptors over 31 miles away.

Due to these and other model limitations, it cannot be used to adequately assess wood smoke emissions from the proposed burning slash piles or broadcast burning in this project area.

Table 37. FOFEM Daily Burning Emission Estimates for Burning Up to 100 Acres of Slash Piles Per Day.

Emission	Amount
PM 10 lbs/acre	287
PM 10 total lbs	28,700
PM 2.5 lbs/acre	244
PM 2.5 total lbs	24,400
CO lbs/acre	2,291
CO total lbs	229,100

Assumptions used in FOFEM runs included burning a maximum of 100 acres per day for slash pile burning, and burning a maximum of 600 acres per day for broadcast burning. For the No Action with Wildfire alternative we assumed 20,000 acres could burn within the first day. This is the approximate acreage that burned in the first day of the Vieveash Fire, which is located close to the Watershed and is comprised of very similar topography, vegetation, soils and other site conditions. We divided the 20,000 acres of catastrophic fire into two parts: 12,000 acres on northeast aspects and 8,000 acres on southwest aspects, to account for differences in the fuel models (fuel loads) between those aspects. This was based on the fact that approximately 60 percent of the slopes in the Watershed face north and east and have a slightly different fuel type compared to the 40 percent that face south and west. Table 37 displays daily emission estimates for slash pile burning. The amount of emissions shown would be the same for each action alternative on a daily basis as all six alternatives include burning slash piles. However, the number of days of slash pile burning would vary by alternative, thereby affecting the total emissions during project implementation. Table 38 displays daily emission estimates for broadcast burning or a wildfire by alternative. Table 39 displays the relative number of burn days by alternative, based on the acreage estimates for slash pile burning and broadcast burning. Parameters used in FOFEM and details about FOFEM are contained in the project record.

Alternative A

No Action Without Wildfire

Existing air quality conditions previously described would continue for the local Santa Fe area. A minor amount of road dust would continue to be produced along the unsurfaced access road in the canyon bottom. No measurable impacts would be associated with this alternative. There would be no burning and, therefore, no smoke emissions from this alternative.

No Action With Wildfire

This alternative assumes the occurrence of a large, high-severity wildfire similar to the past several large wildfires that occurred in northern New Mexico, consuming 20,000 to 46,000 acres before suppression actions could become effective. These high-severity crown fires generally burn during extreme fire danger rating conditions. Wildfires generally burn for a much longer time than prescribed fires.

In the event of a large wildfire, the amount and dispersal of smoke could not be controlled. The amount of smoke generated by such a wildfire would be much greater than that produced from a prescribed burn where smoke management techniques are employed. The amount of smoke from such a fire would contain large amounts of pollutants that would be likely to exceed Federal air quality standards for particulate levels. Firefighters working close to the fire and smoke could be affected by CO emissions.

The fire would probably produce significant adverse effects to air quality within a large perimeter around the fire. This was evidenced in recent large wildfires in northern New Mexico. In 1996, the Dome Fire reduced air quality and visibility in Santa Fe and on Interstate 25, over 20 miles away from the fire. The 2000 Cerro Grande Fire near Los Alamos affected the entire northern Rio Grande Valley, from Española into Colorado, impairing visibility and causing air quality alerts and precautionary evacuations in Española. Based on phone conversations with staff at the Española Hospital, there was a noticeable increase in people coming to the hospital with respiratory problems during the Cerro Grande Fire.

A review of the FOFEM estimates in Table 38 shows that just during the first day of a large wildfire, PM-10 emissions would be 12,508,000 pounds (6,254 tons). The PM 2.5 emissions would be 10,612,000 pounds

(5,306 tons), and CO₂ emissions would be 117,892,000 pounds (58,946 tons). Daily particulate loads from a wildfire would be four to six times more than those for prescribed burning, and smoke effects would be predicted to last for approximately 10 to 14 days.

This long smoke exposure period combined with high concentrations of pollutants increases the potential for adverse health effects. There would be eye and upper respiratory irritations. The odor of smoke would be present and local smoke alerts may occur to warn people about the potential health hazard. People with asthma, bronchitis, or angina would be advised to leave the area. People with compromised respiratory systems may begin to have trouble breathing. All others would be advised to stay indoors with windows and doors closed.

Visibility along roadways near the Watershed could be less than one-quarter mile. This could result in a high risk of traffic accidents, highway closures or other impacts to motorists such as along portions of Upper Canyon Road, Hyde Park Road, or U.S. Highway 84/285. There is a potential for major visibility impairment in portions of the Pecos Wilderness, along the Hyde Park Road Scenic Byway and from scenic vistas like the top of Aspen Vista and Tesuque Peak Trails.

Effects for Alternatives B1, C1 and D1 (Including Broadcast Burning)

On the 560 acres of roadside thinning with wood and slash removal, there would be no smoke generation. Hauling away the wood products and slash material would eliminate the immediate need to burn. There

Table 38. FOFEM Daily Burning Emission Estimates by Alternative for Wildfire and Broadcast Burning.

	No Action Alternative Wildfire	Alternatives B1, C1, and D1 Broadcast Burn	Alternatives B2, C2, and D2 N/A
Wildfire or Broadcast Burn NE Slopes	(12,000 ac)	(600 acres)	
PM 10 lbs/acre	791	537	0
PM 10 emissions, lbs	9,492,000	322,200	0
PM 2.5 lbs/acre	671	456	0
PM 2.5 emissions, lbs	8,052,000	273,600	0
CO lbs/acre	7,425	4,892	0
CO emissions, lbs	89,100,000	2,935,200	0
Wildfire or Broadcast Burn SW Slopes	(8,000 acres)	(600 acres)	
PM 10 lbs/acre	377	341	0
PM 10 emissions, lbs	3,016,000	204,600	0
PM 2.5 lbs/acre	320	289	0
PM 2.5 emissions, lbs	2,560,000	173,400	0
CO lbs/acre	3,599	3,125	0
CO emissions, lbs	28,792,000	1,875,000	0
Wildfire or Broadcast Burn Totals	(20,000 acres)		
PM 10 emissions (lbs.)	12,508,000	SW: 204,600 -or- NE: 322,200	0 0
PM 2.5 emissions (lbs.)	10,612,000	SW: 173,400 -or- NE: 273,600	0 0
CO emissions (lbs.)	117,892,000	SW: 1,875,000 -or- NE: 2,935,200	0 0

would be other minor impacts to air quality by these activities, such as exhaust from vehicles, heavy equipment, and chain saws. Road dust would be slightly higher than current conditions during these activities unless they are conducted while the ground is frozen or the roadbed is moist.

When burning slash or broadcast burning, most of the smoke from daytime burning would likely dissipate to the northeast over the Pecos Wilderness. Smoke could be noticeable perhaps in Cowles, Mora, and towns northeast of Mora. It may also be slightly noticeable in

the Interstate 25 corridor to Las Vegas. These would be the affected areas if planned climatic conditions prevail. Should there be unexpected wind shifts, smoke could travel into areas on the western flanks of the Sangre de Cristo Mountains, such as Tesuque, Chimayo, and Cundiyo.

In the evenings as the air cools, residual smoke would probably settle into the Santa Fe River canyon bottom and move toward lower elevations. It would flow into Upper Canyon Road and portions of the east side of Santa Fe. Wisps of residual smoke might, under certain meteorological conditions, find their way into drainages in Tesuque, Pojoaque, Santa Cruz, or Chimayo. These effects would be short lived and relatively minor.

The smell of smoke may occur long enough to become a bit of a nuisance. Because the slash pile burning activities would be conducted in the fall or winter when temperatures are cooler, there would be an increased potential for the smoke to linger due to weather inversions. Inversions cause smoke to remain in low areas for extended periods of time, thereby decreasing visibility and increasing particulate matter concentrations. Early morning inversions often lift after about 10 a.m. However, residual smoke in Santa Fe could affect the most smoke-sensitive people by causing eye, throat, and nose irritations and coughing, depending on the sensitivity of the individual. The general population would probably not be affected with eye or respiratory irritations.

There is a potential for slight visibility impairment in portions of the Pecos Wilderness. Because of the controlled nature of proposed burning, this impact should be short lived and not of great magnitude. Any impacts to visibility from these proposed prescribed burns would be significantly less than those caused by wildfire. There should be no visibility impacts serious enough to cause problems with airport or highway safety, assuming weather conditions do not change unpredictably. Attention to weather changes by personnel conducting the burns would prevent serious impacts.

Table 39. Total Number of Burn Days (i.e. smoke emission days) by Alternative. Burn days for the No Action Alternative with wildfire are consecutive, whereas, days for prescribed burning would be spread out over the 5- to 10-year project implementation period.

Alternative	No Action Wildfire	B1	B2	C1, D1	C2, D2
Slash Burning Acres	-	2,010	1,730	4,520	4,340
Number of days at 50-100 acres per day	-	20-40	17-34	45-90	43-86
Wildfire or Broadcast Burning Acres	20,000 to 46,000+	4,700	-	2,190	-
Number of days at 300-600 acres per day	-	8-16	-	4-8	-
Total Burn Days	10-14*	28-56	17-34	53-98	43-86

* Estimate based on Viveash and Cerro Grande Fires where smoke production visible from Santa Fe lasted 10 to 14 days, respectively.

During the day while the burn is being conducted, the greatest intensity of smoke would probably last for a couple hours after the burning reaches maximum, and then begin to dissipate. Smoke from prescribed burning may be a hazard to ground crews at the site. Workers conducting the burns are at the greatest risk of health impacts from inhaling smoke due to their greater exposure time and close proximity to the smoke. Effects on workers may include eye irritation, coughing, and shortness of breath in moderate to heavy smoke concentrations. Following health and safety precautions listed in the "Mitigation and Monitoring" section would reduce this effect.

The point at which nuisance smoke becomes a problem is very subjective. The public, if properly prepared and informed, should be able to tolerate a certain degree of nuisance smoke. However, if this nuisance smoke grows in volume, density, or duration, it might become a real problem, resulting in air quality alerts, permit violations, and regulatory actions. Monitoring air quality would be conducted and prescribed burning activities would cease if PM-10 levels reach 80 percent of the Federal standard threshold.

While it is possible for smoke from prescribed burning to travel as far as Las Vegas (31 to 47 miles east of the project area) or Taos (47 to 62 miles north of the project area), those areas are not likely to notice significant amounts of smoke, as long as mitigations and monitoring measures are followed. Burning under good smoke

dispersion conditions would minimize this potential. Site specific burn plans, including smoke management plans, would be developed and approved by the appropriate line officers and regulatory offices before any ignition occurs. Burn permits would be obtained from New Mexico Environment Department. The public would be notified in advance of the burning. Based on experience conducting an average of 12,000 acres of prescribed burning per year on the Santa Fe National Forest, surrounding communities are not likely to experience prolonged periods of heavy smoke, and we are not likely to exceed air quality standards or cause air quality alerts.

Implementation of Alternative B1 would produce less smoke over the life of the project than Alternatives C1 and D1. This is due to less acreage being thinned, so there would be fewer slash piles to burn (Table 39). Broadcast burning for Alternatives C1 and D1 would result in the same amount of emissions as the same acreage would be burned (Table 38).

Alternative B2, C2, and D2 (No Broadcast Burning)

Alternative B2 would produce the least amount of smoke during project implementation because of the limited amount of acreage treated with thinning (i.e. reduced slash piles to burn) and the exclusion of broadcast burning. However, under B2, there would be a substantially large contiguous area of untreated forest that would remain moderately susceptible to catastrophic wildfire. If a wildfire occurs under this alternative, either during or after project implementation smoke impacts would be similar to those described for the No Action with Wildfire Alternative.

Alternatives B2, C2, and D2 would produce less overall smoke emissions than Alternatives B1, C1, and D1 as they would not conduct broadcast burning (Table 38). They would produce the same amount of daily smoke emissions from slash burning (Table 37).

Alternatives C2 and D2 would produce about the same amount of emissions as they both burn the same number of slash piles. The untreated areas in Alternatives C2 and D2 would occur as small, scattered patches separated by treated areas, thus they would be less susceptible to catastrophic wildfire. One minor difference between Alternative C2 and Alternative D2 (and C1 and D1) is that burning the piles of whole trees would probably result in slightly more smoke and longer smoldering periods, since the machine piles would contain large diameter fuels compared to the hand-built slash piles. In addition, in areas where track-mounted

machines drive over rows of piled trees, the fuels would be compacted, resulting in longer lasting smoke emissions (i.e. more smoldering).

Option A: No Wood Removal

This option leaves more fuel on the ground subject to burning. This option would increase slash burning acreage by 560 acres or about 6 days of pile burning. Overall, this potential increase in burning is not expected to impact air quality enough to change the effects described in the various alternative discussions.

Option B: Thin Large Conifers in Canyon Bottom

This option leaves more fuel on the ground subject to burning. Overall, this potential increase in fuel consumption is not expected to impact air quality enough to change any of the effects described in the various alternatives.

Cumulative Effects

Cumulative effects include those from reasonable and foreseeable activities producing pollutants in the same general area predicted for the proposed project. The areas subject to cumulative effects from this proposed project would include northern New Mexico from Santa Fe to the northern border with Colorado, eastward to the Las Vegas and Mora areas. Generally, this area lacks large industry capable of contributing significant PM-10 or carbon monoxide. Other potential sources of these pollutants in this area are: operation of combustion engines (e.g. vehicles, lawn mowers), use of fireplaces and wood stoves, dust from unpaved roads, industry emissions, prescribed burning by other land managers, burning on private lands, and wildfires in other areas of the forest. Emissions from a catastrophic fire, broadcast burning, or slash pile burning, coupled with existing emissions could increase the amount of pollutants distributed to areas down wind.

Of these other potential sources of PM-10 and carbon monoxide, prescribed burning and fireplace smoke are the most common. Prescribed burning can be coordinated between Federal land managers so as not to overwhelm the air resource. Fall/winter pile burning could contribute incrementally to the cumulative smoke effects from the use of wood stoves and fireplaces in this general area. Even so, this increase in cumulative effects is not expected to be significant enough to approach concentrations that would exceed air quality standards causing "non-attainment."

Very small particles can travel great distances and add to regional haze problems. Regional haze can sometimes result from multiple burn days and/or multiple owners utilizing the air shed over too short a period of time. The cumulative particulate load may be the result of prescribed burning only, or urban and industrial sources only, or a combination of the two. The causes of regional haze are difficult to identify.

Although a significant cumulative increase in emissions could move Santa Fe County, the City of Santa Fe, or other communities into non-attainment status for particulates, this seems highly unlikely, as these areas are well within attainment status and there is no indication that this project, or any others, would significantly increase PM-10 or carbon monoxide emissions.

Social Environment

An issue related to the social environment is:

Increased traffic from wood-hauling trucks and other vehicles may affect quality of life along the travel route, particularly for residents along Upper Canyon Road and visitors to the Audubon Center. Effects could be pedestrian or vehicle accidents, increased noise, lengthy traffic delays, vibration damage to older homes, and road damage.

Affected Environment

The City and County of Santa Fe comprise the primary social environment of people living in and adjacent to the project area and Watershed. Forest resources play an important social role for the people in this area, and the Watershed provides approximately 40 percent of the City's water supply.

Demographics and Land Settlement History

Humans have been an integral part of the Southwest for over 12,000 years. Generally, as Native American populations grew and technological innovations advanced, these impacts affected larger areas. Relatively large villages were established along the Rio Grande and its tributaries, including the lower reaches of the Santa Fe River, for cultivation by Puebloan groups (RMRS-GTR-5).

The first European to reach the Watershed may have been Castano de Sosa on January 8, 1591. He described the event: "It was bitterly cold and snowing.

When we emerged from the sierra, we came to a river, frozen so hard that the horses crossed on the ice without breaking through" (Hammond and Rey 1966). People who traveled north on the Camino Real established the settlement of Santa Fe between 1605 and 1610. The physical character of the small village of Santa Fe during this early settlement consisted most likely of low-lying adobe buildings centered around the plaza (City of Santa Fe 1999).

The opening of the Santa Fe Trail in 1821 augmented the commercial growth of Santa Fe. Soon afterwards Santa Fe became a gateway on the trail from Independence, Missouri to Chihuahua, Mexico. The U.S. Army seized the City of Santa Fe on August 18, 1946 as the United States pushed westward for expansion (City of Santa Fe 1999).

In the 1850's Santa Fe experienced critical water shortages. The available water, nonetheless, was described as "excellent" for drinking. A dam was constructed near the headwaters of the Santa Fe River in 1866, but the water supply was still not sufficient to meet the needs of the community (Clark 1987).

In the 1870's and 1880's the railroad linked the Southwest to population centers of the east and west coasts. Even with the advent of the railroad during this period, the City of Santa Fe grew very slowly until World War II. Urban areas were confined to an oval area measuring a mile by three-quarters of a mile with the farthest residence areas within a 10-minute walk of the plaza (City of Santa Fe 1999). The majority of the City centered itself on the plaza and the Santa Fe River.

One of the most distinct areas of the City today is the Downtown and Eastside Historic District that represents the area's first Spanish settlement along the Santa Fe River. This area was designated a historic district in 1957. It includes the City's oldest and best examples of Spanish Pueblo and Territorial styles of architecture. Prominent Spanish colonial planning features such as narrow streets, buildings constructed up to the property lines, the central plaza and an extensive acequia network still exist today in this district (City of Santa Fe 1999). This area, adjacent to the project area, includes the downtown commercial areas and extends east up the Santa Fe River through Canyon Road, Cerro Gordo, Acequia Madre and Camino Del Monte Sol neighborhoods.

The current projected population for the Santa Fe Metropolitan Statistical Area (MSA) is 142,000 residents. The City of Santa Fe accounts for almost half of the MSA, which includes Santa Fe and Los Alamos Counties (U.S. Census Bureau 2000). Santa Fe County

has been experiencing an average annual growth rate of 2.7 percent that is almost twice that of the statewide average (1.5 percent). The majority of the growth in the county is occurring immediately adjacent to the city limits of Santa Fe and in areas outside the Santa Fe urban area (USDA Forest Service 1995, City of Santa Fe 1999), including areas immediately adjacent to the Watershed. The resident population is largely composed of white non-Hispanic and Hispanic (Figure 48).

The most dramatic change anticipated within the Santa Fe region through 2020 will be the overall aging of the population, rather than the high rate of population growth that marked the 1970's and 1980's. By year 2020, there will be fewer residents in the region between ages of 35 and 54 than today as the last of the baby boomers have reached their late 50's. Over a quarter of the population may be 65 and older, as between 1990 and 2020 this age group is expected to triple in number (City of Santa Fe 1999).

Population growth projections for the greater Santa Fe area indicate an additional 30,000 residents by the year 2020. This increase would create an additional demand for water of approximately 7,125 annual acre-feet to serve the projected growth. This demand would need to be met through water resources outside the Watershed (City of Santa Fe 1999).

Lifestyles

The Santa Fe area has been subject to the influences of growth and change over many centuries. Coupled with a superlative natural setting, the unique architecture, culture and celebrations of Santa Fe have made the area very attractive to both permanent residents and visitors (USDA Forest Service 1995).

The traditional pattern of residential development consisted of adobe buildings lining narrow streets that were built with little or no setback. Remnants of this type of development can be found in neighborhoods such as those near the project area (City of Santa Fe 1999).

With the growth of Santa Fe, residents have built houses next to forested lands including the Watershed. Residents enjoy the rural character and feeling of living in the country that large lots provide (Santa Fe County 2000). Many people want to live closer to a natural environment. Hyde Park Estates and Santa Fe Summit are among several developments directly adjacent to national forest lands in the Watershed. These neighborhoods are fairly well established with limited access that provides an even greater feeling of seclusion.

Santa Fe Metropolitan Statistical Area

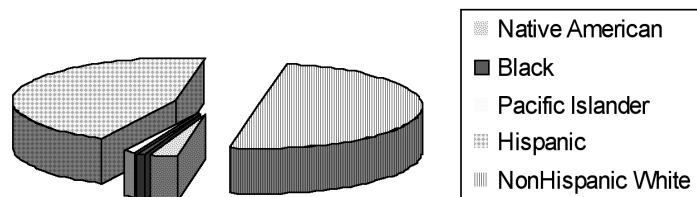


Figure 48. Percentage of Population in Santa Fe Metropolitan Area by Race (1996). Source: Census Bureau.

The City has 58 parks that total over 1,000 acres. The majority of these acres are found in open space parks that serve the entire community and are primarily used for informal recreation. The City is also trying to develop a system of connecting public parks and natural preserves along the Santa Fe River corridor from the base of the project area to the community of La Cienega (City of Santa Fe 1999). Upper Canyon Road is a popular running, walking, and bicycling route for local residents.

Growth of the City has been accompanied by an increase in jobs and a decline in residential population in the downtown area. Increasing distances between jobs and residences have created an ever-increasing number of commuters. Santa Fe residents identified traffic flow and congestion as primary concerns of the area (Research & Polling 1993).

Traffic on the access road into the Watershed has continued to increase. Upper Canyon Road provides the only road access into the project area. The lower section of Upper Canyon Road experiences an estimated 2,000 vehicles per day (Vehicle Count Survey, Project File). The vast majority of vehicles (93 percent) were passenger vehicles, however 6 percent were commercial vehicles. Approximately 20 percent of the traffic is using Upper Canyon Road to access Cerro Gordo neighborhoods. Heavy truck traffic is generally associated with residential projects such as landscaping, building and reconstruction, and delivering materials to small businesses. A moving truck was seen on one occasion and utility trucks and heavy equipment were observed several times. The majority of this heavy truck traffic occurs during normal business hours.

The City is part of a larger commuting area that extends out to the more rural areas of the county and even as far away as Albuquerque. Most workers (87 percent) live and work within the county (City of Santa Fe 1999). The

City is exploring alternate public transportation systems and recently established a municipal bus system. Bicycling has also started to grow in popularity as a means for commuting within certain areas of the City.

According to a county poll (Research & Polling 1993), the majority of residents are very satisfied with their jobs (69 percent) and a larger majority is very satisfied with their current housing. The majority of residents lived in the same residences (56 percent) or a different residence (14 percent) in the City of Santa Fe 5 years prior to the survey. The largest percentage of newcomers (62 percent) came from outside of New Mexico within the past 5 years. Being in or near Santa Fe was the most common response to why people had moved in the past 5 years.

Noise levels also are included in perceptions of quality of life. Noise is unwanted sound or the psychological evaluation of sound (Gramann 1999). Noise sensitive areas near the project area include residential areas, parks, and places of religious assembly (City of Santa Fe 1999). Sources of human-generated sounds observed immediately adjacent to the project area include vehicle traffic in residential areas and along Hyde Park Highway, light construction activities, small equipment and tools such as lawn mowers, leaf blowers, welding torches, and table saws. One point of higher peak sounds is near the bridge over Santa Fe River between Upper Canyon Road and Cerro Gordo. This location is probably the most popular “party” spot within the area (pers. comm. with area residents July 29, 2000). Additionally there are sounds associated with the water treatment facility and occasional peaks from music or other sounds associated with functions at the Audubon group facility. There are public parks and schools on the outskirts of the affected area that have occasional higher peaks of sounds due to outdoor activities.

According to the Santa Fe Police Department (City of Santa Fe 1999), residents complain about excessive noises from two occasional sources:

- Party disturbances, including loud music, loud talking/yelling, traffic noises, and other noises that disturb the general peace; and
- Electronic noise which is most often associated with loud audio equipment audible to citizens located at significant distances from the vehicular sources.



Figure 49. Upper Canyon Road is a narrow road lined with old homes within a historic district of Santa Fe.

Noise monitoring data for the affected area are unavailable. Baseline noise levels were estimated using daytime and nighttime equivalent noise levels (Ldn) in decibels weighted to an A-weighted meter for human hearing (dBA). A typical value in Ldn - dBA for suburban area with similar population densities to the areas adjacent to the Santa Fe Watershed is 50. Noise levels are generally considered:

- Low when below 45 dBA;
- Moderate in the 45 to 60 dBA range; and
- High above 60 dBA.

A 50 dBA is typical in a small town or a wooded residential area whereas a 75 dBA is more common in major downtown metropolitan areas. Even remote settings have “background” levels of noise. A rural farm would have a noise level of 40 to 45 dBA.

Attitudes, Beliefs, and Values

During the early 1990's, the American public could be characterized as having predominantly biocentric [or passive use] values toward forests (Steel 1994). In other words, many people believed in protecting forests because they felt it was important, independent of any utilitarian motive. This view contrasts with anthropocentric views of forests, in which forests are valued because of their utility to humans. The reservoirs were established and the Watershed was designated to provide a utilitarian benefit to the City in the form of a consumptive water supply.

The Watershed is comprised of inventoried roadless and wilderness areas, and the entire Watershed has been closed to public use since 1932. People often assign biocentric, passive use values to natural resources such as roadless areas and places with unique ecological characteristics (USDA Forest Service 2000c). Passive use values include existence and bequest values. Existence values are things, places, or conditions such as roadless areas that people value simply because they exist, without any intent or expectation of using them (Peterson and Sorg 1987, Randall 1992). Bequest value is the desire to allow others, such as future generations, to benefit from a resource. For example, many people believe that forests and wildlife have inherent worth in and of themselves, independent of their utility to humans, and should therefore be protected.

A Research & Polling Public Opinion Poll (1993) found that what residents like best about living in Santa Fe County was related to geography. They most liked living in the country or rural environment, and secondly they liked the mountains, rivers, wilderness, and living in a nice neighborhood. About 89 percent of county residents support the acquisition and/or preservation of scenic lands. Older residents more frequently cite the weather or climate as what they like about living in Santa Fe County, and senior citizens and Hispanics were more likely to mention being close to family as one of their favorite features. The poll also indicates that water, growth and traffic are the major issues facing the community.

For many Hispanic residents whose families were colonists from Spain, agriculture and the acequias (irrigation ditches) are the building blocks for their attitudes and beliefs about the area. "Agriculture has shaped both the community and culture of Santa Fe County. Due to its past role, agriculture remains an integral and complex part of Santa Fe County. It is simultaneously an economic development issue, an open space concern, an important water element, and a key ingredient in valuation of rural character and lifestyle consideration throughout the County. In all of these respects, the agrarian history of the County provides the foundation for considering how the important and positive aspects of this rural culture can be extended into the future." (Submitted by Santa Fe County to the Bureau of Land Management for the Statewide Standards and Guidelines for Range, 1998).

A plurality of respondents (46 percent) to the Public Opinion Poll indicated that increased population was what has changed the most in the past 10 years. This was especially true for people with higher property

values. Hispanics are more inclined than Anglos to feel too many "outsiders" have moved into the area (Research & Polling 1993).

Social Organization

The City of Santa Fe and the accompanying residential communities make up the bulk of the social fabric of the area. Changing demographics and the number of visitors may pose significant challenges to the community capacity of the area. Neighborhood associations began forming in the 1960's as groups of neighbors came together to discuss common issues and ideas. Today the City recognizes over 100 different registered associations (City of Santa Fe 1999).

Tenure within the County and the City of Santa Fe is relatively high. About 62 percent of residents have been in the county for more than 10 years and a surprising 45 percent of residents have been in the area for more than 20 years. High tenure rates tend to contribute to involved human capital.

Community capacity is the collective ability of residents in a community to respond to external and internal stresses, to create opportunities and meet needs of residents. It consists of three broad categories: physical capital, human capital, and social capital. The community of Santa Fe appears to perform well in all these categories. There is active planning occurring in the community both at the City and County level, city streets and infrastructure are maintained and in good condition, civic events are well attended and frequent. There also appears to be several collective themes throughout the community. Many of these themes are identified in the City of Santa Fe's General Plan (1999).

The City and County are also collaborating on planning on the area immediately outside the city limits to provide a better overall plan and community services to the residents. An evaluation of county provided services was completed in 1993 (Research & Polling) that showed strong satisfaction with fire protection and sheriff services. This survey also indicated non-satisfaction with enforcement of county building codes and road maintenance.

The Sangre de Cristo Water Services Division, part of the City's Public Utilities Department, is responsible for the management of water and the development of an integrated water resource plan. The City provides water service for nearly all of Santa Fe, plus some portions of the "extraterritorial zone."

Acequias are traditional irrigation ditches that made agriculture possible for the Indian and Hispanic settlers in early New Mexico. The acequias used today also serve as a social network with a governing body or “association.” Acequias traditionally have cooperative ownership and maintenance responsibilities that knit communities together. There are four remaining acequias within the City of Santa Fe that benefit from the Santa Fe River, including an association immediately adjacent to the project area (City of Santa Fe 1999).

The Native American populations also have their own social organizations that revolve around tribal governments, kivas, chapters, communities, grazing associations, and families. Each Tribe/Nation is uniquely different in its organization although Federal agencies such as the Bureau of Indian Affairs and Indian Health Services provide similar structure to part of the social organization. The Eight Northern Indian Pueblos Council was established to assist the Northern Pueblos in the areas of health, welfare, and economic development. Tesuque Pueblo, which is the southernmost of the Eight Northern Indian Pueblos, is the closest tribal entity to the Watershed. There are several other Pueblos and tribes that have ancestral ties to the Santa Fe River and Watershed.

Wildland-Urban Interface

The wildland-urban interface refers to an area where urban structures, mainly residences, lie directly adjacent to flammable fuels found on forest lands. Developed subdivisions surrounding the Watershed that could be affected by a fire and also increase the risk of a human-caused fire in the area, include the following¹:

- Several high-density, rapidly growing residential areas off Hyde Park Road, totaling approximately 400 acres, such as Hyde Park Estates, Santa Fe Summit, Los Cerros, as well as older lots and some businesses. These subdivisions were given an average hazard rating of very high. Hyde Park Estates has the closest proximity to the project treatment area, is an older subdivision with limited water availability, a single access road, and homes built with flammable materials on steep slopes and ridgetops.

- La Barberia area (approximately 160 lots covering 2,560 acres) includes several neighborhoods and homeowner associations located 1 mile southwest of the Watershed. Average hazard rating in this area is extreme, due to fuels, limited access roads and expected fire behavior.
- Residential areas off the Old Santa Fe Trail and El Gancho Road, County Roads 36 and 67G, and Raven’s Ridge Road, including La Vista, Camino Monte Feliz, and Cloudstone communities along with other remote residences. Average hazard rating is high due to poor access, fuels and increasing housing density.
- Canada de Los Alamos (approximately 242 lots covering approximately 3,320 acres), located 3 miles south of the Watershed. Average hazard rating is high due to increasing density, fuel complexity and poor access.
- Glorietta Conference Center (approximately 200 structures and landscaped property covering 2,400 acres) and Glorietta Estates (approximately 100 lots covering 720 acres), just southeast of the Watershed. Average hazard rating is high due to fuels and poor access.
- La Cueva Canyon, located southeast of the Watershed on County Roads 50 and 63 (approximately 189 lots covering 3,480 acres). Average hazard rating is high, due to poor access, fuels, lack of water availability, and growth.
- Tesuque, about 6 miles north of the Watershed (approximately 552 lots covering 2,160 acres). Average hazard rating is high, due to increasing growth, poor access and fuel complexity.
- Apache Ridge and Ojo de la Vaca, off Old Las Vegas Hwy. southeast of the Watershed. Average hazard rating is very high, due to poor access, limited water, fuel complexity and increasing residential density.

Environmental Justice

Executive Order 12898 (February 11, 1994) directs Federal agencies to focus attention on the human health and environmental conditions in minority communities and low-income communities. The purpose

¹ Hazard ratings were based on evaluation of fuel hazard, risk of ignition, and property values. Lot size information was based on a public database at the Santa Fe County Assessors Office.

of the Executive Order is to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. This section evaluates how the alternatives proposed in the Environmental Impact Statement affect subsets of the general population identified through Civil Rights Legislation and policies, and Executive Order 12898.

Portions of the Watershed have a long history of use by Native Americans and Hispanic communities. Prehistoric use of the Sangre de Cristo Mountains is quite evident. A variety of Native American cultures periodically used the Watershed until increased populations of Spanish colonists made the location less desirable. The Santiago Ramirez Grant was established in 1744. Santa Fe Canyon supported a variety of activities including homesteading, mining, livestock grazing, and logging by Hispanic settlers until the Watershed was closed to public access in 1932 (USDA Forest Service 1998). These two ethnic groups are well represented in Northern New Mexico and the Santa Fe area today and reflect the diverse culture in the area.

As discussed elsewhere in this document, the Watershed serves as a municipal watershed for the majority of the population of the Santa Fe area. The water from the canyon along with other water sources make up the City of Santa Fe's common water supply and as such does not serve a particular segment but is distributed throughout the community.

Effects on the Social Environment

Alternative A

No Action Without Wildfire

Under this alternative there would be no thinning and burning activities to affect the quality of life of residents living in proximity to the project area. There would be no additional truck traffic on Upper Canyon Road area due to Forest Service activities under this No Action alternative. However, truck traffic on Upper Canyon Road would increase if the City treats their lands in the project area.

Current noise levels would not change in the surrounding residential areas. Noise levels would still occasionally be higher due to normal activities in these residential areas. These higher peaks are generally short term in nature and associated with neighborhood activities, such as lawn equipment. Other activities that produce

noise, such as "partying" and loud music that occurs at night, are not as well accepted.

No Action With Wildfire

A great deal of attention has been focused on the increasing size and severity of wildfires occurring on forested lands, particularly in ponderosa pine forests of the west. Forests, such as the one found within the project area, which evolved with frequent low-severity wildfires, are at the greatest risk. Recent wildfires on the Santa Fe National Forest have demonstrated that these fires are larger, hotter and more lethal to vegetation and soil than historic fires in ponderosa pine ecosystems. Additionally, these wildfires are more dangerous or damaging to human settlements, property, and values because of settlement patterns of humans within these environments.

It has been estimated that there is a 20 percent chance of a large-scale, stand-replacement fire in the Watershed in any given year, based on existing fuel loading, climatic conditions, and ignition sources ("Forest Vegetation, Fuels, and Fire Behavior" section). This suggests a 90 percent probability of a catastrophic fire within the next 10 years. Such a fire would be expected to significantly affect the quality of life for surrounding neighborhoods and the community of Santa Fe. The extent, severity, and duration of the wildfire would determine the exact impacts to the social environment. A large, uncontrolled fire could threaten the numerous subdivisions and homes previously described within the surrounding wildland-urban interface. These homes typically have: dense and continuous vegetation surrounding them; inadequate space between flammable fuels; lack of fire-resistant landscaping; wood structures, rooftops or decks; woodpiles or other flammable debris near the house; limited water availability for firefighting; poor road access and limited escape routes, and other factors that create a high-risk of fire ignition. Evacuation of the majority of homes adjacent to the Watershed would be likely, and it is expected that some homes would be consumed if a large, catastrophic fire burns through the Watershed and into the wildland-urban interface. Aesthetics, privacy and other property values in the burned area would be significantly diminished.

If this large, catastrophic wildfire were to happen, large amounts of smoke would affect the entire City of Santa Fe and surrounding communities for many miles. The smoke at Los Alamos during the 2000 Cerro Grande Fire limited visibility to less than 100 feet at times. Smoke from such a wildfire would present health problems to

the elderly and persons with respiratory problems. The “Air Quality/Smoke” section contains a description of smoke impacts.

Residents throughout the City, but more intensely so within northeastern neighborhoods, would experience increased traffic and noise associated with suppression activities. For comparison, over 1,200 fire suppression personnel were assigned to the Cerro Grande Fire at one time. Depending on the location and severity of the wildfire, there could be a variety of equipment used such as fire engines, water tankers, or large lowboy trailer rigs carrying bulldozers. Neighborhoods adjacent to the area would experience increased noise levels associated with suppression activities. It is likely that suppression resources would also include helicopters and planes, which would result in noise above conversational levels that residents could hear along Upper Canyon Road, Cerro Gordo Road and outside other residences adjacent to the project area.

A large fire with a high-severity rating similar to the Cerro Grande and Viveash Fires, would have long-term indirect effects. Soil movement, mud and woody debris flows, and flooding would occur during the rainy season following the fire. Sediment delivery to the water supply would occur following a large crown fire. This would affect the quality of water in the City’s system and require additional treatment or would result in eliminating the City’s use of this water supply. The increase in sediment, ash and woody debris in the reservoirs would likely continue for several years following a major fire. It could fill a large portion of the reservoirs resulting in less storage capacity and requiring dredging the reservoirs at a high cost. Refer to the “Soil and Water Resources” section for more details regarding these probable impacts to City residents and surrounding communities.

Significant increases in peak flows would be expected following a major fire, resulting in flooding along the Santa Fe River. Engineered channels confine the river as it leaves the Watershed and enters the City, and there is no riparian floodplain to help dissipate peak flows. Based on computer models and predictions made by several hydrologists, a large-scale crown fire event in the project area would likely result in flooding through the City along the Santa Fe River, impacting residential neighborhoods and downtown Santa Fe. Flooding could also impact residential, recreational and business areas along the Rio Tesuque or Upper Pecos River corridors, depending on the direction and magnitude of the fire.

Effects for All Action Alternatives

Effects of Thinning and Hauling

All alternatives, other than Option A, include 560 acres of roadside thinning, and hauling the wood products and slash (as chips) out of the Watershed. The number of trucks needed to haul 2,500 to 3,333 cords of wood products and 33,000 to 50,000 yd³ of chips out of the Watershed each year for 3 years is estimated to range from 1,350 to 7,750 trucks annually, based on estimates made by forestry specialists and described in Chapter 2 of this EIS. The low end of the estimate (ca. 1,350 trucks per year) is based on using semi-trucks and the high end (ca. 7,700 trucks per year) is based on using 5-ton or 40 yd³ dump trucks. The road alignment in the last few miles of the access road within the canyon limits the feasibility of using semi-trucks along the entire length of the road. Assuming that hauling could occur approximately 9 months per year, it would require 7 to 40 trucks per day making roundtrips, which means 14 to 80 truck passes per day along Upper Canyon Road and the rest of the haul route. From these calculations, residents on this route could estimate that an average of approximately 40 to 50 trucks would pass their house each day during the hauling periods. Two to 11 trucks per day would be necessary if just the wood products were removed and the slash was burned rather than chipped and hauled out.

An increase of 40 to 50 haul trucks traveling along Upper Canyon Road would impact leisure activities such as walking, bicycling and jogging on this route. This disruption would occur approximately 9 months a year during the first 3 years of treatment activities. Limiting hauling to between approximately 9 a.m. and 4 p.m. on weekdays would reduce some of the conflicts, particularly with commuting and school traffic, but would still reduce the enjoyment of recreating along Upper Canyon Road. Early mornings and evenings, as well as weekends, would still be relatively free of any traffic associated with treatment in the upper Watershed. Using larger haul trucks would reduce the frequency of the impact considerably. Refer to the “Mitigation and Monitoring” section for more detail.

The structural condition of homes along Upper Canyon Road could also be impacted by the expected increase in truck traffic. Vibration from these trucks could cause additional cracking of certain structures. Four homes along Upper Canyon Road were identified as particularly being vulnerable to the increased frequency of vibration caused by dump trucks. It is

largely the frequency of this low level vibration that can cause foundations, particularly mud foundations, to shift and reduce the structural integrity of a home or structure. The trucks would be filled with “green” wood that is very heavy. The total weight of these loads combined with the increased frequency of haul trucks could also damage the road and result in costly road repair or replacement.

The sounds from large haul trucks can range up to 90 dBA from 50 feet away under normal hauling conditions. At slower speeds the sound level would be reduced. For the purpose of this analysis, it was assumed that dump trucks would produce a sound level of 80 dBA at 10 feet due to reduced speeds and smaller engines. Seixas et al. (1999) documented most logging equipment, such as a skidder, to be at 80 dBA or less at the operator station, which is similar to the sound of someone shouting or an old fashion alarm clock with bells ringing at the bedside. Figure 50 illustrates that sound usually decreases about 6 dBA with a doubling of the distance from the source. Thus at 40 feet, the level of sound of heavy equipment such as a dump truck would be approximately 70 dBA, similar to a vacuum cleaner.

Increases in noise would be experienced within approximately 500 feet of the haul route during the removal of products such as chips and firewood. The noise generated by the haul vehicles is similar in loudness to other sounds during this time of day but at a more frequent occurrence. Thus, although the average day/night levels (Ldn) would not increase significantly, there would be more frequent disruptions during the day hours. The topography, screening by walls, other homes and vegetation can also influence how noise is perceived at various distances.

During all thinning activities, residents within approximately two-thirds of a mile of thinning units would be able to hear chain saws during the period of time they would be working in the area. Approximately 15 percent of the acres to be thinned without wood removal would be within two-thirds of a mile of the residences in the upper most portion of Canyon Road. Most residences are over a mile away from the majority of chain saw operations. Most thinning would occur east of Nichols Reservoir, with very little thinning needed within the piñon-juniper zone directly adjacent to the City boundary.

Under Alternatives C1, C2, D1 and D2, thinning would occur within two-thirds of a mile of Hyde Park Estates, hence some residents of this subdivision would be able to hear noises associated with treating acres in the northwest section of the project area. A chain saw, which has a higher decibel level than dump trucks, would be similar in loudness to casual conversation when heard from two-thirds of a mile distance (pers. comm., R.B. Rummer, USDA Forest Service, Southern Research Station, August 8, 2000). When thinning operations occur throughout the eastern half of the project area, City residents would probably not experience an increase in noise levels from chain saws or other machines.

Under Alternatives D1 and D2, thinning with a mechanical feller-buncher in areas away from the road would result in less noise than the manual thinning (B and C alternatives). The feller-buncher saws operate at a lower decibel rating than chain saws, thus the sound would not be heard as far away. Residents would only occasionally be able to hear the feller-buncher, primarily when located on a ridgetop directly across from homes.

Unlike other alternatives, C1 and C2 require the need to thin and build slash piles manually on slopes over 40 percent would result in an increased likelihood of personal injury to forest workers. The hazards involved in working on steep slopes would be reduced under Alternatives D1 and D2 due to using a machine rather than manual labor to thin and pile slash.

Effects of Prescribed Burning

For all action alternatives, the potential social effects from burning treatments include the risk of escape fire, smoke impacts to health and safety, and increased traffic. Alternatives B1, C1 and D1 have a higher chance of escape fire compared to alternatives B2, C2 and D2 that do not include broadcast burning. How-

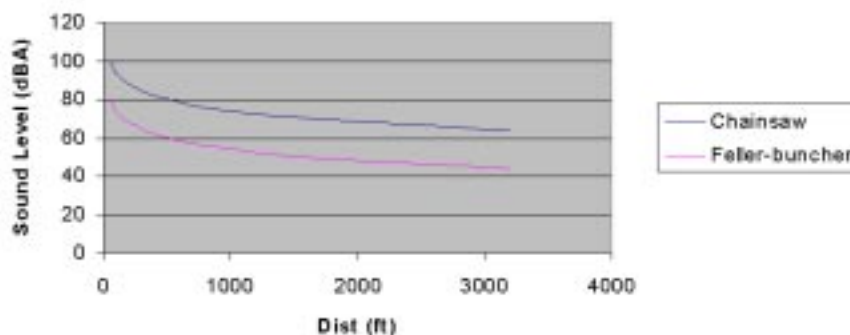


Figure 50. Noise level of equipment proposed to be used in Santa Fe Watershed.

ever, the risk is minimized by the mitigation measures and monitoring required prior to and during broadcast burning treatments. For all alternatives, smoke from slash pile burning and/or broadcast burning would be noticeable in the adjacent neighborhoods especially during the night or early mornings following burning operations. To avoid duplication, refer to the “Forest Vegetation, Fuels and Fire Behavior” section regarding the risk of escape fire. Refer to the “Air Quality/ Smoke” section for the predicted effects of smoke and the number of burn days associated with each alternative. There would be a slight increase in traffic along Upper Canyon Road associated with contractors and Forest Service crews during the burning periods, which would usually occur during the fall and winter months.

For Alternatives B1 and B2, relatively large portions of the project area would not be mechanically thinned to desired fuel levels, allowing portions of the project area to remain at a moderate risk of a wildfire ignition, as described in detail in the “Forest Vegetation, Fuels and Fire Behavior” section. Alternative B2 would remain at the highest risk of a crown fire compared to the other treatment alternatives. Alternatives C1 and D1 have the lowest risk of wildfire ignition after treatment. For all alternatives, unthinned portions of the project area and surrounding forest would be at risk for experiencing a crown fire, however the geographic extent and severity of such a fire would be reduced by the treatments. Social effects of high-severity crown fire, including smoke and potential flooding, would be similar to those described for the No Action Alternative With Wildfire, although the severity of impacts would be greatly reduced. Refer to the “Soil and Water Resources” section and “Air Quality/Smoke” section for details.

Environmental Justice

Although there is a high percentage of ethnic minority populations in Northern New Mexico and the Santa Fe area, it does not appear that this alternative would disproportionately affect these groups. The adverse effects of this proposal on these groups are not likely to appreciably exceed those of the general population.

Noise from this project would largely be focused along Upper Canyon Road and for some alternatives in the Hyde Park Estates area. Smoke from burning activities and wildfire would mostly be dispersed into the atmosphere and would not concentrate on any recognized subset community. Tesuque Pueblo is close to the project area but the prevailing wind direction would likely keep the smoke out of this community to the same extent as the greater Santa Fe area.

Flooding, if it were to occur, would be along the banks of the Santa Fe River that runs through the east side of Santa Fe and the downtown area. Flooding would be driven by the channel morphology of the riverbank and would not be a disparate impact on any particular community group.

Option A: No Wood Removal

This option would eliminate the need for trucks to haul wood out of the Watershed. Thus, impacts associated with these vehicles (i.e. noise and traffic congestion) would be eliminated. Burning the slash on the 560 acres along roads would only slightly increase the amount of smoke production from the project.

Option B: Thin Large Conifers in Canyon Bottom

The difference in the number of trees felled in this option could result in an additional 2 to 5 days of hauling down Upper Canyon Road, where those felled trees are within the 560-acre road corridor.

Cumulative Effects

The City of Santa Fe and surrounding area will continue to grow in the future. The majority of this growth is expected to occur and is planned for in the south and western portions of the Santa Fe area. The lands immediately adjacent to the Watershed are classified as Mountain or Low Density Residential (City of Santa Fe 1999). Along Upper Canyon Road there are no plans for future large residential developments, thus there would not be a significant increase in traffic or noise in the area. There would continue to be minor amount on “infill” and reconstruction in the area. Along Hyde Park Road there is opportunity for some cluster developments provided the density remains at less than one residence per 10 acres. This would lead only to a slight increase in noise and traffic.

Maintenance activities in the Watershed are expected to remain about the same outside of the project. Currently there is an average of approximately three to four vehicles per day associated with administering the Forest Service and City lands within the upper Watershed. There are occasional peaks of higher vehicle use. During the project there would be an increase in use but this would likely decline again to current levels once the project is completed.

The City is planning to treat approximately 200 to 300 acres of their lands within the project area regardless of whether the Forest Service is able to treat the lands

they manage. If the City proceeds with these plans, it would include a portion of the 560 acres proposed to be thinned with this joint Forest Service-City project. The City would only thin trees less than 6-inch diameter in size. This City project would be an initial entry and it is assumed that some of the same stands may need to be thinned again to a lower overstory density of trees in order to meet fuel reduction objectives. Therefore, there would be a cumulative or additive effect regarding traffic and noise from thinning operations, by thinning the same stands twice and hauling products off the same acreage twice. The impacts to the quality of life along Upper Canyon Road from increased traffic, vibration and noise would be the same as previously described. The City contractor estimates the operations would last for approximately 8 months. Approximately 38 dump trucks a day would be needed to haul the materials from the thinning area.

Economics

There are no significant economic issues for this project due to the fact that the only effects would be: a minor positive effect on employment, little or no generation of revenues, and a cost that is substantially less than the costs associated with a large crown fire in the Watershed.

Affected Environment

In 1998, Santa Fe had a per capita personal income of \$29,375 annually. This compares with the national average of \$27,203 and New Mexico's average of \$21,164. The average annual rate of growth for per capita personal income was 5 percent, just slightly more than the national average of 4.6 percent.

The largest industries in Santa Fe in 1998 were state and local government with 36.8 percent of earnings. The service industry was the second largest sector at 30 percent. Since the 1970's, government and service employment has dominated the local economy. The local economy has a small business orientation with the typical establishment employing eight persons and the majority of businesses having fewer than five employees (New Mexico Department of Labor Statistics).

Historically, Santa Fe has a low unemployment rate. The Santa Fe MSA, which includes Santa Fe and Los Alamos counties, traditionally has an unemployment rate of 2-5 percent and is generally 1-3 percent lower than the state average. In May 2000, the unemployment rate for Santa Fe MSA was 3.4 percent due in part to the temporary layoffs at Los Alamos because of the

Cerro Grande Fire. Los Alamos County experienced a quadruple increase in unemployment between April and May of that year from 1.5 percent to 6.2 percent.

Economic diversity is considered an important component of economic resiliency, whether measured at community, county, or regional levels. A measure of economic diversity using the Shannon-Weaver Diversity Index is available by county. This index is based on the number and variety of industry sectors and associated employment using data from the IMPLAN input/output model. A greater number of industry sectors provide a greater diversity of employment opportunities. Therefore, the higher the diversity index, the more likely that a county's economy can absorb and rebound from changing conditions than those with a lower index. Indices range between zero (no diversity) and 1.0 (perfect diversity). In 1996 Santa Fe County had an index of 0.77250. Compare this to 1977 when the Shannon-Weaver Index for economic diversity was 0.50458.

The county's economic development policy is to pursue a strategy that provides diverse business and employment opportunities in appropriate areas throughout Santa Fe County, within community centers, and at locations where transportation and other services are feasible (Santa Fe County, 2000). Research & Polling (1993) determined three quarters of the residents in the area would like to see new economic development and job opportunities in the county. High-tech industries, manufacturing, educational industries, and environmentally clean industries were the top four types of development suggested for development in the county.

Housing has become one of the most critical economic problems facing the City of Santa Fe. Neighborhoods are changing in ways that are not traditional to the city. Poorer families have fled or are being pushed out, and neighborhoods have become more homogeneous at higher income levels. It is becoming ever more difficult to provide and preserve affordable housing (City of Santa Fe, 1999).

Effects for All Alternatives

An economic analysis was conducted to determine the direct and indirect costs, revenues and jobs. The Forest Service Manual and Handbook provide direction on conducting economic analysis during the NEPA process. Agency guidelines indicate that the level of detail in an economic analysis should be commensurate with the scope and complexity of the proposed action, and with economic issues related to the proposed action. A brief, financial cost analysis using Quick Silver Investment Analysis Software was found to be the best fit, as

economics was not identified as a key issue or objective for this fuel reduction project. Economic factors and market values play little or no role in selecting an alternative for this project, because the primary objective is to reduce fuels and prevent a catastrophic fire that could impact the municipal water supply and other resources. Thus, the selection of an alternative will be based on the non-market environmental and social effects associated with the various alternatives, rather than on economic criteria.

This analysis does not attempt to attribute monetary values to natural resource values or effects. Although such analyses are informative, they would not resolve conflicts because such analyses are grounded in judgments. Such tradeoffs are always based on personal “values.” The analysis of environmental and social effects tradeoffs described in this DEIS provides sufficient information to make an informed resource management decision for this project, without the need to assign subjective financial values to resource effects. The main objectives for this project have been identified, and meeting these objectives involves a high financial investment, with little or no financial returns.

Cost Estimates

A variety of assumptions were made in order to calculate costs for implementing each management alternative. These assumptions are based on the best available information and past experiences of land and resource managers. Details of the Quicksilver transactions and associated assumptions are contained in the project record. The treatment types and acreages used in the Quick Silver program are those described in the “Alternatives Considered in Detail” section in this EIS. Acreages used in the Quick Silver program were rounded to the nearest 100 acres. Other assumptions used in the analysis include the following:

- Administrative cost of each alternative, estimated to be 15 percent of the total cost, was not included in the analysis, nor was the planning cost. Only treatment costs were used.
- Thinning and slash piling costs were influenced by the slope and distance from the road. For example, thinning and slash treatments in Alternatives B1 and B2 are generally closer to the roads and on gentler terrain compared to the same treatments in other alternatives. Thinning and piling slash using machines was assumed to cost more than manual thinning and slash piling because the machine thinning companies are all from outside New Mexico and have high travel, setup and lodging costs.

- Slash burning costs were slightly lower for burning the hand-built piles compared to the machine-built piles.
- Broadcast burn costs per acre were assumed to be higher than most other broadcast burns on the national forest, due to the higher level of complexity, sensitivity and monitoring involved in wildland-urban interface areas, particularly when burning within untreated stands and on steep slopes.
- Roadside fuels treatment and removal costs were higher than off-road treatment costs without fuel removal (Option A).
- Costs for Alternative A With Wildfire were based on the actual suppression and rehabilitation costs incurred for the recent Cerro Grande Fire near Los Alamos on the Santa Fe National Forest. The Cerro Grande Fire was a recent large crown fire in similar vegetation within a sensitive wildland-urban interface area. Resource professionals on the analysis team believe that a fire in the Watershed would incur similar costs. Fire suppression costs of \$22 million were those expended up to the time of containment. Rehabilitation costs of \$50 million include those immediate emergency actions taken to minimize mass soil erosion, runoff, flooding, and other environmental hazards, along with additional reclamation actions currently scheduled or in progress. Costs excluded from this analysis are those billions of dollars associated with repairing or replacing homes destroyed by the fire, medical expenses incurred by firefighters or residents, and other indirect socio-economic costs. Costs associated with a catastrophic fire in the Watershed also include dredging the reservoirs to remove accumulations of soil, silt, ash and woody debris that would be predicted to follow such a fire, as well as the cost of hauling that material away. That \$80 million cost is a conservative estimate based on assuming accumulations of approximately 2,000 acre-feet of sediments (50 percent of reservoir capacity), multiplied by a cost of \$25 per yd³ to dredge and haul that material from the Watershed. Refer to the “Soil and Water Resources” section.

Quick Silver results (Figure 40) show costs for each alternative in present net value (PNV). The present net value cost is the discounted cost representing what it would cost if all activities were done this year (the required discount rate for the agency is 4% at a zero inflation rate).

Alternative B2 is the least expensive venture due to the limited amount of treatment acreage involved, and not including any broadcast burning. Alternative B1 is less expensive than C1 or D1 because in B1 only about 35 percent of the acreage is mechanically thinned and the remaining acreage is broadcast burned, and it is less expensive to broadcast burn than to mechanically thin. D1 is the most expensive.

Roadside Wood Removal (560 acres)

Only a portion of the wood products that can be removed from along existing roads could be sold by the thinning contractor in order to offset some of their costs. Most of the firewood would be given away to low-income families to help the community. The contractor may also elect to not remove and sell products or not chip and remove slash. Wood product value, based on current Federal government selling values for all the thinned trees on 560 acres would be \$81,200. Only a portion of this total could be used as an offset to the contract cost. Wood product volumes are based on the stand data and thinning prescriptions in terms of the sizes and numbers of trees to be cut on approximately 560 acres along the roads.

Firewood	\$59,400
Vigas	\$ 7,200
Latillas	\$15,000
Total	\$81,200

Employment Effects

Direct jobs would be created through activities associated with vegetation treatments. Activities such as thinning, slash piling, chipping and hauling would create new employment opportunities in the area. The Forest Service would probably conduct the broadcast burning using agency employees, thus those activities would not create new jobs (other than new agency hires). The type of jobs created would mostly be low to moderate income outdoor labor jobs. More specialized and higher paying jobs, such as feller-buncher operators, would be created with Alternatives D1 and D2.

Alternatives C1 and C2 would create the most jobs over a 5-year period of time (Figure 41) as these alternatives treat the greatest number of acres with laborers. These jobs tend to pay less than many

other industry jobs but higher than the service sector. Alternatives D1 and D2 use a machine to complete much of the thinning and piling away from the road. This equipment is currently not available in the local area thus a portion of these jobs would result in "leakage" where the majority of their income is spent outside the local area.

Indirect jobs can be difficult to estimate as data collected on the forest industry in the past has been collected on a more traditional commercial venture. Thus spending patterns may vary when the work is largely accomplished through a labor force. Also the small scale of the operation makes it difficult to complete an input/output model. The best estimate at this time involves using a simple multiplier of 1.1 as defined by IMPLAN modeling for northern New Mexico. This multiplier assumes that for every direct job created, an additional 1.1 indirect jobs are supported elsewhere in the local economy. As stated earlier, Alternatives D1 and D2 would have a portion of this benefit lost, as there would be 1.6 to 2.3 direct jobs whose benefits would likely go to another economic area.

Table 40. Total Costs For Each Alternative.

Alternative		PNV Cost
Alternative A, with large crown fire		\$152 million
Fire suppression: \$22 million		
Rehabilitation: \$50 million		
Reservoir dredging: \$80 million		
Alternative B1 Thin/slash-burn	2,570 ac	\$2.08 million
Broadcast burn	4,700 ac	
Alternative B2 Thin/slash burn	2,290 ac	\$1.50 million
Alternative C1 Thin/slash burn	5,080 ac	\$3.25 million
Broadcast burn	2,190 ac	
Alternative C2 Thin/slash burn	4,900 ac	\$2.93 million
Alternative D1		\$3.77 million
Machine thin/slash burn	5,080 ac	
Broadcast burn	2,190 ac	
Alternative D2		\$3.43 million
Machine thin/slash burn	4,900 ac	
Option A. No wood removal		Reduces cost by \$600,000
Option B. Thin larger trees on		Insignificant

The commercial sale of firewood is a small subsector economic enterprise. Currently the Santa Fe National Forest sells approximately 5,000 to 6,000 cords of firewood per year in the Santa Fe area through the Española and Pecos district offices. It is not possible to estimate with any precision the amount of firewood that is consumed in the Santa Fe area, but it is probably well over 20,000 cords given the number of homes that have fireplaces and wood burning stoves. All the action alternatives would produce about 2,000 cords of firewood each year for the first 3 years. This volume could be considered part of the forest's normal offer, thus the forest would continue to provide 5,000 to 6,000 cords of firewood from the Española and Pecos Ranger Districts.

The amount of firewood given away to needy families should not have a significant impact on commercial firewood vendors, because it is a relatively small volume in relation to their sale volume and the high demand for firewood. Selling some of the firewood would largely be a substitution of jobs as the 7.5 jobs associated with harvesting and selling the product could displace others who would benefit from selling firewood acquired elsewhere. Selling the product would circulate this value in the economy, thus providing additional indirect jobs. Giving some of the wood away without compensation would help meet the demand for firewood but would not contribute toward additional indirect jobs.

Other Indirect Effects

There are many indirect effects that would enhance Santa Fe's economy but because forestry is such a small entity and employment income from these jobs is relatively small, the effects do not materialize in the input/output models. The removal of fuels from the Watershed would produce economic activities from contracts with local companies and loggers. Other indirect effects include all the environmental, non-market benefits following the fuel reduction treatments. Reducing ladder and crown fuels from this area would limit the serious damage to soil, water, air, wildlife habitat, and forest vegetation that a large crown fire could have in this area, as previously discussed in this EIS. Thus, there are many positive non-market benefits to the local public expected to result from this project, including restoration of sustainable watershed conditions and protection of the water supply. There are positive financial benefits as well. As a result of reducing the chance of a catastrophic crown fire in the Watershed, there would be a major financial savings to public taxpayers in implementing this project, compared to the costs associated of experiencing a catastrophic fire (see Table 40).

Another indirect effect is related to worker safety and labor-time efficiency, which is better under Alternatives D1 and D2 compared with other alternatives. Machine thinning and slash piling is substantially safer on steep slopes, and production rates are much higher than manual thinning and piling.

Cumulative Effects

As mentioned earlier, the Santa Fe economy is fairly diverse. The forestry sector makes up only a small percentage of the overall local economy. Jobs created by the activities proposed would benefit the families of those who successfully obtain these jobs. Families from the more rural parts of the county could obtain these jobs, as this is where the skills and experience to complete the work most likely can be found. Families from the more rural part of the economic area tend to have less opportunities for income related jobs, thus this could be a benefit for this social group. Additional forestry jobs generated by similar wildland-urban interface fuel reduction projects in New Mexico could contribute to cumulative benefits to the employment situation in this state. Other past, present and foreseeable future activities considered would not measurably add to the economic effects predicted for this project.

Heritage Resources

Heritage resources are generally regarded as those resources associated with human use of an area. They can include archaeological sites or ethnographic locations associated with past and present use of an area by a community. These can be physical remains, intangible traditional use areas, and entire landscapes. Heritage resources encompass the remains from past cultures, plus living, changing, modern-day cultures. Present day cultures can identify with both physical site remains and subtle cultural elements that further distinguish and define a groups' cultural identity. Remains of heritage resources are usually referred to as "sites" or historic properties. The physical remains are frequently referred to as archaeological sites. If these remains are associated with living peoples and meet the definition of sites below, they may be considered ethnographic resources. Most often ethnographic resources are associated with "traditional cultural properties" which have "traditional cultural significance" (National Register Bulletin 38).

A few heritage resource inventories have been completed within the proposed project boundaries. These have predominately focused on the canyon bottom adjacent to the Santa Fe River, or near the road in the

bottom of the canyon to the Pecos Wilderness boundary. Several heritage resource sites have been identified as a result of these investigations. An archaeological survey of areas to be affected by projects within the

Table 41. Number of Jobs by Management Alternative.

Alternative	Year				
	1	2	3	4	5
B1	12	27	27	0	0
B2	12	24.5	24.5	0	0
C1	27	27	27	15	15
C2	24	24	24	12	12
D1	14.3	14.3	14.3	1.6	0
D2	14.3	14.3	14.3	1.8	0

Table 41 displays total number of direct jobs created by alternative. Direct jobs were calculated by using total number of persons needed to complete task in given timeframe. Season of work is assumed to be 150 working days between April and November.

Watershed, and consultation under Section 106 would be initiated prior to the signing of the final decision.

An issue associated with heritage resources is:

Thinning and burning activities may potentially damage the integrity of archaeological sites and other areas of traditional heritage or cultural concern.

Affected Environment

Historic Overview of the Santa Fe Municipal Watershed

Little is known about aboriginal use of the Watershed, and limited archaeological research has been conducted in this area of the Sangre de Cristo Mountains. Knowledge of local culture-history is extrapolated from adjacent areas. Overall, prehistoric use of the mountain range appears limited but consistent, beginning as early as the Paleoindian period (10,000 to 5,500 B.C.) up to the present. Aboriginal sites recorded in the general area are surface artifact scatters consisting of projectile points, flakes, manuports (non-local unmodified stones) and scrapers (Wendorf and Miller 1959).

No evidence from earlier survey exists for long-term occupation in the Watershed by ancestral Tewa or Keres

Puebloan populations. Remains of temporary or seasonal high-elevation hunting camps and limited activity sites may be obscured by duff and slash. Based on their longevity in the river valleys below the mountains, it is assumed that Puebloan populations used the high mountain areas extensively for hunting, gathering and other traditional activities. Evidence of these activities would be limited to low density artifact scatters or seemingly temporary structures. For Puebloan populations, water courses with running water, lakes and high mountain regions hold traditional significance. Evidence of such activity may be minimal to nonexistent except in the oral traditions of the communities.

The City of Santa Fe was established in 1610, in part due to the narrow, perennial flow of water in the Santa Fe River and a moderate climate at an altitude of 7,000 feet (Simmons 1988). The river provided the sole source of domestic and agricultural water until at least the middle of the eighteenth century when wells were first established in downtown Santa Fe (Deyloff 2000). In the 1880's, the Water and Improvement Company began developing a series of reservoirs along the Santa Fe River.

Presumably, the population base of Santa Fe grew steadily throughout the eighteenth century and into the nineteenth century, particularly with the opening of the Santa Fe Trail in 1821 (Deyloff 2000). Population estimates for Santa Fe in the 1850's range from 4,000 to 6,000, increasing to 8,000 to 10,000 by the 1880's, and up to 20,000 into the 1920's. Santa Fe Canyon and Santa Fe River provided the City residents with a close supply of resources, supporting a variety of activities including homesteading, farming, mining, livestock grazing, and logging. With an increase in human population over each decade, there would come additional pressure to exploit the hinder lands for resources. Sheep and goats heavily grazed the area for centuries until they were expelled from the canyon under a City ordinance in 1927. The canyon and surrounding area were also logged, probably for fuel until this time (Stabler 1906). Recent archaeological reconnaissance in the Watershed south of Black Canyon and north of McClure Reservoir revealed cross-cut saw ponderosa pine stumps probably dating to this time. Gold mining claims were filed near Granite Point in the early part of the twentieth century, and the geographic feature also gave its name to a Forest Service ranger station that operated during these years. Small homesteads were scattered throughout the canyon during much of the historic period (Sabo 1980).

Early land use in the canyon is documented in historic photos available through the Photo Archive at the

Palace of the Governors in Santa Fe, New Mexico. Photos of small homesteads and afternoon vehicle excursions up the canyon, show denuded hillsides and an open, gravelly stream bed where the Santa Fe River flowed. Josiah Gregg, an early traveler along the Santa Fe Trail, describes his first view of Santa Fe in the early 1830's: "Ascending a table-ridge, we spied in an extended valley to the northwest occasional groups of trees skirted with verdant corn and wheat fields, with here and there a square block-like protuberance reared in the midst" (Gregg 1844). Upon closer inspection these "block-like protuberances" turned out to be adobe houses.

As use of the Watershed grew, organized efforts to manage the City's water supply began in 1887 with the establishment of the Water and Improvement Company of New Mexico. Their purpose was to administer the dispersal of water to the City of Santa Fe by completing a series of three reservoirs (Lewis 1996). This led to the development of the Old Stone Dam in 1881, followed downstream by the construction of Two Mile Dam, in 1893. Two Mile Dam has been said to embody "...the distinct characteristics of a tamped earth dam, through its design and construction techniques" (Lewis 1996). It was determined unsafe and breached in 1994.

In the mid-1920's the New Mexico Power Company installed a hydro-electric unit that was later removed, and in the 1970's a water treatment plant was erected near the Two Mile Reservoir site (Sabo 1980). In 1926, after the administrative authority of the Watershed had been transferred to the New Mexico Power Company, McClure Dam was constructed between 1941 and 1942 about 3.5 miles east (upstream) of Two Mile Reservoir. The administration of the Watershed was transferred to the Public Service Company of New Mexico, and the dam was modified in 1947 to increase its water holding capacity after (Sabo 1980). Nichols Dam, located between Two Mile Reservoir and McClure Reservoir, was constructed from 1926 to 1928 by the New Mexico Power Company (Sabo 1980).

In 1926, an agreement between the Forest Service and New Mexico Power Company limited grazing and forest products gathering to certain portions of the area to protect the safety and overall quality of the domestic water supply. In 1930, the City of Santa Fe issued an ordinance prohibiting bathing, camping, fishing, picnicking and grazing in the Santa Fe Canyon below Monument Rock (approximately 5 miles from Santa Fe). By November 1932, the Santa Fe Municipal Watershed was officially closed, at the request of the City of Santa Fe, to public entry by a Closing Order

issued by the Secretary of Agriculture under the authority of the Organic Administration Act of 1897, as amended by the Transfer Act of 1905 (Project Record).

Known Heritage Resource Sites

A records search of the project area indicates that four heritage resource sites have been formally recorded within the project area. These include three historic habitation sites and an historic road. One of the four recorded sites is considered eligible for the National Register while the eligibility of two others is undetermined. One site has been determined not eligible for the National Register and all evidence of the site has been removed. There are remains of other historic structures at some of the homesteads and other historic locations, although these features have not been recorded as heritage resources. Specifically, there are a number of structures at the location of the "Elks Club" and in the vicinity of homesteads shown on historic maps.

Known Ethnographic Information

"Ethnographic resources and sites include materials, places and things associated with living human communities, as well as physical remains matching the definition of archaeological sites" (USDA Forest Service 1995). A particular geographic area where a community of people traditionally gather plants or hunt could be considered an ethnographic resource. Additionally, a shrine or heritage resource site with significance to a modern cultural could also be considered an ethnographic resource.

Very little is known about the ethnographic use of the Watershed aside from the historic documentation already described. Based on research conducted for the Santa Fe Ski Area Environmental Impact Statement, it seems likely that there is still a connection between modern Puebloan people in the Tewa and Keres communities and the Watershed. It is the headwaters of the Santa Fe River that runs into the traditional lands of the Pueblo of Cochiti. Running water courses in high mountains generally have traditional importance for the Pueblo communities, although ethnographic accounts of the mountain are confined to references to Lake Peak, at the far north end of the Watershed in the wilderness, where no treatment is proposed. As it winds its way to the confluence with the Rio Grande, it passes through traditional territories of other Keres communities and near ancestral communities of modern day Tewa villages. Its origin in the high peaks of the west side of the Sangre de Cristos lies within the

traditional location of the important eastern mountains for the Tewa communities. In addition to Puebloan links to the mountain and the river, local Hispanic communities have strong ties to the area. The Santa Fe River Canyon provided firewood, livestock forage and other resources for local communities prior to the closure.

Ethnographic and historic sources indicate past widespread use of forest resources around the project area. No traditional locations are known or documented within the Watershed but the potential exists for such locations. The canyon may have been used for hunting and gathering for which some evidence may be documented during survey. Important traditional hunts, as well as subsistence hunting, are still done by Pueblo people in the Sangre de Cristo Mountains. Plants provide valuable resources primarily for medicinal and religious uses, and to a lesser extent as a food source (Bremer 1994). In the Puebloan worldview, any location, regardless of whether it has a physically altered landscape or not, can potentially function as a shrine or other traditional use. Undoubtedly, the Sangre de Cristo Mountains provide the living Pueblo people with ceremonial and religious benefits. In addition, other traditional communities like Chupadero and Tesuque have long standing land use relationships with the mountains.

Little extant use is anticipated although if traditional locations exist within the canyon, they may still retain their place name and relative importance. For the Hispanic and American period, it is expected that ethnographic concerns for non-Indian communities will be addressed during the archaeological survey. No traditional communities have contacted the forest for permission to collect boughs or plants or to conduct other traditional activities in the Watershed.

Effects on Heritage Resources

Alternative A

No Action Without Wildfire

With this alternative, no action would be undertaken to reduce fuels on national forest land in the Watershed. The City may continue to reduce live fuel loads on their lands. In the short term, there would be no immediate effects to heritage resources.

No Action With Wildfire

A wildfire in the Watershed under the No Action alternative presents one of the highest risks to heritage resources. All heritage resources within the Watershed and surrounding areas, particularly the Santa Fe Ski Area, could be damaged or destroyed by a large, high-severity crown fire. With the removal of vegetation from burning, there is an increased threat of soil erosion or soil movement. Tree roots can burn through causing them to tip over taking with them a substantial root ball. Each of these scenarios has a detrimental effect on site integrity, stability and protection.

Known heritage resource sites located within the Watershed, the adjacent areas of the Pecos Wilderness, and the Santa Fe Ski Area include stone structure foundations, portions of an historic ranger station, a wooden corral, rock piles or rock features, an historic road, historic and prehistoric trails, and lithic scatters. In the event of a wildfire, mortar in rock foundations could be weakened, stones would be blackened and rocks would spall. All burnable materials could be damaged or destroyed, and all heritage resource sites would be subject to exposure and erosion.

Impacts from fire suppression efforts are another direct threat to heritage resources. The use of bulldozers to construct fire containment lines, plus hand lines and the use of water and fire retardant from aircrafts are all significant threats to heritage resources.

Additional sites may be exposed by a wildfire event through the elimination of vegetation and the consequential exposure of the ground surface. Based on known prehistoric and historic character of the Watershed, it is unlikely that any more site types would be revealed.

In the event of a large crown fire, traditional use areas and Traditional Cultural Properties (TCPs) including shrines, could be significantly damaged and altered. Local communities in Northern New Mexico were impacted by the recent, widespread destruction of forested lands burned in the Cerro Grande Fire. Many people, regardless of cultural affiliation, expressed a loss of wholeness because of the fires. The mountains have long represented a sense of spiritual strength and a tie to the land. Because they are so visible, they are a tangible part of the landscape, and a large fire in the Watershed would effectively be as much a physical loss as an emotional and psychological one.

Alternative B1

This alternative increases the potential for affecting heritage resource sites sensitive to broadcast burning that may not be located during an archaeological survey. However, due to the number of acres being treated, this alternative has the potential to better protect sites from a possible wildfire event, compared to Alternatives A or B2.

All the proposed action alternatives include a combination of ground disturbing activities comprised of low-severity broadcast burning, pile burning, tree thinning, removing some trees along roadsides, and constructing fire control hand lines on ridges. Heritage resource sites documented during the inventory would be avoided by all project activities.

Selective thinning of the smaller size trees in each stand would have no effect on known heritage resource sites provided felling of trees occurs outside of site boundaries as proposed. There is the potential to impact undiscovered sites or instances where trees accidentally fall within known site boundaries. Impacts may include damage to wooden or stone features or altering surface features such as hearths, field houses or lithic scatters.

All sites would be evaluated for their fuel loading. In some cases, treatment may include removing excessive fuels from on and around sites. Prescribed burning could directly or indirectly affect site features and artifacts by flames and exposure to heat. Slash piles to be burned would be placed so that no piles are within known heritage resource site boundaries, and broadcast burns would be conducted to avoid burning perishable remains on heritage resource sites. See the "Mitigation and Monitoring" section for detailed descriptions of protective measures. Thinning along the bottom of the canyon near the road and around the reservoirs would have little effect on heritage resource sites since it can be assumed this area has been disturbed in the past through previous flooding events and human activities.

Any ground disturbing activities and increased access to remote areas could inadvertently affect heritage resource sites. While disturbance to the sites would result in direct impacts, increased access can lead to vandalism, theft, and other indirect impacts. If previously unidentified sites are encountered during implementation, a forest heritage resource specialist would consult with the State Historic Preservation Office to determine the significance of the discovery and the effects of the project upon them as well as possible treatment.

Alternative B2

Potential impacts would be similar to those described for Alternative B1, except that this alternative treats fewer acres and, therefore, poses the least threat of impacts to heritage resources during thinning and slash treatment activities. It would be the least effective fuel reduction treatment among the action alternatives; hence, over time this alternative poses a greater threat to heritage resources due to the extent and severity of a potential wildfire in the Watershed.

Alternatives C1, C2, D1, and D2

The potential for impacting unknown heritage resource sites with these alternatives is increased simply by the overall amount of land being treated. However, mitigation and monitoring measures are expected to be effective in creating a low risk of damage to heritage sites, based on past experience with similar thinning and burning projects on the Santa Fe National Forest.

Broadcast burning under Alternatives C1 and D1 has the same effects described for Alternative B1. There is little potential for finding heritage resource sites on slopes 55 percent or greater where much of the broadcast burning would be conducted.

Alternatives C2 and D2 eliminate broadcast burning and the associated potential for impacts to flammable remains of heritage resource sites.

The machine-operation alternatives (D1 and D2) present a slightly higher potential for site damage because the machine operator is removed from the ground and cannot easily spot potentially undiscovered heritage resource sites. With the other alternatives, the forest workers walking up and down the slopes to conduct manual thinning and slash piling would more likely notice artifacts on the ground.

In general under any of these alternatives, survey and site marking procedures along with the other mitigation and monitoring actions would provide for a low risk of site damage in this area. These alternatives would reduce fuels in most of the project area, leaving only scattered patches of untreated forest fuels. Thus, post-treatment risk of catastrophic wildfire is relatively low. If a wildfire should occur in this area in the future, it could result in similar impacts to heritage resources as those described for the No Action with Wildfire alternative, although the severity and extent of impacts should be substantially diminished.

Option A: No Wood Removal

With this option, effects on the 560 acres of roadside thinning would be the same as those described for the other action alternatives where the wood is left in place. There would be slightly less ground disturbance with this option by leaving the wood on site, reducing the chance of direct impacts to sites on those roadside acres.

Option B: Thin Large Conifers in Canyon Bottom

Increasing the numbers and size of conifers felled in the canyon bottom would slightly increase the chance for direct impacts to heritage resource sites with the 100 acres that this option applies to. However, survey, site marking, and other mitigation and monitoring actions would provide for a low risk of site damage in this canyon bottom area.

Cumulative Effects

Activities currently occurring in the project area could result in damage to heritage resource sites from people walking over sites or removing artifacts during public tours, data collection activities or unauthorized recreation. Unauthorized cattle grazing known to occur in the area can result in trampling of sites. The known sites in the area are relatively stable, with no noticeable impacts from soil erosion or runoff, and current erosion rates in the Watershed appear to be fairly stable. There are no reasonably foreseeable future activities that would affect heritage resource sites in the project area, other than possibly the thinning that may occur on City lands prior to implementation of this proposed project. However, there is a low risk of direct or indirect impacts to heritage resource sites from the treatment alternatives, if conducted in accordance with actions described in the "Mitigation and Monitoring" section. The added potential for impacts from current and ongoing activities would not significantly increase the risk of impacts to heritage resource sites above the level predicted for this project.

Recreation and Scenery

An issue related to recreation and scenery is:

Noise from thinning operations or smoke from burning may possibly affect the quality of recreation or enjoyment of scenery near the project area, such as at developed recreation sites or along trails.

Affected Environment

The Secretary of Agriculture closed the Watershed to all uses in November 1932 for the protection of water quality. It has remained closed to all public access since then. The issue of opening the Watershed to public use surfaced in the 1980's during development of the Forest Plan. The Forest Plan decision in 1987 was to retain the public use closure for the Watershed. During the planning process for this project, representatives from the City of Santa Fe and the Forest Service reviewed the existing conditions assessment and reasons for the closure, and to determine whether this issue should be reconsidered. There is evidence from throughout the forest as well as from past use of the Santa Fe River Canyon that public recreational use along fragile riparian areas contributes to water quality degradation. At the present time, however, the major concern about allowing unregulated public access for recreational uses in the Watershed is the potential for accidental or deliberate starting of a wildfire, which could quickly become a large-scale catastrophic event due to current fuel conditions. Forest Service and City officials agree that until the wildfire risk is adequately reduced, the closure should stay in effect. However, during periods of low fire risk, agency officials have agreed that it is acceptable to allow for educational public tours of the project area, guided by Forest Service or City officials. These public field trips, conducted mostly as half-day hikes, have been ongoing almost every month for the past 2 years. Groups of 10 to 25 individuals typically participate in these monthly trips.

Another ongoing concern is the number of individuals illegally entering the Watershed to hike, mountain bike or fish, and the effect they may have on wildfire ignitions. While the exact number of individuals who have entered the Watershed is unknown, we know they have been the cause of several fires. Since 1970 there have been seven human-caused recorded fires in and adjacent to the Watershed. These fires did not spread into crown fires because of the higher fuel moistures at the time of ignition or because they were rapidly suppressed with aerial retardant drops and ground crew firefighters. The City of Santa Fe hired a private security firm to patrol the Watershed and enforce the closure order. Again exact numbers are not known but the City believes that the number of individuals entering the Watershed has decreased since the security patrols began.

Hyde Park Road (also known as State Highway 475) is a major recreational corridor located about 1 to 2 miles north of the Watershed boundary. It provides numerous developed and primitive recreational sites and trails that are just 15 minutes drive outside the City of Santa

Fe. Recreation sites include: Black Canyon Campground (40 camping units), Hyde Memorial State Park (50 camping units, 3 group areas, numerous trails and a lodge), the Santa Fe Ski Area, Aspen Basin campground (10 units), Big Tesuque Campground (7 units), Aspen Vista Trail and Picnic Area, Little Tesuque Picnic Area, and other small picnic grounds and trailheads. At the top of Hyde Park Road is the trailhead for Forest Trail #254. This trailhead located on the west end of the Ski Area parking lot is a major entry point for the Pecos Wilderness. Trail counters indicate annually approximately 20,000 people use this trailhead for entry into the wilderness.

Estimated number of visitors annually, including approximately 200,000 visitors to the ski area during the winter, is 1.5 million. Hyde Park Road is also a designated State Scenic Byway, and the majority of these visitors (approximately 1 million) drive it to enjoy the scenery and views. The developed campgrounds are typically full throughout the summer and on many holiday weekends. The Ski Area also offers summer-time recreation by operating lifts to transport visitors to the mountaintop viewpoints, as well as providing hiking and mountain biking opportunities. In the fall, Hyde Park Road is a major destination for fall foliage viewing opportunities, as the large stands of gold-colored aspen leaves provide a beautiful contrast among the dark green conifer trees. Winter recreation activities include downhill skiing and snowboarding at Santa Fe Ski Area, sledding and snow play at Hyde Memorial State Park, cross-country skiing, snowmobiling and snowshoeing.

The scenery within the project area is not a major concern, primarily because it is closed to public use. There are no trails that lead directly into the Watershed, and there are no overlook points from any roads, trails or recreation sites that provide views into the project area. On the southwest side of the Watershed, there is the Atalaya trail system that approaches within a mile of the Watershed boundary. It also does not provide views into the project area.

Effects on Recreation and Scenery

Alternative A

No Action Without Wildfire

Under this alternative public field trips into the Watershed would continue and it would otherwise remain closed to the public. Unauthorized use would occur at

current levels, though increased law enforcement may reduce the number of individuals entering the Watershed. Recreational uses adjacent to the Watershed would not be affected by the routine maintenance activities that would continue within the project area.

No Action With Wildfire

There could be a major impact on recreation and scenery if a large crown fire either starts in the Watershed or burns through the Watershed and enters the Big and Little Tesuque drainages, along Hyde Park Road. A fire in the Watershed would be likely to burn north toward Hyde Park Road and Big and Little Tesuque drainages due to prevailing winds. Based upon fire behavior exhibited at the recent Cerro Grande Fire, it is expected that the ponderosa pine and mixed conifer stands would burn hot and kill most, if not all, trees. Depending on the severity of the burn, the developed campgrounds listed in the “Affected Environment” section could be severely damaged or destroyed. This would result in closures for an extended period of time (potentially years if the sites are destroyed by the fire). In addition, the desirability of using these popular recreation sites would be reduced if fire kills the trees, destroying aesthetic values. A study of changes in scenic values following fire found that a severely burned forest has the least desirable aesthetic qualities compared with stands that have been thinned to various intensities (Scott 1998). If much of the Hyde Park corridor burns severely, there would be few, if any, shade trees available, and the recreational facilities may be unuseable. While some people would still drive the highway, hike or cross-country ski to view the burned areas, most overnight use would be eliminated and other recreational activities would likely be reduced by at least 50 percent.

Smoke produced during the wildfire event would be likely to impact recreational activities in parts of the Hyde Park Road corridor, depending on the wind direction and smoke dispersion conditions at the time of the fire. It could impact visibility in the Pecos Wilderness as well (Refer to the “Air Quality/Smoke” section).

A fire in the Watershed would have minimal effects of the scenic quality within the project area, since it is not visible from any key viewing points along roads or trails. A fire burning into Big and Little Tesuque Creek drainages would impact scenery from key viewpoints from Santa Fe and U.S. Highway 84. In this situation the effect on scenic quality would be long term. The fire could potentially burn through the aspen stands, seriously affecting this prime fall foliage viewing area.

However, aspen often survives wildfires that consume surrounding coniferous stands, as was seen in some aspen patches within the Viveash Fire area. In addition, aspen resprouts following mortality by fire, thus there could be more aspen in the area in the future following a large wildfire event.

Effects of All Action Alternatives

The alternatives would not affect recreation use in the project area, which is closed to recreational use. There may be minimal effects to users of the adjacent trail system in the Atalaya area due to increased noise. This effect would be short term (only during actual work periods) and only when work is occurring within 1 mile of the trail. When thinning is occurring on the northern perimeter, such as to create the north fuel break, noise from chain saws would likely be heard within two thirds of a mile away, such as at Black Canyon Campground and Little Tesuque Picnic Ground and trail. The decibel level of the noise at this distance would not be considered “high” and should not significantly detract from the natural, quiet surroundings (see the “Social Environment” section for more information about noise levels).

There would be no effect to the scenic quality in the project area from the treatments, because the area is closed and the public does not view the project area from any roads, trails or viewpoints. However, some people would participate in guided field trips in order to see the results of treatments. During the first year after a portion of the area is thinned, the public would be likely to notice piles of slash and numerous cut logs on the forest floor, along with a healthy stand of primarily ponderosa pine trees. Several years later, most of the evidence of the cutting—such as stumps and slash—would not be evident and the forest floor would have increased grasses, shrubs, wildflowers and other plants growing under the trees because they are spaced further apart. The forest would appear more mature, with larger trees (mostly over 12-inch diameter) dominating the landscape rather than smaller trees (5 to 12-inch diameter) crowded together. Ponderosa pine stands treated with fuel-reducing, thinning-from-below prescriptions are typically more aesthetically appealing than dense, untreated ponderosa pine stands (Scott 1998). Thus, even though visual quality is not an objective for this area and few people are allowed to enter the area, the landscape in the project area would have dense patches and openings, would be more diverse, and more aesthetically appealing in the long-term.

The portion of the Pecos Wilderness outside of the Watershed that is open for recreational use is more than 8 miles away from the project area. There would not be any direct effect on wilderness use from any of the alternatives. The potential for smoke from burning to drift into the wilderness and affect users would be unlikely, due to the distance from the treatment areas, the limited amount of smoke produced, and the dispersion conditions under which the burning would be conducted. Smoke would also be unlikely to affect recreational activities in the Hyde Park Road corridor or along the Atalaya Trail (see the “Air Quality/Smoke” section).

The major benefit to recreation use from any action alternatives would be the potential to reduce the likelihood of a fire entering the adjacent Big and Little Tesuque watersheds and the Hyde Park Road recreation corridor. Alternatives C2 and D2 would be the most effective fuel reduction treatments, while Alternative B2 would not be very effective, and the other alternatives (B1, C1, D1) would be more moderate in their effectiveness (refer to the “Forest Vegetation, Fuels, and Fire Behavior” section). Thus, depending on the degree of relative effectiveness of treatments, a wildfire could still occur within the project area and impact recreation in the adjacent area if it spread quickly to the north of the Watershed.

Options A and B: No Wood Removal; Thin Larger Conifers in the Canyon Bottom

These options would not alter the effects of alternatives previously described. There would be no effects on recreation or scenery within the project area and little if any effect in the nearby recreational areas.

Cumulative Effects

As there would be no noticeable direct or indirect effects on recreation or scenery from implementing the action alternatives, there could be no cumulative effects.

Facilities

An issue associated with facilities is:

Burning produces ash that could enter the water supply during rainstorms and damage the water filtration system. This may also affect water quality and taste, especially when burning adjacent to the river and reservoirs.

Affected Environment

Water Storage and Treatment Facilities

McClure Dam and Nichols Dam impound surface water collected from the Santa Fe Canyon Watershed. McClure Reservoir is located at an elevation of approximately 7,900 feet above mean sea level (amsl) and has a storage capacity of 3,257 acre-feet. The elevation of Nichols Reservoir is approximately 7,500 feet amsl and has a storage capacity of 685 acre-feet. Water from Nichols Reservoir is released into the Santa Fe River or diverted through the reservoir dam tower into the Canyon Road water treatment plant. Releases are controlled in response to demands from the water treatment plant and downstream users (e.g. acequias).

The water treatment plant is located downstream from the reservoirs where it treats the water from the two reservoirs. The treated water is delivered into the two million gallon tank at the water treatment plant. The treatment plant consists of multiple stages of treatment. In the first stage the water is injected with preoxidant (MIOX), lime, and alum (prior to the Static Mixer) and a coagulant aid before entering the Flocculation/Clarifiers. Once the water enters the Flocculation/Clarifier, a flocculent aid is added to enhance flocculation and settling of the captured solids. With this series of chemical added to the raw water, the Flocculation/Clarifier serves as the first point in the treatment of the raw water where small solids and particulates, naturally occurring in the water, are gradually separated from the liquid. The pH, temperature and turbidity all determine the amount of chemicals and length of time for each stage of treatment.

The clearer water, separated from the floc that settles to the bottom, flows to the next treatment process, the filters. The purpose of the filters is to remove fine organic and inorganic materials from the water, as well as bacterial content contained in the water and removing contaminants which may cause taste and odor problems. The filter consists of anthracite coal and sand.

Roads

The service road into the Watershed is gravel and is in good repair. The City and the County share in maintaining it. The surface is rut free, and at least 5 feet of widening is provided at every curve. Turnouts are frequent, often less than 1,000 feet apart, and average 10 feet by 70 feet. According to City staff, the road is graded once every 2 months on the average.

The existing alignment of the Watershed service road does not totally lend itself to accommodating a Lowboy with an 18-foot tractor and a 36-foot trailer. This vehicle requires certain minimum Federal standards. Problems are evident about 3.4 miles from the locked gate that accesses the Watershed. At this point, there is a tight horizontal curve possessing a centerline 50-foot radius. A lane width of 27 feet would be needed here for the existing radius; only 14 feet plus 5 feet of curve widening is provided. To further complicate the situation here, the approaching gradient to this curve is greater than positive 15 percent as measured with a clinometer. At mile 3.7 above the gate, another tight curve is encountered that would hamper further progress of the aforementioned vehicle. At this location, the measured radius is something less than 100 feet and the required lane width here should be 21 feet; less than 19 feet is provided. Lastly, the switchback found at mile 4 cannot be negotiated without some major realignment. The centerline radius provided here is less than 40 feet and a minimum of 60 feet is required with a lane width of 27 feet.

Along Upper Canyon Road, the posted speed limit is 25 mph with a 15 mph limit passing through a school zone. Vehicles have been observed exceeding these limits. Upper Canyon Road through the residential area narrows to an average width of 14 feet and frequently has vehicles parked along it.

Two bridge-type structures are encountered on Upper Canyon Road. The first is at 0.3 mile south from the forest gate. It is approximately 25 feet long and composed of 3 corrugated metal arches with a 5-foot separation from end to end, each having a span of 50 inches and a rise of 31 inches. The height-of-cover averages 18 inches. The second bridge is a true bridge with a concrete deck and mortared headwalls located 1.7 miles from the forest gate. The length of this bridge is approximately 40 feet. Both structures have experienced loads of 40 tons in the past, and neither the first nor the second bridge has posted ratings.

Effects on Facilities

Alternative A

Short-Term Effects in the Absence of Fire

If no fire occurs in the Watershed, a decrease in yield from the reservoirs would be anticipated. No damage to the water system facilities, other than that which would result from insufficient water supply, would be

expected. There would be no additional effects on roads beyond that of normal use.

Wildfire Effects

If a catastrophic fire occurs, severe impacts to the reservoirs may result. Siltation of the reservoirs that would result from heavy rains following a severe fire would reduce the capacity of the reservoirs, and thus reduce the City's water supply. Most of the supply is captured during spring runoff, and thus, is not a constant source derived from the Santa Fe River. The amount of sediment produced during such a catastrophic fire has been estimated to be 577 acre-feet the first year following a severe wildfire and 1,571 to 3,249 acre-feet 10 years after a catastrophic fire. This would result in loss of more than 50 percent of the reservoir capacity.

The sediment loading would not only reduce the capacity of the reservoirs, but the turbidity of the water would impair use of the water. The City of Santa Fe is dependent on the Santa Fe River during the summer months to meet daily demands. Therefore, if turbidity increases for any extended period, the City would have to prohibit all outdoor watering until such time that the treatment plant could be returned to normal operating capacity.

If the City is forced to use water from the reservoirs because of the demand on the system immediately after a heavy runoff event, the heavy silt load could clog sensing lines and would decrease the daily output of the plant. Any disturbance of the Watershed surface could change the balance of nutrients and result in a need to reevaluate the chemical treatment of the water. Other chemical changes may occur, such as increases in magnesium from pine needles. This has been observed in other watersheds following fires. The increase in magnesium would result in the need to increase chlorination by two to three times. It is expected that there would also be undesirable effects to water odor and taste.

A wildfire would create additional traffic on Upper Canyon Road and the service road for a relatively short period of time. Most of this traffic would be light-duty trucks, fire engines, and other fire suppression related vehicles.

All Action Alternatives

Although a semi-tractor trailer truck cannot presently negotiate the entire 6.8 miles of the Watershed service road, it can be considered with the simultaneous use of

small dump trucks and loaders. There is an area along the service road measuring 70 by 50 feet that could be enlarged to accommodate the transfer of wood chips from a dump to a semi-truck for transporting through the adjacent neighborhood. This area is located 0.9 mile from the forest gate. There are a few roads that branch to the left at miles 2.65, 3.20, and 3.35 that could be used to turn a semi-truck around or temporarily stage small dump trucks.

The increased use of a wood chipping operation over a period of 3 years would require an aggregate base course of 6 inches in depth on the service road. Frequent road grading and watering to minimize erosion, rutting, and control dust problems would be warranted. The estimated cost of placing aggregate base course for 6.8 miles is \$254,000. The estimated cost for realignment has not been analyzed but this figure would probably exceed \$50,000. This is assuming an aggregate of 1 mile of realignment to lessen horizontal curves only.

A semi tractor-trailer truck can travel through the adjoining neighborhood along Upper Canyon Road, but this should only be attempted with the use of an escort vehicle with lights flashing. The narrow width combined with vehicles parked along this road could cause problems for a semi-truck attempting to pass with traffic approaching from the opposite direction.

There would be no direct effects to the water treatment facilities from the action alternatives. Minor increases in sediment during project implementation and afterwards until ground vegetation is reestablished would not be great enough to contribute to cumulative effects on the operation of the water treatment facilities.

Option A: No Wood Removal

This option would eliminate effects on the service road and Upper Canyon Road that would be anticipated from hauling wood (e.g. wear-and-tear, possible upgrading).

Option B: Thin Large Conifers in Canyon Bottom

This option would have no effect on facilities.

Cumulative Effects

Cumulative effects on the service road in the Watershed and local neighborhood streets would result from implementation of any of the action alternatives combined with ongoing City, County, Forest Service and private activities. This includes recent increases in the number

of vehicles on the service road for security patrols, public tours, and regular maintenance. Future increases in traffic would result from immediate and also more long-term research and monitoring projects and from routine management activities such as maintenance burns. The effect of increased vehicles, some of them particularly heavy trucks, during project implementation would combine with existing routine use and other increased uses to result in accelerated deterioration of these roads.

Unavoidable Adverse Effects

The Santa Fe Municipal Watershed was closed to public use in 1932 to protect the water supply that is the source for about 40 percent of the City of Santa Fe drinking water. Currently, runoff from snow and rain in the mountains that rim the Watershed provides very high quality drinking water for citizens of the community. The action alternatives proposed for this project would provide positive action to ensure that the water supply remains protected. In doing so, there would likely be some short-term adverse effects to human, wildlife, and other natural resources.

There would be increased noise levels in the Watershed and surrounding residential areas that may disturb wildlife or humans. This includes noise from operating machinery required for forest thinning (e.g. chain saws or mechanical feller-buncher) and noise from increased traffic on the Watershed service road and along adjacent residential streets. In particular, trucks hauling firewood from the Watershed may lead to a temporary decrease in the quality of life in neighborhoods along Upper Canyon Road and Cerro Gordo Road, for example.

Smoke created from burning slash piles or conducting broadcast burns may become thick enough to be a nuisance in the Santa Fe area or other communities downwind of the burning. Even with careful planning, a weather change could deposit much more smoke in residential areas than planned for, causing minor irritations for many people and possibly severe symptoms for a few people.

Minor increases in soil erosion and stream sedimentation would occur during project implementation. However, this effect would not be great enough to adversely affect the drinking water supply. With proper implementation of mitigation measures described in the "Mitigation and Monitoring" section, all other potential other adverse effects could be avoided.

Relationship Between Short-Term Uses and Long-Term Productivity

Short-term uses that may potentially occur include the thinning, slash piling and pile burning, broadcast burning, possible chipping and hauling, and monitoring activities. These uses would occur over a 5- to 10-year period, depending on the alternative selected. The analysis shows that these short-term land uses would not have an adverse impact on long-term soil or vegetative productivity, or on water production. In fact, the analysis indicates that long-term productivity would be enhanced by the treatments, through creating openings in the closed-canopy forest areas and reintroducing low-intensity surface fires, which together should improve productivity.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are those that cannot be reversed except in the extreme long-term. For example, the extinction of a species is an irreversible commitment as is the removal of minerals during a mining operation. Irretrievable commitments of resources are those that are lost for a period of time, such as building a shopping center on farmland; the land will not be productive again unless it is restored for farming.

Implementation of any of the action alternatives would indirectly result in an irreversible commitment of resources. Irreversible commitments from the proposed project would generally be limited to the use of petroleum products for operating forestry machinery (e.g. chain saws, feller-buncher) for thinning. Also, vehicles used to access the Watershed for thinning and burning activities and to transport firewood from the Watershed would also use petroleum products. Petroleum products are made from natural resources that cannot be restored except in the extreme long-term. In addition, use of road maintenance materials, such as placement of aggregate on the road, would be considered irreversible commitment as well due to the inability to replace these resources except over centuries.

Any heritage resource site that is inadvertently damaged during project implementation would constitute an irretrievable commitment, too. Once damaged, the site could never be fully restored to its original condition. Mitigation measures described in the "Mitigation and Monitoring" section are expected to avoid any such commitment of heritage resources.

Irretrievable commitments of resources would result from the action alternatives. Irretrievable commitments would include the loss of soil productivity from erosion and sterilization. Soils disturbed during thinning that subsequently erode would lead to loss of soil productivity in those areas. This may result, to a minor extent, from the use of thinning machinery or even from informal trails created by woods workers doing manual thinning. Other areas that may be affected would include small areas along the road used for piling firewood for removal from the Watershed. Prescribed burning in the form of slash pile burning and/or broadcast burning may also result in lost soil productivity if soils become too hot and are sterilized. Either condition -loss of soil through erosion or loss of productivity from sterilization-would persist for a very long time until the soils can rebuild.

The greatest chance of an irretrievable or irreversible commitment of resources occurring is with the No Action Alternative in the event of wildfire. If a wildfire should occur, all of the previously described irretrievable and irreversible commitments would likely result but at an exponential scale. Thousands of acres of soil may be sterilized and even more eroded away. Many heritage resource sites could be damaged or destroyed without advance notice to allow protective measures to be taken. And the use of petroleum products for fire suppression activities (e.g. slurry bombers, helicopters, tanker trucks) would be likely to greatly exceed those used for thinning and prescribed burning.

Chapter 4 • List of Preparers

Name	Position/ Organization	Contribution	Education	Relevant Years Experience
Armstrong, William	Forestry Technician Espanola Ranger District Santa Fe National Forest	Fuels and Fire Behavior Air Quality/Smoke	B.S. Forestry Graduate of Technical Fire Mgmt.	20
Baldwin, Anne	Archaeologist Coyote-Espanola Resource Area Santa Fe National Forest	Heritage Resources	M.A. Cultural Anthropology B.A. Archaeology	25
Barkmann, Gretchen	Biological Scientist Santa Fe National Forest	Air Quality/Smoke	M.S. Environmental Engineering B.A. Biology	12
Barros, John, P.E.	Civil Engineer Tonto National Forest	Road Analysis	B.S. Civil Engineering	10
Bremer, Michael	Heritage Program Mgr./ Forest Archaeologist Santa Fe National Forest	Heritage Resources	M.A. Anthropology B.A. Anthropology	25
Bruin, John	Lands Program Leader Santa Fe National Forest	Recreation, Scenery, Lands	B.S. Forestry Graduate of Recreation Management Program	23
Bruin, Susan	Forest Planner Santa Fe National Forest	Project Leader EIS Editor	M. S. Natural Resource Policy, Administration, & Law B.S. Natural Resource Mgmt. Forest Ecology	21
Cassidy, Regis	Regional Silviculturist Southwestern Region	Forest Vegetation	M.S. Forest Genetics/Physiology B.S. Forest Management Graduate of Silviculture Program	28
DeGray, Marie	Fuels/Fire Use Specialist Jemez/Cuba Resource Area Santa Fe National Forest	Fuels and Fire Behavior Air Quality/Smoke	A.S. Forestry Graduate of Technical Fire Mgmt.	20
Harris, Aurelia B.	Regional Economist Southwestern Region	Economics	Ph.D. Economics M.S. Natural Resource Economics B.S. Accounting	18
Hudnell, Laura	Air Resource Specialist Western Zone and Southeastern Region	Air Quality/Smoke	B.S. Geography L.P.N.	15
Karsian, Anne	Natural Resource Planner Santa Fe National Forest	Heritage Resources	M.S. Forest Ecology B.A. Anthropology	15
Lewis, Amy	Water Resource Planning Coordinator City of Santa Fe	Facilities, Monitoring Plan	M.S. Hydrology B.S. Geology	15

List of Preparers

Name	Position/ Organization	Contribution	Education	Relevant Years Experience
McCord, Jim	Senior Hydrogeologist Hydrosphere, Inc.	Hydrology, Soils	Ph.D Hydrology B.S. Civil Engineering	15
Neff, Phil	Fire Management Officer Jemez Ranger District Santa Fe National Forest	Fuels and Fire Behavior	Graduate of Prescribed Fire Behavior Analysis and Complex Prescribed Fire Mgt. Programs	26
O'Brien, Stephen	Logging Engineer Helena Ranger District Helena National Forest	Helicopter Analysis, Logging Systems	B.S. Forest Science Graduate of Adv. Logging Systems	24
Orr, Mary	Wildlife Biologist Espanola / Coyote Resource Area Santa Fe National Forest	Threatened, Endangered and Sensitive Species	B.S. Biology B.S. Wildlife Biology	20
Pittenger, John	Senior Biologist Blue Earth Ecological Consultants, Inc.	Riparian Areas and Wetlands, Aquatic Habitat and Biota, Terrestrial Habitat and Wildlife	M.S. Fisheries Science B.S. Biology Graduate work in plant ecology	14
Sandoval, Al	GIS Technician Santa Fe National Forest	GIS Maps and Data	B.A. Business Administration	7
Seesholtz, David	Social Science Coord. Southwestern Region	Social Environment	B.S. Forest Resource Management and Wildlife Biology	15
Standish, Claudia	Fire Prevention Coord. Santa Fe National Forest	Wildland-Urban Interface Fire Hazard Analysis	Graduate of Technical Fire Mgmt. and Ecosystem Mgmt. (CEEM)	20
Winchester, John	Water Resource Engineer Hydrosphere, Inc.	Hydrology, Soils	M.S. Civil Engineering /Hydraulics B.S. Watershed Sciences	9
Yori, Karen	Environmental Planner Blue Earth Ecological Consultants, Inc.	EIS Compilation	B.S. Forestry B.A. Social Work	13

Note: This list does not include several research scientists from outside the National Forest System who provided advice and review of the EIS, as well as other Forest Service consultants and reviewers.

Chapter 5 • List of Agencies, Organizations and Persons to Whom Copies of the DEIS Are Sent

Pueblos

Pueblo of Cochiti
Pueblo of Nambe
Pueblo of Pojoaque
Pueblo of San Juan
Pueblo of Santa Clara
Pueblo of San Ildefonso
Pueblo of Santo Domingo
Pueblo of Tesuque

Federal Agencies

Advisory Council on Historic Preservation, Planning and Review
Bureau of Indian Affairs, Branch of Forestry
Bureau of Reclamation, Albuquerque Projects Office
Federal Aviation Administration, Office of the Regional Administrator
Federal Highway Administration, Midwestern Region
Interstate Commerce Commission, Energy and Environment
National Marine Fisheries Service, Protected Species Division
National Park Service, Intermountain Region
National Park Service, Santa Fe
Natural Resource Conservation
Office of Civil Rights, Policy and Planning Division
Pecos National Historical Park
Region VI Environmental Protection Agency (5)
Rocky Mountain Research Station
U.S. Army Engineers, Southwest Division
U.S. Department of the Interior, Office of Environmental Policy & Compliance (18)
U.S. Fish & Wildlife Service
U.S. Department of Agriculture, Natural Resources Conservation Service, Santa Fe
USDA APHIS PPD/EAD
USDA, National Agricultural Library, Acquisitions & Serials Branch (3)
USDI - Bureau of Land Management, New Mexico State Office
USGS Jemez Mountain Field Station
USDA Forest Service: Carson National Forest, Cibola National Forest, and Southwestern Region

State Agencies

New Mexico Department of Game and Fish
New Mexico Division of Forestry
New Mexico Economic Development Office
New Mexico Environment Department
Surface Water Bureau
Air Quality Bureau
New Mexico State Engineer's Office

Local Governments

County of Santa Fe, Commissioners
City of Santa Fe
Office of the Mayor
Planning and Land Use Division
Sangre de Cristo Water Division (3)

Colleges and Universities

College of Santa Fe
University of Arizona, Laboratory of Tree Ring Research (2)
New Mexico Highlands University
University of New Mexico (2)

Libraries

Albuquerque Public Library, Main Branch
College of Santa Fe Library
Española Public Library
Mesa Public Library, Los Alamos
NM Highlands University, Las Vegas
NM State Library (2), Santa Fe
Santa Fe Public Library, Main Branch
University of NM Library, Albuquerque

Organizations

Canyon Preservation
Center for Holistic Resource
Cerro Colorado Association
Common Ground
Forest Conservation Council
Forest Trust

List of Agencies, Organizations and Persons to Whom Copies of the DEIS Are Sent

National Audubon - New Mexico State
NM Earth First!
NM Environmental Law Center
NM Heritage Preservation Alliance
Santa Fe Forest Watch
Santa Fe Watershed Association
Sierra Club, New Mexico State Chapter
Sierra Club, Santa Fe Chapter
Southwest Forest Alliance
SW Center for Biological Diversity
SW Environmental Center
New Mexico Natural History Institute
Southwest Planning and Marketing
The Santa Fe Canyon Association
The Nature Conservancy
Western Environmental Law Center
Wilderness Gate Association

Individuals

John Buchser
Leslie Davis
James H. Duncan, Sr.
Delores Durnell
Lee Few
Martha Ann Freeman
George Grossman
David M. Hutt
Stephen Van Luchene
Matthew McQueen
Wayne Nelson
Mark Z. Oldknow
Al Perrin
Melissa Savage
Rick Schrader
Robert J. Werner
Mike & Sharon Wirtz

Note:

Approximately 400 individuals or groups on our mailing list received notification of availability of the DEIS and Summary on our website, and plan to use the web to access the DEIS. Many other individuals and offices asked for the Summary only.

Chapter 6 • Literature Cited

- Agee, J.K. 1993. *Fire Ecology of Pacific Northwest Forests*. Island Press. Covelo, CA. 493 pp.
- Agee, J.K. 1996. The Influence of Forest Structure on Fire Behavior. In: *Proceedings of 17th Forest Vegetation Management Conference*. Redding CA., pp. 52-68.
- Agee, J.K., B. Bahro, M.A. Finney, P.N. Omi, D.B. Sapsis, C.N. Skinner, J.W. vanWagtendonk, and C.P. Weatherspoon. 2000. The use of shaded fuelbreaks in landscape fire management. *Forest Ecology and Management* 127:55-66.
- Albini, F.A. and J. Brown. 1978. Predicting slash depth for fire modeling. INT-GTR -206.
- Alexander, M.E. 1988. Help with making crown fire hazard assessments. In: *Protecting People and Homes from Wildfire in the Interior West, Proceedings of the Symposium and Workshop*, USDA Forest Service GTR INT-251, pp.147-156.
- Alexander, R.R., C.A. Troendle, M.R. Kaufmann, W.D. Shepperd, G.L. Crouch, and R.K. Watkins, 1985. *The Fraser Experimental Forest Colorado: Research Program and Published Research 1937-1985*. USDA, Forest Service, General Technical Report RM-118. 46p.
- Allen, C.D. 1989. Changes in the landscape of the Jemez Mountains, New Mexico. Doctoral dissertation, University of California, Berkley. 346 pp.
- Allen, C.D. 1994. Elk response to the La Mesa Fire and current status in the Jemez Mountains. Pages 179-69 in: Allen, C. D. (ed.). *Fire effects in southwestern forests, proceedings of the second La Mesa Fire symposium*. USDA Forest Service General Technical Report RM-GTR-286.
- Alward, G. 1995. IMPLAN folder/Economic Diversity index. USDA Forest Service, Fort Collins, CO.
- American Ornithologists' Union. 1957. *Checklist of North American birds* (fifth edition). Lord Baltimore Press, Baltimore, Maryland.
- Andariese, S.W. and W.W. Covington. 1986. Changes in understory production for three prescribed burns of different ages in ponderosa pine. *Forest Ecology and Management* 14:193-203.
- Anderson, H.E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. Ogden, UT: U.S. Dept of Ag. For Serv., Intermountain For. Ran. Ex. Sta., 22.
- Andreu, V., J.L. Rubio, J. Forteza, and R. Cerni, 1996. Postfire Effects on Soil Properties and Nutrient Losses. *Int. J. Wildland Fire* 6(2), pp. 53-58.
- Arno, M. K. 1986. Re-establishing fire-adapted communities to riparian forests in the ponderosa pine zone. In: Hardy, C. C. and S. F. Arno (eds.). *The use of fire in forest restoration: a general session at the annual meeting of the Society for Ecological Restoration*. USDA Forest Service General Technical Report INT-GTR-341.
- Arno, S.F. and M.G. Harrington. 1999. Eighty-eight years of change in a managed ponderosa pine forest. 1999. USDA Forest Service, General Technical Report RMRS-GTR-23.
- Arno, S. F. and T. D. Petersen. 1983. Variation in estimates of fire intervals: a closer look at fire history on the Bitterroot National Forest. USDA Forest Service Research Paper INT-301.
- Bailey, A. M. and R. J. Niedrach. 1965. *Birds of Colorado, volume 2*. Denver Natural History Museum, Denver, Colorado.
- Baker, M.B. Jr., 1990. Hydrologic and water quality effects of fire. In: Krammes, J.S., technical coordinator. *Effects of Fire Management of Southwestern Natural Resources*. USDA Forest Service, General Technical Report RM-191, pp. 31-42.
- Barfield, B.J., R.C. Warner, C.T. Haan, 1985. *Applied Hydrology and Sedimentology for Disturbed Areas*.
- Barnes, B.V. 1966. The clonal growth habit of aspen. *Ecology* 47:439-447.
- Bartos, D. L. and W. F. Mueggler. 1981. Early succession in aspen communities following fire in western Wyoming. *Journal of Range Management*. 34:315-318.
- Baxter, J.O. 1987. *Las Carneradas*. University of New Mexico Press. Albuquerque, New Mexico.
- Bengston, D. N. 1993. *Changing Forest Values and Ecosystem Management*. Society of Natural Resources, Volume 7, pp. 515-533.
- Biggs, J., K. Bennett, and P. Fresquez. 1997. Evaluation of habitat use by Rocky Mountain Elk in north-central New Mexico using Global Positioning System (GPS) radio collars. In *Abstracts of the 30th Joint Annual Meeting of The Wildlife Soci-*

Literature Cited

- ety, New Mexico and Arizona Chapters, and American Fisheries Society, Arizona-New Mexico Chapter. February 1997.
- Biondi, F. and F.Dallmeier. 1998. Twentieth-century growth trends at the Gus Pearson Natural Area, Arizona, USA. In: Forest biodiversity in North, Central and South America and the Carribbean: research and monitoring, 107-147, Man and the Biosphere Series, Vol. 21, Parthenon Publishing Group, Carnforth, UK.
- Biswell, H.H. 1960. Danger of wildfire reduced by prescribed burning in ponderosa pine. California Agriculture. 14(10):5-6.
- Biswell, H.H., H.R. Kallander, R. Komarek, R.J. Vogel, H. Weaver. 1973. Ponderosa pine management. Miscellaneous Publication 2. Tallahassee, FL: Tall Timbers Research Station. 49p.
- Biswell, H.H. 1989. Prescribed Burning in California Wildlands Vegetation Management. Univ. of Calif, Berkeley, CA. 253p.
- Bogan, M.A., T.J. O'Shea, P.M. Cryan, M.M. Ditto, W.H. Schaedla, and L. Ellison. 1996. Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains Annual Review of Threatened and Endangered Species Habitat Management Plan. Los Alamos National Laboratory October 16, 1996.
- Bosch J.M., and J.D. Hewlett, 1982. A review of catchment experiements to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology 55:3-23.
- Bozek, M. A. and M. K. Young. 1994. Fish mortality resulting from delayed effects of fire in the Greater Yellowstone ecosystem. Great Basin Naturalist. 54:91-95.
- Brandenburg, Andrea M., and Carroll, Matthew S. 1995. Your Place or Mine?: The Effect of Place Creation on Environmental Values and Landscape Meanings. Society and Natural Resources, Volume 8, pp 381-398. Sept-Oct, 1995.
- Bremer, J.M. 1994. Summary of Heritage Resources and Recommendations of Eligibility for Historic Properties for the Santa Fe Ski Area. Report Number 1989-10-116 E. On file at the Santa Fe National Forest Supervisor's Office. Santa Fe.
- Bright, Alan D., K. H. Cordell, and A. P. Hoover. 1999. In Press. Guidelines for Conducting Social Assessments within a Human Dimensions Framework.
- Brown, H. W. 1958. Gambel oak in west-central Colorado. Ecology. 39:317-327.
- Brown, D.E. and K.P. Davis. 1973. Forest fire: control and use. 2d ed. New York: McGraw Hill. 686 p.
- Brown, J. K. and N. V. DeByle. 1987. Fire damage, mortality, and suckering in aspen. Canadian Journal of Forest Research. 17:1100-1109.
- Brown, S., M. M. Brinson, and A. E. Lugo. 1979. Structure and function of riparian wetlands. Pages 107-117 in: R.R. Johnson and J. F. McCormick (eds.). Strategies for protection and management of floodplain wetlands and other riparian ecosystems. USDA Forest Service General Technical Report WO-12.
- Buckley, A.J. 1992. Fire Behaviour and fuel reduction burning: Bemm River wildfire, October 1988. Australian Forestry 55, 135-147.
- Busse, M.D., P.H. Cochran and J.W. Barrett. 1996. changes in ponderosa pine site productivity following removal of understory vegetation. Soil Science Society of American Journal 60:1614-1621.
- Campbell, R.E., M.B. Baker, Jr., P.F. Ffolliott, F.R. Larson, and C.C. Avery. 1977. Wildfire effects on a ponderosa pine ecosystem: an Arizona case study. USDA Forest Service, Research Paper RM-191.
- Cannon, S.H., P.S. Powers, W.Z. Savage, 1998. Fire-related Hyperconcentrated and Debris Flows on Storm King Mountain, Glenwood Springs, Colorado, USA. Environmental Geology, v.35(#2-3) pp. 210-218.
- Cannon, S.H., 1997. Evaluation of the Potential for Debris and Hyperconcentrated Flows in Capulin Canyon as a Result of the 1996 Dome Fire, Bandelier National Monument, New Mexico. US Geological Survey, Open-File Report 97-136, 20 p.
- Canter, L. W. 1996. Environmental Impact Assessment, 2d ed. McGraw-Hill, Inc. New York, New York.
- Canton-Thompson, J. and D. Silviesu. 1999. Understory burning gets the job done. Ecoreport, RMRS, Fall 1999.

- Carlton, D.W. and S.G. Pickford. 1982. Fuelbed changes with aging of slash from ponderosa pine thinnings. *Journal of Forestry*, 3p.
- Carter, J. L. 1997. Trees and shrubs of New Mexico. Mimbres Publishing, Silver City, New Mexico.
- Cassidy, R. 1998. Existing forest conditions, Santa Fe Watershed. Unpublished report, USDA Forest Service, Santa Fe National Forest, Supervisor's Office, 23 February 1998.
- Cassidy, R. 2000. Santa Fe Municipal Watershed, projected ground vegetative response following tree stocking reduction. Unpublished report, USDA Forest Service, Santa Fe National Forest, Supervisor's Office, 9 June 2000.
- City of Santa Fe. 1999. General Plan. City of Santa Fe, New Mexico Resolution No. 1999-45. Update of General Plan.
- Clark, Ira G. 1987. Water in New Mexico: A history of its management and use. University of New Mexico Press, Albuquerque, New Mexico.
- Cook, J. A. 1986. Occasional Papers the Museum of Southwestern Biology No. 4 June 30, 1986. The Mammals of the Animas Mountains and Adjacent Area, Hidalgo County, New Mexico. University of New Mexico. 45 pp.
- Cooper, C.F. 1960. Changes in vegetation, structure, and growth of Southwestern pine forests since white settlement. *Ecological Monographs*. 30(2):129-164.
- Cooper, C.A. 1996. Summary of 1995 surveys for willow flycatchers in New Mexico. New Mexico Department of Game and Fish. Contract #96-516.51.
- Covington, W.W. and S.S. Sackett, 1986. Effect of periodic burning on soil nitrogen concentrations in ponderosa pine. *Soil Science Society of America Journal* 50:452-457.
- Covington, W.W. and M.M. Moore. 1994. Southwestern ponderosa forest structure: changes since Euro-American settlement. *Journal of Forestry* 92(1): 39-47.
- Cowardin, L. M., V. Carter, F. C. Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, FWS/OBA-79/31.
- Covington, W.W. and S.S. Sackett. 1988. Fire effects on ponderosa pine soils and their management implications. Pages 105-111 in: Krammes, J. S. (technical coordinator). Effects of fire management of southwestern natural resources, proceedings of the symposium. USDA Forest Service General Technical Report RM-191.
- Crane and Fischer, E.A. Beringer, S.J. Hejl, and L. Bacon. 1999. Effects of logging and burning on birds during the nonbreeding season, shelterwood cutting unit RMRS-GTR-23.
- Cryan, P.M. 1993. Euderma Maculatum Survey of the Santa Fe National Forest.
- Culver, D. 1998. Literature review of fire ecology and effects, United States Air Force Academy, Colorado Springs, Colorado. The Colorado Natural Heritage Program Research Report No. 2, Fort Collins, Colorado.
- Cunningham, J.B., R.P. Balda, and W.S. Gaud. 1980. Selection and use of snags by secondary cavity-nesting birds of the ponderosa pine forest. USDA Forest Service Research Paper RM-222.
- DeBano, L.F., 1991. The effect of fire on soil properties. In: Harvey, A.E., and L.F. Neuenschwander, compilers. Proceedings: Management and Productivity of Western-Montane Forest Soils. USDA Forest Service, General Technical Report INT-280, pp. 151-156.
- DeBano, L.F., P.F. Ffolliott, and M.B. Baker, Jr. 1996. Fire severity effects on water resources. In: Ffolliott, P.F., L.F. DeBano, M.B. Baker, Jr., G. J. Gottfried, G. Solis-Garza, C.B. Edminster, D.G. Neary, L.S. Allen, and R. H. Harnre, technical coordinators, Effects of Fire on Madrean Province Ecosystems: A Symposium Proceedings. USDA Forest Service, General Technical Report RM-GTR-289, pp. 77-84.
- DeBano, L.F., D.G. Neary, P.F. Ffolliott. 1998. Fire's Effects on Ecosystems, John Wiley & Sons, Inc., New York, NY.
- DeByle, N. V. 1985. Wildlife. Pages 135-152 in: DeByle, N. V. and R. P. Winokur (eds.). Aspen ecology and management in the western United States. USDA Forest Service General Technical Report RM-119.
- DeByle, N. V., C. D. Bevins, and W. C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. *Western Journal of Applied Forestry*. 2:73-76.

Literature Cited

- Deyloff, G. 2000. Results of Archival Study and Archaeological Monitoring of La Posada de Santa Fe Resort and Spa (LA129141). Prepared for La Posada de Santa Fe by Southwest Archaeological Consultants, Inc., Santa Fe, New Mexico. Report #SW 434B.
- Dick-Peddie, W. A. 1993. New Mexico vegetation, past, present and future. University of New Mexico Press, Albuquerque.
- Dodd, N. L. 1988. Fire management and southwestern raptors. Pages 341-347 in: Glinski, R. L., B. G. Pendleton, and M. B. Moss (eds.). Proceedings of the Southwest raptor symposium and workshop. National Wildlife Federation Scientific and Technology Series 11, Washington, D.C.
- Doucet, R. 1989. Regeneration silviculture of aspen. The Forestry Chronicle. Feb.:23-27.
- Dunne, T., and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, San Francisco.
- Edminster, C.B. and W.K. Olsen. 1995. Thinning as a tool in restoring and maintaining diverse structure in stands of southwestern ponderosa pine. USDA Forest Service General Technical Report RM-278. pp. 62-68.
- Erwin, W. J. and R. H. Stasiak. 1979. Vertebrate mortality during the burning of reestablished prairie in Nebraska. American Midland Naturalist. 101:247-249.
- Endangered Species Information [Online]. USDI Fish and Wildlife Service, Southwest Region Ecological Services. Available: ifw2es.fws.gov/endangeredspecies/lists/ListSpecies.cfm [2000, August 24].
- Federal Register: July 21, 2000 Volume 65, Number 1411 Proposed Rules Page 45336-45353 from the Federal Register Online via GPO Access [wais.access.gpo.gov]
- FEMA. 1993. Federal Emergency Management Agency Flood Insurance Study for the City of Santa Fe, Santa Fe County, New Mexico. Community Number - 350070.
- Fenton, M.D., D.C. Tennant, and J. Wyszecski. 1987. Using echolocation call to measure the distribution of bats: the case of *Euderma maculatum*. J. Mammal. 69:142-144.
- Ffolliot, P.F., and D.B. Thorud. 1977. Water yield improvement by vegetation management. Water Resources Bulletin 13:563-571.
- Fiedler, C.E., C.E., Deegan, S.F. Arno, and R.J. Barbour. 1997. Utilization as a component of restoring ecological processes in ponderosa pine forest. USDA Forest Service General Technical Report FPL-GTR-100, 24-29.
- Finch, D.M. 1992. Threatened, Endangered and Vulnerable Species of Terrestrial Vertebrates I the Rock Mountain Region. USDA Forest Service General Technical Report RM-215.
- Finch, D.M., J.L. Ganey, W.Yong, R.T. Kimball, and R. Sallabanks. 1997. Effects and interactions of fire, logging, and grazing. In: Songbird ecology in southwestern ponderosa pine forests: a literature review. USDA Forest Service General Technical Report RM-GTR-292, Pp. 103-136.
- Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque, New Mexico.
- Fitzgerald, J.P., C.A. Meany, and D.M. Armstrong. 1994. Mammals of Colorado. Denver Museum of Natural History and University Press of Colorado, 467pp.
- Foxx, T.S. 1994. Vegetation succession after the La Mesa Fire at Bandelier National Monument In: Fire effects in southwestern forests, proceedings of the second La Mesa fire symposium. USDA Forest Service General Technical Report RM-GTR-286, Pp. 47-69.
- Frey, J.K. 1995. Mammals of Negrito Creek Watershed, Gila National Forest, Reserve Ranger District, Catron County, New Mexico. A Final Report Submitted to: Gila National Forest, Reserve District, USDA Forest Service 38 pp.
- Frey, J.K. and T.L. Yates. 1996. Mammalian diversity in New Mexico. New Mexico Journal of Science. 36:4-37.
- Garcia, M.T. (1999). Hispanic Perspectives and Values in Driver, B.L., Dustin,D., Baltic, T., Elsner, Peterson, G. (1999) Nature and the Human Sprit, Toward an Expanded Land Management Ethic, Venture Publishing, Inc.
- Gehring, C. and T. Whitham. 1995. Environmental stress influences aboveground pest attack and mycorrhizal mutualism in pinyon-juniper wood-

- lands: implications for management in the event of global warming. In: Desired future conditions for pinyon-juniper ecosystems. Gen. Tech. Rpt. RM-258. Fort Collins, CO, USDA Forest Service RMRS 30-37.
- Glenn-Lewin, D.C. 1977. Species diversity in North American temperate forests. *Vegetation* 33:153-162.
- Goodwin, J.G. Jr., C.R. Hungerford. 1979. Rodent population densities and food habits in Arizona ponderosa pine forest. USDA Forest Service Research Paper RM-214.
- Gosz, J.R., 1981. Nitrogen cycling in coniferous ecosystems, in Clark and Rosswall (eds.) *Terrestrial Nitrogen Cycles*, *Ecol. Bulletin*, 33:405-426.
- Gottfried, G.J., and L.F. DeBano. 1990. Streamflow and water quality responses to preharvest prescribed burning in an undisturbed ponderosa pine watershed. In: *Effects of Fire Management of Southwestern Natural Resources*. USDA Forest Service, General Technical Report RM-191, pp. 222-228.
- Graham, R., A. Harvey, T. Jain, and J. Tonn. 1999. Effects of thinning and similar stand treatments on fire behavior in western forests. USDA Forest Service General Technical Report PNW-GTR-463.
- Gramann, James. Dr. 1999. The Effect of Mechanical Noise and Natural Sound on Visitor Experiences in Units of the National Park System. *Social Science Research Review*. Vol. 1(1), Winter 1999.
- Green, H. et al. 1994. Characteristics of Roost sites used by Forest Dwelling Bats on Coconino National Forest - Preliminary Results. In: *Abstracts from Presentations at the Arizona/New Mexico Chapters of The Wildlife Society*, Sierra Vista, AZ.
- Green, L.R. 1977. Fuelbreaks and other fuel modification for wildland fire control. *USDA Agriculture Handbook*, 499 pp.
- Gregg, J. 1844. *Commerce of the Prairie*. Edited by M. Quaife, 1967. University of Nebraska Press. Lincoln, Nebraska.
- Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. *Transactions of the North American Fisheries Society*. 128:193-221.
- Griggs, J. 1997. *American Bird Conservancy's Field Guide to All the Birds of North America*. Harper Collins New York, NY, 72 pp.
- Grissino-Mayer, H.D., C.H. Baisan, and T.W. Swetnam. 1995. Fire history in the Pinaleno Mountains of southeastern Arizona: effects of human-related disturbances. In: *Biodiversity and management of the Madrean Archipelago: the Sky Islands of southwestern United States and northwestern Mexico*, 1994 September 19-23, Tucson, AZ. Gen. Tech. Rpt. RM-264. Fort Collins, CO. USDA Forest Service RMRS:399-407.
- Gruell, G.E. and L.L. Loope. 1974. Relationships among aspen, fire and ungulate browsing in Jackson Hole, WY. Ogden, UT: USDA Forest Service, Intermountain Region. 33p.
- Gruell, G.E., W.C. Schmidt, S.F. Arno, and W.J. Reich. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana – implications for resource management. USDA Forest Service General Technical Report INT-130. 42 p.
- Haase, S.M. 1986. Effect of prescribed burning on soil moisture and germination of southwestern ponderosa pine seed on basaltic soils. USDA Forest Service Research Note RM-462.
- Haddow, D., R. Musselman, T. Blett, and R. Fisher. 1998. Guidelines for evaluating air pollution impacts on wilderness within the Rocky Mountain Region. USDA Forest Service General Technical Report. RMRS-GTR-4. 31p.
- Hall, F.C. 1976. Fire and vegetation in the Blue Mountains- implications for land managers. In: *Proceedings, Tall Timbers Fire Ecology Conference*. 15:155-163.
- Hall, E.R. 1981. *The Mammals of North America*. Vol. 1. John Wiley and Sons, New York, NY.
- Hammond, G.P. and A. Rey, 1966. The rediscovery of New Mexico, 1580-1594: The explorations of Chamuscado, Espejo, Castano de Sosa, Morlete, and Leyva de Bonilla and Humana. University of New Mexico Press, Albuquerque, NM.
- Hardaway, G.D., and J.R. Thompson. 1962. A Study of Water Yield from the Santa Fe River Watershed. USDA Forest Service, Station Paper No. 70.

Literature Cited

- Harrington, J.P. 1916. The Ethnography of the Tewa Indians. Twenty-ninth Annual Report of the Bureau of American Ethnography, Smithsonian Institution. Washington D.C.
- Harrington, M.G. 1987. Predicting reduction of natural fuels by prescribed burning under ponderosa pine in southeastern Arizona. USDA Forest Service Research Note RM-472. 4p.
- Harrington, M.G. 1999. Influence of selection harvest and prescribed fire on soil nitrogen. USDA Forest Service General Technical Report RMRS-GTR-23.
- Harrington, M. and S.Arno 1999. Ameliorating unhealthy forest conditions. EcoReport, RMRS, Fall 1999.
- Harrington, M. and S.Sackett. 1990. Using fire as a management tool in southwestern ponderosa pine. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station General Technical Report RM-191.
- Harris, G.R. and W.W. Covington. 1983. The effect of a prescribed fire on nutrient concentration and standing crop of understory vegetation in ponderosa pine. Canadian Journal of Forestry Research. 13:501-507.
- Harris, R.R., R.J. Risser, and C.A. Fox. 1985. A method for evaluating streamflow discharge - plant species occurrence patterns on headwater streams. Pages 87-90 in: Johnson, R.R., C.D. Ziebel, D.R. Patton, P.F. Ffolliott, and R.H. Hamre (technical coordinators). Riparian ecosystems and their management: reconciling conflicting uses. USDA General Technical Report RM-120.
- Hauck W.L. and C.S. White. 1996. The assessment of current water quality status and potential nitrite loss from forest ecosystems within the Santa Fe Municipal Watershed, New Mexico, USA. Final Report. USFS contract 43-8379-6-0153, unpublished.
- Hawksorth, F.G. 1995. Dwarf mistletoes: biology, pathology, and systematics. Agriculture Handbook 450. USDA Forest Service.
- Helms, J.A. 1979. Positive effects of prescribed burning on wildfire intensities. Fire Management Notes 40, 10-13.
- Helvey, J.D. 1980. Effects of a north central Washington wildfire on runoff and sedimentation. *Water Resources Bulletin* 16:627-634.
- Hoffmeister, D.F. 1986. Mammals of Arizona. Univ. of Arizona Press and Arizona Game and Fish Department. 602 pp.
- Horton, S.P. and R.W. Mannan. 1988. Effects of prescribed fire on snags and cavity-nesting birds in southeastern Arizona pine forests. *Wildlife Society Bulletin*. 16:37-44.
- Hubbard, J.P. 1978. Revised checklist of the birds of New Mexico. New Mexico Ornithological Society Publication No. 6.
- Hubbard, J.P. 1987. The Status of the Willow Flycatcher in New Mexico. New Mexico Department of Game and Fish. 29 pp.
- Huff, D.D., B.Hargrove, M.L. Tharp and R. Graham. 2000. Managing forests for water yield- the importance of scale. *Journal of Forestry* Vol. 98 (12):15-19.
- Hunter, M.L. 1990. Wildlife, forests, and forestry, principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, NJ.
- Hutto, R.L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain conifer forests. *Conservation Biology*. 9:1041-1058.
- Jencsok, E.I. 1969. Hydrology Design for Highway Drainage in Arizona.
- Johnson, E.A. 1992. Fire and Vegetation Dynamics: Studies from the North American Boreal Forest. Cambridge University Press, Cambridge, Massachusetts. 129 pp.
- Johnson, T.H. and R.H. Wauer. 1994. Avifaunal response to the 1977 La Mesa fire. Pages 70-94 in: Allen, C. D. (ed.). Fire effects in southwestern forests, proceedings of the second La Mesa fire symposium. USDA Forest Service General Technical Report RM-GTR-286.
- Kalabodkidis, K.D. and R.H. Wakimoto. 1992. Prescribed burning in uneven-aged management of ponderosa pine/Douglas-fir forests. *Journal of Environmental Management* 34(3):221-235.
- Kalabodkidis, K.D. and P.N. Omi. 1998. Reduction of fire hazard through thinning/residue disposal in the urban interface. *International Journal of Wildland Fire* 8(1):29-35.

- Kennedy, P.L. 1984. The Nesting Ecology of Cooper's Hawks and Northern Goshawks in the Jemez Mountains of New Mexico. Report to the New Mexico Department of Game and Fish and the U.S. Forest Service.
- Klopaatek, C.C., L.F. DeBano, J.M. Klopatek. 1990. Impact of fire on the microbial processes in pinyon-juniper woodlands: management implications. In: Effects of fire management of Southwestern natural resources, 1988 November 15-17, Tucson, AZ. Gen. Tech. Rpt. RM-191. Fort Collins, CO. USDA Forest Service RMRS:197-205.
- Koonce, A.L. and L.F. Roth. 1980. The effects of prescribed burning on dwarf mistletoe in ponderosa pine. In Proceedings, 6th Conference on Fire and Forest Ecology; 1980 April 22-24; Seattle WA. 197-203.
- Kranz, J.J. and R.L. Linder. 1973. Value of Black Hills forest communities to deer and cattle. *Journal of Range Management*. 26:263-265.
- Kunzler, L.M. and K.T. Harper. 1980. Recovery of Gambel oak after fire in central Utah. *Great Basin Naturalist*. 40: 127-130.
- Kutiel, P., H. Lavee, M. Segev, Y. Benyamini, 1995. The Effect of Fire-Induced Surface Heterogeneity on Rainfall-Runoff-Erosion Relationships in an Eastern Mediterranean Ecosystem, Israel. *Catena*, v.25 (#1-4) pp.77-87.
- Kutiel, P., M. Inbar, 1993. Fire Impacts on Soil Nutrients and Soil-Erosion in a Mediterranean Pine Forest Plantation. *Catena*, v.20 (#1-2) pp. 129-139.
- Lamb, S.H. 1971. Woody plants of New Mexico and their value to wildlife. New Mexico Department of Game and Fish, Bulletin No. 14.
- Laudenslayer, W.F., H.H. Darr and S. Smith. 1989. Historical effects of forest management practices on eastside pine communities in northeastern California. USDA Forest Service General Technical Report RM-185, pp. 26-34.
- Leopold, A. 1924. Grass, brush, timber and fire in southern Arizona. *Journal of Forestry* 22(6):1-10.
- Leopold, L.B. 1951. Vegetation of Southwestern watersheds in nineteenth century. *Geographic Review* 41:295-316.
- Lewis, K. 1996. Two Mile Dam and Reservoir: The Final Documentatio of the Life and Breach of a Public Resource 1893-1994. Public Service Company of New Mexico, Environmental Services.
- Lissoway, J.D. 1994. Remembering the La Mesa Fire. Pages 7-10 in: Allen, C. D. (ed.). Fire effects in southwestern forests, proceedings of the second La Mesa Fire symposium. USDA Forest Service General Technical Report RM-GTR -286.
- Lowe, C.H., Jr. 1961. Biotic communities in the sub-Mogollon region of the inland Southwest. *Journal of the Arizona Academy of Sciences* 2:40-49.
- Lyon, J.L., R.G. Hooper, E.S. Telfer, D.S. Schreiner. 1982. Fire Effects on Wildlife Foods. USDA Forest Service General Technical Report RMRS-GTR-42(1). 51p.
- Malanson, G.P. 1993. Riparian landscapes. Cambridge University Press, Cambridge, U.K.
- Martin, R.E. 1989. Use of prescribed fire to reduce wildfire potential. USDA Forest Service General Technical Report PSW-109, pp. 17-22.
- Martine, K. 1998. A Heritage Resource Survey of the Santa Fe Watershed Road. Report Number 1997-10-086. On file at the Santa Fe National Forest Supervisor's Office. Santa Fe.
- Maser, C. and J.M. Trappe (eds.). 1984. The seen and unseen world of the fallen tree. USDA Forest Service, General Technical Report PNW-164.
- Mayer-Grissino H.D.. 1995. Tree Ring Reconstruction of Climate and Fire History at El Malpais National Monument, New Mexico. Ph.D. dissertation University of Arizona, Tucson, Arizona.
- Maynard, W.R. 1995. Summary of 1994 surveys efforts in New Mexico for Southwestern willow flycatcher (*Empidonax trailii extimus*). New Mexico Department of Game and Fish. Contract #94-515-69.
- McCune, B. 1983. Fire frequency reduced two orders of magnitude in Bitterroot Canyons, Montana. *Canadian Journal of Forestry Research*. 13:212-218.
- Meffe, G.K. and C.R. Carroll. 1994. Principles of conservation biology. Sinauer Associates, Sunderland, Massachusetts.
- Meneely, S.C. and S.C. Schemnitz. 1981. Chemical composition and in vitro digestibility of deer browse three years after a wildfire. *Southwestern Naturalist* 26:365-374.

- Minshall, G.W., D.A. Andrews, J.T. Brock, C.T. Robinson, and D.E. Lawrence. 1990. Changes in wild trout habitat following forest fire. Pages 174-177 in: Richardson, F. and R. H. Hamre (eds.). Wild trout IV: proceedings of the symposium. Trout Unlimited, Arlington, Virginia.
- Moeur, S. and D.A. Guthrie. 1984. The effects of clearing fire-killed trees on wildlife. Pages 135-144 in: Foxx, T. S. (compiler). La Mesa fire symposium. Los Alamos National Laboratory, LA-9236-NERP.
- Monleon, V.J. and K. Cromack Jr. 1996. Long-term effects of prescribed underburning on litter decomposition and nutrient release in ponderosa pine stands in central Oregon. *Forest Ecology and management* 81: 1-3, 143-152.
- Moody, T., M. Wirtanen, K. Knight, and W. Odem. 2000. Integrating regional relationships for bankfull stage in natural channels of Arizona and New Mexico. Draft integration report. Northern Arizona University, Water Resources Engineering Laboratory, Flagstaff, AZ.
- Morrison, J.L. 1992. Persistence of the Meadow Jumping Mouse, *Zapus hudsonius luteus*, in New Mexico. *The Southwestern Naturalist*, Vol. 37, no. 3.
- Mutch, R.W. and W.A. Cook. 1996. Restoring fire to ecosystems: methods vary with land management goals. USDA Forest Service General Technical Report INT-341:9-11.
- Naiman, R.J., J.M. Melillo, and J. M. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). *Ecology*. 67:1254-1269.
- Nakamura, G. 1996. Harvesting forest biomass reduces wildfire fuel. *California Agriculture* 50(2):13-16.
- National Audubon Society. 1990. Bird checklist for the Randall Davey Audubon Center. Santa Fe, NM.
- National Geographic Society. 1987. Field Guide to the Birds of North America. 2nd edition. Pub. The National Geographic Society, Washington, D.C. 464 pp.
- New Mexico Department of Game and Fish (Santa Fe, NM 87503). 1988. Handbook of Species Endangered in New Mexico. G-130: 1-2.
- New Mexico Department of Game and Fish [Online]. August 2000. Biota Information of System of New Mexico. New Mexico Department of Game and Fish electronic database, BISON, Version January 2000, Santa Fe, New Mexico.
- New Mexico Native Plants Protection Advisory Committee. 1984. A Handbook of Rare and Endemic Plants of New Mexico. University of New Mexico Press, Albuquerque, NM. 291 pp.
- Newton, I. 1994. The role of nest sites in limiting the numbers of hole-nesting birds: a review. *Biological Conservation*. 70:265-276.
- Nilsson, C. 1982. Effect of stream regulation on riparian vegetation. Pages 93-106 in: Lillehammer, A. and S. J. Saltveit (eds.). Regulated rivers. Universitet Sforlaget As, Oslo, Norway.
- Novak, M.A. 1988. Impacts of a fire-flood event on physical and biological characteristics of a small mountain stream. Unpublished M.S. Thesis, Montana State University, Bozeman, Montana.
- Omi, P.N. 1996. the role of fuelbreaks. In: Proceedings of the 17th Forest Vegetation Management Conference. Redding, CA, pp 89-96.
- Oswald, B.P. and W.W. Covington. 1984. Effect of a prescribed fire on herbage production in southwestern ponderosa pine on sedimentary soils. *Forest Science*. 30:22-25.
- Pacheco, Richard. No date. Old Traditions – Different Values: Communities Talk with Forest Managers in New Mexico. Western Network, Santa Fe, NM. Pp 201-214.
- Pase, C.P. and A.W. Lindenmuth, Jr. 1971. Effects of prescribed fire on vegetation and sediment in oak-mountain mahogany chaparral. *Journal of Forestry*. 69:800-805.
- Patton, D.R. and J.R. Jones. 1977. Managing aspen for wildlife in the Southwest. USDA Forest Service General Technical Report RM-37.
- Peterson, G.L. and C.F. Sorg. 1987. Towards the Measurement of Total Economic Value. Gen. Tech. Report. RM-148. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- Peterson, D.L. and Sackett, S.S. 1994. The effects of repeated prescribed burning on *Pinus ponderosa* growth. *International Journal of Wildland Fire* 4:4, pp.239-247.

- Peterson, R.T. 1990. A Field Guide to Western Birds. 3rd edition Houghton Mifflin Company, Boston. 432 pp.
- Petts, G.E. 1984. Impounded rivers: perspectives for ecological management. John Wiley and Sons, New York, NY.
- Pippin, W.F. and B. Nichols. 1994. Observations of arthropod populations following the La Mesa fire of 1977. In: Fire effects in southwestern forests. Proceedings of the second La Mesa fire symposium. USDA Forest Service General Technical Report RM-GTR-286, pp. 161-165.
- Pittenger, J.S. 2000. Biological resources report for the Santa Fe Watershed project prepared for the Santa Fe National Forest by Blue Earth Ecological Consultants, Inc. Santa Fe, NM.
- Pollet, J. Omi, P. 1999. Effect of thinning and prescribed burning on wildfire severity in ponderosa pine forests. Final Report, INT-95075-RJVA. 48 p.
- Propst, D.L., J.A. Stefferud, and P.R. Turner. 1992. Conservation and status of Gila trout, *Oncorhynchus gilae*. Southwestern Naturalist. 37:117-125.
- Raish, Carol. 1995. Historic land use and grazing patterns in northern New Mexico. USDA Forest Service RMRS. RM-GTR-272. pp.189-197.
- Raish, Carol (in press) Environmentalism, the Forest service and the Hispano Communities of Northern New Mexico, Society and Natural Resources.
- Raish, Carol (in press) Lessons for Restoration in Traditions of Stewardship and Sustainable Land Management in Northern New Mexico In: Gobster, Paul H. and R. Bruce Hull, (in press), Restoring Nature, Perspectives from the Social Sciences and Humanities, Island Press.
- Randall, A. 1992. A total value framework for benefit estimation. In: Valuing Wildlife Resources in Alaska. Westview Press, Boulder, CO, pp. 87-111.
- Randall-Parker, T. and R. Miller. 1999. Effects of prescribed fire in ponderosa pine on key wildlife habitat components: preliminary results and a method for monitoring. Paper presented at the Dead Wood Ecology and Management Symposium, Reno, NV.
- Ream, C.H. 1981. The effects of fire and other disturbances on small mammals and their predators: an annotated bibliography. USDA. Forest Service General Technical Report INT-106.
- Reinhardt, et al. 1991. Woody fuel and duff consumption by prescribed fire in northern Idaho logging slash. USDA Forest Service General Technical Report INT-443. 174 pp.
- Research & Polling, Inc. 1993. Santa Fe County - Public Opinion Poll on Growth and Development Issues. August 1993. Unpublished.
- Reynolds, H.G. 1969. Aspen grove use by deer, elk, and cattle in southwestern coniferous forests. USDA Forest Service Research Note RM-138.
- Reynolds, H.G., W.P. Clary, and P.F. Ffolloitt. 1970. Gambel oak for southwestern wildlife. Journal of Forestry. 68: 545-547.
- Rinne, J.N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates in the southwestern United States. North American Journal of Fisheries Management. 16:653-658.
- Robichaud, P.R., T.A. Waldrop, 1994. A Comparison of Surface Runoff and Sediment Yields from Low- and High-Severity Site Preparation Burns. Water Resources Bulletin, pp. 27-34.
- Rosenstock, S.S. 1998. Influence of Gambel oak on breeding birds in ponderosa pine forests of northern Arizona. Condor. 100:485-492.
- Rosgen, D.L. 1994. A classification of natural rivers. Catena. 22:169-199.
- Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.
- Rothermel, R. 1972. A mathematical model for fire spread predictions in wildland fuels. USDA Forest Service General Technical Report INT-115. 40 pp.
- Rothermel, R. 1991. Predicting behavior and size of crown fires in the northern Rocky Mountains. USDA Forest Service General Technical Report INT-438.
- Rowe, J.S. and G.W. Scotter. 1973. Fire in the boreal forest. Quaternary Research
- Ryan, M.G. and W.W. Covington. 1986. Effects of a prescribed burn in ponderosa pine on inorganic

- nitrogen concentrations of mineral soil. USDA Forest Service Research Note RM-464. 5p.
- Sabo, D.G. 1980. Vegetation management program for the Santa Fe Canyon watershed. Public Service Company of New Mexico. On file at the Santa Fe National Forest Supervisor's Office. Santa Fe, New Mexico.
- Sackett, S.S. 1979. Natural fuel loadings in ponderosa pine and mixed conifer forest of the Southwest. USDA For. Serv. Res. Pap. RM-213, Fort Collins, CO.
- Sackett, S.S. 1984. Observations on natural regeneration in ponderosa pine following a prescribed fire in Arizona. USDA Forest Service Research Note RM-435. 8p.
- Sandberg and Dost. 1993.
- Santa Fe County. 2000. Open Land and Trail Plan: For the Wildlife, Mountains, Trails and Historic Places Program. Adopted May 22, 2000. Unpublished.
- Santa Fe National Forest, Upper Santa Fe Watershed Assessment, 2000
- Schier, G.A. and R.B. Campbell. 1976. Differences in *Populus* species in ability to form adventitious shoots and roots. Canadian Journal of Forestry Research. 6:253-261.
- Schmidley, D.J. 1977. The mammals of Trans-Pecos Texas. Texas A&M University Press, College Station.
- Schmidt, W.C., 1985. Managing trees and stands susceptible to spruce budworm, USDA Forest Service, Washington DC Tech Bull 1695, 111pgs.
- Schmidt, W.C. and R.H. Wakimoto. 1988. Cultural practices that can reduce fire hazards to homes in the Interior West. In: Proceedings of the Symposium and Workshop. USDA Forest Service General Technical Report INT-251: 131-137.
- Scott, J. 1998a. Fuel reduction in residential and scenic forests: a comparison of three treatment in a western Montana ponderosa pine stand. USDA Forest Service Research Paper RMRS-5. 19 p.
- Scott, J. 1998b. Reduce fire hazards in ponderosa pine by thinning. Fire Management Notes. 58(1):20-25.
- Scott, D.F. 1993. The hydrological effect of fire in South African mountain catchments. *Journal of Hydrology* 150:409-432.
- Severson, K. E. 1982. Production and nutritive value of aspen understory, Black Hills. *Journal of Range Management*. 35:786-789.
- Seixas, Fernando; Barbosa, Rafael Alex, and Rummer, Robert. 1999. Noise Level Determinations in Forestry Machines. *Forest Engineering for Tomorrow, Machinery Technical Papers*, June 28-30, 1999, Edinburgh University, Edinburgh Scotland.
- Severson, K. E. and A. L. Medina. 1983. Deer and elk habitat management in the Southwest. *Journal of Range Management Monograph No. 2*.
- Severson, K.E. and J.N. Rinne. 1988. Increasing habitat diversity in southwestern forests and woodlands via prescribed fire. Pages 94-104 in: Krammes, J. S. (technical coordinator). Effects of fire management of southwestern natural resources, proceedings of the symposium. USDA Forest Service General Technical Report RM-191.
- Simmons, M. 1988. New Mexico: An Interpretive History. W. W. Norton & Company, Inc. New York, New York.
- Simons, L.H. 1991. Rodent dynamics in relation to fire in the Sonoran desert. *Journal of Mammalogy*. 72:518-524.
- Smith, J.K. (ed.). 2000. Wildland fire in ecosystems: effects of fire on fauna. USDA Forest Service General Technical Report RMRS-GTR-42(1).
- Snow, F.H. 1881. List of Coleoptera collected in Santa Fe Cañon, New Mexico. *Journal of the Kansas Academy of Science*. VII:67-71.
- Soto, B., F. Diaz-Fierros, 1998. Runoff and Soil Erosion from Areas of Burnt Scrub: Comparison of Experimental Results with those Predicted by the WEPP Model. *Catena*, V. 31(#4) pp. 257-270.
- Spencer, C.N. and F.R. Hauer. 1991. Phosphorus and nitrogen dynamics in streams during a wildfire. *Journal of the North American Benthological Society*. 10:24-30.
- Stabler, H.O. 1906. Proposed Addition to the Pecos National Forest, New Mexico. On file at the Santa Fe National Forest Supervisor's Office. Santa Fe, New Mexico.
- State of New Mexico. 2000. Water quality and water pollution control in New Mexico. Water Quality Control Commission 305B Report. Water Quality Control Commission, Santa Fe, New Mexico.

- Stebbins, R.C. 1985. A Field Guide to Western Reptiles and Amphibians. 2nd edition. Houghton Mifflin Company, Boston, MA 336 pp.
- Steel, B.S., P. List, and B. Shindler. 1994. Conflicting values about federal forests: a comparison of national and Oregon publics. *Society and Natural Resources*. 7:137-153.
- Steele, R. 1984. An approach to classifying seral vegetation within habitat types. *Northwest Science* 58:29-39.
- Stephens, S.L. 1998. Evaluation of the effects of silvicultural and fuels treatment on potential fire behavior in Sierra Nevada mixed-conifer forests. *Forest Ecology and Management*. 105:21-35.
- Sublette, J.E., M.D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque, New Mexico.
- Swanson, F.J. 1981. Fire and geomorphic processes. Pages 401-420 *in*: Fire regimes and ecosystems conference. USDA Forest Service WO-26.
- Swanson, F.J., T.K. Katz, N. Caine, and R. G. Woodmansee. 1988. Land form effects on ecological processes and features. *BioScience*. 38:92-98.
- Swetnam, T.W. and C.H. Baisan. 1996. Historical fire regime patterns in the Southwestern US since AD 1700. *In*: Proceedings of the 2nd La Mesa Fire Symposium Fire Effects in Southwestern Forests. USDA Forest Service RM-GTR-286.
- Swetnam, T.W., C.D. Allen, J.L. Betancourt., 1999, Applied Historical Ecology: Using the Past to Manage for the Future. *Ecological Applications*, 9(4), pp. 1189-1206
- Szaro, R.C. 1989. Riparian forest and scrubland community types of Arizona and New Mexico. *Desert Plants* 9(3-4):1-138.
- Tecle, A., W.W. Covington, J.P. McTague, M.T. Richards, and D.R. Patton. 1991. Field guide for multiresource management of southwestern ponderosa pine forests. USDA Forest Service and Northern Arizona University, School of Forestry.
- Tew, R.K. 1970. Seasonal variation in the nutrient content of aspen foliage. *Journal of Wildlife Management*. 34:475-478.
- Tiedeman, A.R., C.E. Conrad, J.H. Dieterich, J.W. Hornbeck, W.F. Megahan, L.A. Viereck, and D.D. Wade. 1979. Effects of fire on water: a state-of-knowledge review. USDA Forest Service, General Technical Report WO-10.
- Tomlinson, R.E., D.D. Dolton, R.R. George, and R.E. Mirarchi. 1994. Mourning dove. Pages 5-26 *in*: Tacha, T.C. and C.E. Braun (eds.). *Migratory shore and upland game bird management in North America*. Allen Press, Lawrence, Kansas.
- Touchan, R. and T.W. Swetnam. 1991. Fire history in northern New Mexico. Final Report to USDA Forest Service, Santa Fe National Forest and USDI National Park Service, Bandelier National Monument. 22pp.
- Toy, T.J., W.R. Osterkamp, 1995. The Applicability of RUSLE to geomorphic studies. *Journal of Soil and Water Conservation*, pp. 498-503.
- Troendle, C.A. 1983. The potential for water yield augmentation from forest management in the Rocky Mountain region. *Water Resources Bulletin* 19:359-373.
- Tuttle, M. 1996. Report to USFS Region 3. Responses from Bat Conservation International (BCI) to USFS Region 3. January 1996. 9 pp.
- U.S. Bureau of Economic Analysis. Regional Economic Information System. 1969-1997 data. Via Internet.
- U.S. Census Bureau. Database C90STF3A. 1990 US Census Data. Housing and Population Divisions. Available via internet.
- U.S. Census Bureau. 1992. U.S. Census Data. Economics and Agriculture Census. Available via internet.
- U.S. Census Bureau. 2000. Population Estimates, 20 October 2000.
- USDA Forest Service. 1987a. Santa Fe National Forest Plan. USDA Forest Service, Southwestern Region. Albuquerque, NM. 366 pages. On file at the Santa Fe National Forest Supervisor's Office, Santa Fe, New Mexico.
- USDA Forest Service. 1987b. Environmental Impact Statement, Santa Fe National Forest Plan. USDA Forest Service, Southwestern Region. Albuquerque, NM. On file at the Santa Fe National Forest Supervisor's Office, Santa Fe, New Mexico.
- USDA Forest Service. 1989. General Technical Report RM-10 1975 as revised. Cavity Nesting Birds of Arizona and New Mexico Forests.

Literature Cited

- USDA Forest Service. 1992. Management Recommendations for the Northern Goshawk in the Southwestern United States. 90 pp.
- USDA Forest Service. 1993. Terrestrial Ecosystem Survey. Santa Fe National Forest. Santa Fe, New Mexico. On file at the Santa Fe National Forest Supervisor's Office, Santa Fe, New Mexico.
- USDA Forest Service. 1995. Final Impact Statement for the Santa Fe Ski Area, Master Development Plan – Volume 1. U.S. Department of Agriculture, Forest Service, Southwestern Region, Espanola Ranger District, Santa Fe National Forest.
- USDA Forest Service. 1996. Status of the Interior Columbia Basin - Summary of Scientific Findings. General Technical Report, PNW-GTR-385. USDA, Forest Service, Pacific Northwest Research Station.
- USDA Forest Service. 1997. An Assessment of Forest Ecosystem Health in the Southwest. USDA Forest Service General Technical Report RM-GTR-295.
- USDA Forest Service. 1998. Upper Santa Fe Watershed Existing Conditions Report. On file at the Santa Fe National Forest Supervisor's Office, Santa Fe, New Mexico.
- USDA Forest Service 1999. Effects of fire on flora and fauna. Available online at fs.fed.us/database/feis.
- USDA Forest Service. 2000a. Santa Fe Municipal Watershed Assessment Report. On file at the Santa Fe National Forest Supervisor's Office, Santa Fe, New Mexico.
- USDA Forest Service. 2000b. Wildland fire in ecosystems- effects of fire on fauna. RMRS-GTR-42(1).
- USDA Forest Service. 2000c. Roadless Area Conservation Final Environmental Impact Statement. USDA Forest Service, Washington, D.C.
- USDA Forest Service. 2000d. Cerro Grande Burned Area Emergency Rehabilitation (BAER) Team Report, unpublished document. USDA Forest Service, Santa Fe National Forest, Santa Fe, NM.
- USDA Forest Service. 2000e. Viveash Burned Area Emergency Rehabilitation (BAER) Team Report, unpublished document. USDA Forest Service, Santa Fe National Forest, Santa Fe, NM.
- USDA Soil Conservation Service. 1973. Engineering Field Manual for Conservation Practices in New Mexico.
- U.S. Department of Commerce - Economic Development Administration. 1996. American Indian Reservations and Trust Areas.
- USDI Fish and Wildlife Service. 1984. Santa Fe, New Mexico, 1:100,000 scale map of National Wetlands Inventory (wetlands classifications from 1:58,000 scale color infrared aerial photographs taken 1982 and other data). U.S. Fish and Wildlife Service, Albuquerque, New Mexico.
- USDI Fish and Wildlife Service. 1995. Recovery Plan for the Mexican spotted owl: Vol. I. Albuquerque, New Mexico. 172 pp.
- USDI Fish and Wildlife Service. 2000. Letter of August 17, 2000.
- Van Wagner, C.E. 1977. Conditions for the start of crown fire. Canadian Journal of Forest Research 3:373-378.
- VanWagner, C.E. 1977. Prediction of crown fire behavior in two stands of jack pine. Canadian Journal of Forest Research 23:442-449.
- Van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. Pp. 1155-1165 In: Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. II, Assessments and scientific basis for management options. University of California, Davis, Centers for Water and Wildland Resources.
- Veblen, T.T., K.S. Hadley, E.M. Nel, T. Kitzberger, M. Reid, and R. Villalba. 1994. Disturbance regime and disturbance interaction in a Rocky mountain subalpine forest. Journal of Ecology 82:125-135.
- Viessman, W., Jr., G.L. Lewis, J.W. Knapp. 1989. Introduction to Hydrology, Third Edition. Harper & Row, Publishers, Inc.
- Vitousek, P.M., J.R. Gosz, C.C. Grier, J.M. Melillo, W.A. Reinert, R.L. Todd. 1979. Nitrate Losses from Disturbed Ecosystems, Science, Vol. 24.
- von Bonin, F., W. Waqui, M. McDonald, and R. Cassidy. 2000. Forest resource assessment. Interagency Burned Area Rehabilitation Team, Cerro Grande Fire. USDA Forest Service, Santa Fe National Forest, Santa Fe, New Mexico.

- Wagle, R.F. and T.W. Eakle. 1979. A controlled burn reduces impact of a subsequent wildfire in a ponderosa pine vegetation type. *Forest Science* 25:123-129.
- Weatherspoon, P. and Skinner. 1996. Landscape level strategies for forest fuel management. Sierra Nevada Ecosystem Project, Final Report to Congress Vol. 2, University of California.
- Weaver, H. 1951. Fire as an ecological factor in Southwestern ponderosa pine forests. *Journal of Forestry* 49(2):93-98.
- Wendorf, F. and J. P. Miller. 1959 Artifacts from High Mountain Sites in the Sangre de Cristo Range, New Mexico. *El Palacio* 66(2): 37-53).
- Weise, D.R. and Sackett, S.S. 1996, Rx Fire Research for southwestern forests, USDA Forest Service, Pacific Southwest Research Station Fire Management Notes. 56: 2, 23-25.
- Williams, G. P. and M. G. Wolman. 1984. Downstream effects of dams on alluvial rivers. Geological Survey Professional Paper 1286.
- White, C.S. 1986. Effects of prescribed fire on rates of decomposition and nitrogen mineralization in a ponderosa pine ecosystem. In: *Biology and Fertility of Soils* 2(2):87-95.
- Whitehead, P.G., and M. Robinson. 1993. Experimental basin studies - an international and historical perspective of forest impacts. *Journal of Hydrology* 145:217-230.
- Woodward Clyde, 1994. McClure Dam Spillway Modification, Project No. 23603. Prepared for Sangre de Cristo Water Company, Santa Fe, New Mexico
- Xu, Zhi; and Bengston, David N. 1997. Trends in National Forest Values among Forestry Professionals, Environmentalists, and the News Media, 1982-1993. *Society & Natural Resources*, 10:43-59.

Literature Cited