Valles Caldera

National Preserve

August 9, 2013

Landscape Restoration & Stewardship Plan - DRAFT Environmental Impact Statement

Valles Caldera Trust

P.O. Box 359

Jemez Springs, NM 87025

505.660.3333

www.vallescaldera.gov

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Valles Caldera National Preserve

Valles Caldera National Preserve
Landscape Restoration and Stewardship Plan
Draft Environmental Impact Statement
Sandoval and Rio Arriba Counties, State of New Mexico

Lead Agency: **Valles Caldera Trust**

Responsible Official: **Dennis Trujillo, Executive Director**
P.O. Box 359, Jemez Springs, NM 87025

Information Contact: **Marie Rodriguez, Director, Planning and Natural Resource Division**
P.O. Box 359, Jemez Springs, NM 87025
505-661-3333, stewardship@vallescaldera.gov

Abstract: *The Landscape Restoration and Stewardship Plan (Stewardship Plan) Environmental Impact Statement (EIS) presents a detailed report regarding a suite of stewardship actions being proposed by the Valles Caldera Trust for management of the Valles Caldera National Preserve over the next 10 years. These actions are aimed at reducing the potential for severe burning and moving the structure, composition and function of the forest, shrubland, grassland and riparian ecosystems towards the reference condition. Reference condition is a functional state that, to the best of our collective knowledge, is known to be sustainable and resilient under current and expected climate and disturbance regimes. Actions being proposed include forest thinning, wildland fire management, road management, wetland and riparian restoration, noxious weed control, and burned area rehabilitation. To address the uncertainties inherent in managing towards future conditions, this plan is supported by a science-based program of adaptive management formed around goals, objectives, and monitored outcomes. The proposed action prioritizes treatments across the landscape based on the potential for severe burning, current degree of ecological departure, and ongoing resource impacts. An alternative action prioritizes treatments in forests that are most likely to stimulate aspen reproduction. The environmental consequences of each of these approaches to landscape restoration, along with taking no action, are presented in a comparative form. Based on this analysis, the proposed action is the trust's preferred alternative.*

It is important that you, as the reviewers, provide your comments at this time. Your comments should be provided prior to the close of the comment period and should clearly articulate your concerns and contentions. The comments we receive in response to this solicitation, including names and addresses of those who comment, will be part of the public record for this proposed action (names and addresses, including email addresses will be redacted from any online versions of the record). We will accept and consider anonymous comments; however, anonymous respondents will have no standing to participate in subsequent judicial reviews.

The EIS is available to view online at: http://www.vallescaldera.gov/stewardship/vctDevProjectMain.aspx?ProjectID=17&pageID=4. You can also navigate to the documents by going to our homepage: www.vallescaldera.gov and selecting "Get Involved" then "Stewardship" from the tabs on the left. This will take you to the stewardship section of our website, which dedicated to planning and public involvement. By selecting "Projects" you can

navigate to this project (Landscape Restoration and Stewardship Plan) or any past, present or future action being planned or implemented on the preserve.

This EIS addresses a matrix of actions and impacts, and is quite lengthy. We have taken several steps to make this review period easier. We posted early drafts of Chapters 1 (*Proposed Action/Purpose and Need*), and 2 (*Issues and Alternatives*) in March of 2013. Chapters 3 (*Setting*) and 4 (*Affected Environment*) were incorporated into the *2012 State of the Preserve*, also posted this spring. Only Chapter 5 has not been previously posted in an early draft version. We have also included maps, graphs, charts, and figures along with the alternative text to make the document easier to read. We encourage you to read the *Executive Summary* first as an aid in deciding which sections of the EIS you may want to examine in detail.

Following your review, comments may be submitted online at: http://www.vallescaldera.gov/stewardship/vctDevProjectMain.aspx?ProjectID=17&pageID=6. Our simple, online system allows you to type in up to 500 words or upload PDF documents up to 2 MG. You can also submit your comments by direct email to stewardship@vallescaldera.gov , or via surface mail to: the Valles Caldera Trust, P.O. Box 359, Jemez Springs, NM 87025.

Comments must be submitted electronically or postmarked on or before September 26, 2013 or 45-days following the publication of the Notice of Availability in the Federal Register; whichever date is latest. Comments submitted will be posted online; your personal information will not be displayed online unless it appears in a PDF that you upload. As previously stated, names and addresses associated with your comments will be entered into an administrative record, which will be available to the public upon request. Such information will be redacted from any electronic copies of the administrative record that are made available to the public online.

EXECUTIVE SUMMARY

Landscape Restoration & Stewardship Plan

"The survival of man in a world in which decency and dignity are possible, is the basic reason for bringing man's impact on his environment under informed and responsible control"

-Senator Henry M. "Scoop" Jackson, upon introducing Senate Bill 1075 (NEPA)

What is this document about?

This document summarizes the content of the EIS (Environmental Impact Statement) that we, the Valles Caldera Trust (VCT, or trust) have prepared for the Landscape Restoration and Stewardship Plan (Stewardship Plan), being proposed to guide the long-term management of the natural and cultural resources of the Valles Caldera National Preserve (VCNP, preserve, or Valles Caldera). We have prepared the associated EIS consistent with the purpose of an EIS as described by the President's Council for Environmental Quality (CEQ) in their procedures for implementing the National Environmental Policy Act (NEPA). These procedures state, "*The primary purpose of an environmental impact statement is to serve as an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government. It shall provide full and fair discussion of significant environmental impact and shall inform decision-makers and the public of the reasonable alternatives, which would avoid or minimize adverse impacts or enhance the quality of the human environment. Agencies shall focus on significant environmental issues and alternatives and shall reduce paperwork and the accumulation of extraneous background data. Statements shall be concise, clear, and to the point, and shall be supported by evidence that the agency has made the necessary environmental analyses. An environmental impact statement is more than a disclosure document. It shall be used by Federal officials in conjunction with other relevant material to plan actions and make decisions*" (CEQ 1978).

As such we will use the information presented here to make a decision about the long-term stewardship of the natural and cultural resources of the VCNP (Valles Caldera National Preserve aka *preserve* or *Valles Caldera)*. The information contained herein will also be used to guide the implementation of any action alternative that is selected.

This EIS is a detailed report and considers multiple actions, alternatives and impact areas and is therefore quite lengthy and somewhat complex. This executive summary presents the major premises and conclusions from the EIS and briefly summarizes each of the major conclusions. The executive summary can help you decide what sections of the EIS you would like to review in detail.

Hold on! What is NEPA?

Put simply, NEPA defines a process for making decisions. The NEPA process refers to the procedures a federal agency, such as the VCT, must follow to evaluate the impacts of a proposed major action that could have significant impacts on the quality of the human environment—in this case, the long-term stewardship of the preserve's natural and cultural resources. Under NEPA, this decision- making process is recorded in a document called an environmental impact statement or an environmental assessment (EA), depending on the degree of impacts expected.

The NEPA process is very similar to decision-making steps people use in their everyday lives. For example, assume you want to buy a car. You would first define what the car should do and why you need it. In the NEPA process, this is referred to as ***the purpose and need*** for the undertaking. You would define one purpose, such as to improve mobility, but could have several needs, such as a need to save money, transport several people or items, improve fuel economy, etc. Need statements answer the question,

why? This first step is crucial because it determines which options you would consider for purchase. These options are referred to as alternatives under NEPA.

Based on your purpose and needs, you would identify a ***reasonable range of alternatives*** from which to choose. If the car is needed to transport your kids to soccer games (among various other needs), you would probably not consider a two-seater sports car. Conversely, if you need the new car to travel in style primarily solo, you would probably not consider a mini-van.

You might involve other people in your decision-making process. You may have family members who would use the car, or want suggestions from friends. This input could change your purpose and need. For example, if you tell your friend you want to buy a car to get around more (i.e., improve your mobility) and also to save money, she may ask, why not take the bus? If you reply that the bus network is not extensive enough, you would revise your purpose to be more focused. Involving other people in the decision-making process is referred to as ***public involvement*** under NEPA, and occurs at various times throughout the process. Although you may seek input from other people, and ultimately the decision remains yours. This is true of agencies when implementing NEPA, too.

Your friend may also suggest purchasing a motorcycle instead of a two-seater sports car. You may reply that you need more safety than you feel a motorcycle can provide. A discussion with a loan officer may indicate that you could not afford the payments and insurance necessary to purchase a luxury car. The motorcycle and luxury car are ***alternatives that you considered but dismissed*** from evaluation because they would not meet your needs (i.e., safety) or were not economically feasible. Such alternatives are also identified during the NEPA process.

After defining your alternatives, you would evaluate the remaining car-buying options based on a variety of categories, such as safety, comfort, maneuverability, cargo room, gas mileage, expected maintenance, etc. Some alternatives may have benefits or drawbacks in some categories but not others, and vice versa. Similarly, during the NEPA process the alternatives are typically ***analyzed against the environmental resources*** that would be affected by the proposed actions or the affected environment. For example, if an agency proposes building a visitor center, it may evaluate the effects of that action on affected resources such as fish and wildlife, cultural resources, vegetation, etc. In addition, NEPA recognizes that some impacts may occur as a result of the proposed alternatives that are unavoidable. These impacts must be disclosed in a NEPA document, as well as other uses or commitments of resources. No matter what car you select there will be a commitment of resources either through the direct purchase or indirectly through required taxes, licenses, and insurance.

After weighing the analysis, you would choose a car to buy from one of those you analyzed. This is known in the NEPA process as the ***preferred alternative***. You would finalize the process and signify your decision by signing an agreement to purchase the car. In the NEPA process, this is accomplished through a ***decision document*** that follows completion of the EIS or EA.

Although the NEPA process is more involved than the car-buying example, the process is similar and used by many people, perhaps even unconsciously, to make informed decisions. NEPA guides federal agencies through this process to, “help public officials make decisions . . . it is not better documents but better decisions that count” (CEQ 1978).

What is covered in the EIS?

In their regulations for implementing the NEPA, CEQ outlined a standard format for an EIS as:

(a) Cover sheet.

(b) Summary.

(c) Table of contents.

(d) Purpose of and need for action.

(e) Alternatives including proposed action.

(f) Affected environment.

(g) Environmental consequences.

(h) List of preparers.

(i) List of Agencies, Organizations, and persons to whom copies of the statement are sent.

(j) Appendices (if any)

This EIS includes the required information organized into five chapters listed and described below.

Chapter 1 – Purpose and Need, Proposed Action:

Describes the proposed action, purpose and need for action, and the scope of the analysis. Scope includes the actions and impacts, environmental documentation, and public involvement.

Chapter 2 - Issue and Alternatives:

Describes the issues and concerns associated with our proposed action, performance requirements (laws, policies and procedures and mitigation measures) that apply to our management actions, and most importantly the detailed description of the alternatives including the “no action” alternative and a comparison of the actions and outcomes of the alternatives, highlighting key issues and differences and the preferred alternative.

Chapter 3 – Setting:

Describes the physical and socioeconomic setting of the preserve, giving context to our actions and analysis.

Chapter 4 – Affected Environment:

Provides a detailed description of the affected environment and the current condition of the resources that would be impacted by taking no action or implementing an action alternative.

Chapter 5 – Environmental Consequences:

Presents the environmental analysis which considers the expected short-term (1-3 yr.), mid-term (3-10 yr.), and long-term (>10 yr.) direct, indirect, and cumulative impacts to the ***human environment*** resulting from implementing one of the alternative courses of action or taking no action at all. The CEQ defines the human environment, as the "…natural and physical environment and the relationship of people with that environment." The analysis will consider activities and impacts at the project and landscape level.

What are we proposing to do?

We are proposing to design and implement a 10-year Stewardship Plan for managing and restoring the natural systems of the Valles Caldera. The proposed Stewardship Plan includes forest management, wildland fire management, wetland and riparian restoration, road management, and noxious weed prevention, control and eradication; and burned area rehabilitation. The activities are being proposed preserve-wide and are aimed at restoring the structure, composition, and function of the preserve's forest, grassland and riparian resources.

The proposed Stewardship Plan consists of a suite of integrated stewardship actions designed to restore the resilience[1] and adaptive capacity of the preserve's forest and grassland systems, protect and improve wildlife habitats, increase soil, riparian, and wetland resilience; reduce soil erosion, and restore watershed function. These actions fall within five categories:

- Forest Management – Thinning small diameter trees and disposing of the associated biomass.
- Wildland Fire Management – Using prescribed fire in association with forest thinning as well as a stand-alone tool and managing wildfire (unplanned) to protect people and property and enhance management objectives.
- Road Management and Erosion Control - closing, decommissioning, and maintaining roads; rehabilitating geothermal exploration areas, log landing sites, aggregate pit source sites;
- Riparian and Wetland Restoration – re-vegetating and otherwise stabilizing stream banks; restoring historic wetland flows;
- Noxious Weed Control – Preventing, detecting, and eradicating noxious weed populations; and
- Burned Area Rehabilitation – Stabilizing areas impacted by wildfire.

All activities include research, inventory, and monitoring actions.

[1] For the purpose of this EIS "resiliency" means the ability of a system to remain within, or return to, its natural path of growth and development (succession) in the event of disturbances including fire, insects, disease and/or climatic events and/or changing climate.

Our proposed Stewardship Plan is based on the collaborative forest landscape restoration strategy developed for the SWJML (Valles Caldera Trust, Santa Fe National Forest 2010) and incorporates New Mexico Forest Restoration Principles[2] and Ecological Restoration of Southwestern Ponderosa Pine Ecosystems: A Broad Perspective (Allen, et al. 2002).

What are the goals of this plan?

The purpose of the proposed Stewardship Plan is to improve the resilience and adaptive capacity of the preserve's natural systems, protect people and resources from destructive wildfire, and to rehabilitate areas impacted by wildfire.

> "It is not enough to be busy. So are the ants. The question is: what are we busy about?"
>
> - *Henry David Thoreau*

The 10-year Stewardship Plan is intended to:

- Move the structure, composition and function of the preserve's natural systems towards the reference condition.
- Reduce the potential for unusually severe or extensive wildfire.
- Reintroduce fire as a natural disturbance and beneficial process on the landscape.
- Improve the characteristics of terrestrial and aquatic wildlife habitat.
- Improve water quality and watershed function.
- Repair and rehabilitate areas adversely affected by historic infrastructure, wildfire and post fire flooding and erosion.
- Enhance the objectives on surrounding lands and benefit local communities and businesses.

Why do we need to take action here and now?

Since we assumed management of the preserve in 2002, we have been working to quantify and characterize the current condition of the preserve's natural systems. This allows us to measure, describe, and define the differences between the existing condition and the condition that we know to be sustainable and resilient in response to natural disturbances such as fire. We call this the *reference condition* and use it as a baseline to measure the degree of departure in terms of the physical and biological components and conditions of the existing ecosystems. Based on our research, it is clear that there is a significant degree of ecological departure between the existing condition of the preserve's natural systems and the reference conditions. In other words, the preserve's ecosystems are completely out of whack!

[2] A team of dedicated professionals representing conservation organizations, land management agencies, industry, and independent scientists collaboratively developed these principles. These principles for restoration should be used as guidelines for project development and they represent the "zone of agreement" where controversy, delays, appeals, and litigation are significantly reduced. These principles can be viewed in their entirety at: http://nmfwri.org/about-us

The structure (age and size) of our forests is most noticeably out of whack. The structure of our forests should vary across the landscape and should be dominated by large and old trees (USDA - Forest Service, USDI 2008, Swetnam and Baisan 1996, C. D. Allen 1989). However, nearly all of the forests in the preserve are dominated by young, dense forests of small diameter trees where large and old trees are scarce or absent.

Currently the natural systems of the preserve cannot respond and adapt to current risks and threats especially high severity wildfire (along with post fire flooding and erosion that are frequently associated with high severity burning) but also forest pests and disease. We need healthier[3] and more resilient natural systems if we are to achieve the goals and purposes for which the preserve was established as well as the goals and purposes of the laws, policies and plans, which guide its management.

These laws, policies, and plans all provide direction for a collaborative approach to management, which involves all interested and affected governments, agencies, organizations, and individuals, and considers all affected lands. For us to meet the intent of the collective laws and policies which guide the management of the preserve and those which guide forest restoration and the management of wildland fire on federal lands, we need a collaborative plan that considers the entire landscape – the preserve as a whole, the objectives on surrounding lands, and the communities and businesses around us.

Based on the existing condition reports we prepared in 2009/10, we determined that the preserve's forests would likely burn with uncharacteristically high intensity and severity in the event of a wildfire and would not be resilient in the event of wildfire, drought, or other disturbance. The 2011 Las Conchas wildfire confirmed this projection. This fire, the largest in New Mexico's history at the time, burned over 156,000 acres including 30,000 acres of the preserve; this significant event was followed by the Thompson Ridge fire that burned just under 24,000 acres on the preserve in June of 2013.

Figure S - 1. Crownfire burning in the 2011 Las Conchas fire

The forest systems and habitats in their current state are degraded. Ecosystem services are inhibited including the capture, storage, and yield of water (watershed function); and the capture and sequestration of carbon. The degraded existing condition of these systems leaves them vulnerable and unable to adapt to current and predicted climatic trends, which are likely to be warmer and drier into the foreseeable future (The Nature Conservancy 2009, Williams, et al. 2010). The current condition of the preserve's natural systems does not support the attainment of the purposes and goals from the Valles Caldera Preservation Act especially: "…the protection and preservation of the scientific, scenic, geologic, watershed, fish, wildlife, historic, cultural, and recreational values of the Preserve" (U.S.C. 2000).

[3] For the purpose of this EIS the adjective "healthy" means a condition similar in structure, composition and function to the reference condition.

Why such a detailed report?

Some, if not most, of the management actions we are proposing (forest thinning, prescribed fire, road maintenance, inventory and monitoring) can be categorically excluded from documentation in an EA or EIS at the project level (Federal Register 2003); and some (wetland and riparian restoration, noxious weed eradication) are already covered to some extent under current NEPA documents (Valles Caldera Trust 2004,2006,2009, Valles Caldera Trust 2009, Valles Caldera Trust 2003, Reviewed 2008, 2010). However, by including all actions under the proposed Stewardship Plan we can ensure that the interactions and cumulative effects of all proposed, as well as, past, present and reasonably foreseeable future, actions are adequately considered. In addition, this enables us to systematically monitor and evaluate outcomes in support of our adaptive management program.

Who will make the final decision?

The Executive Director of the Valle Caldera Trust is the Responsible Official, who will oversee the planning and implementation of the proposed Stewardship Plan. Based on the environmental impact analysis presented in this EIS along with input from the public, tribes and other agencies, the Executive Director will decide whether to select and implement one of the action alternatives as the long-term Stewardship Plan for the VCNP or to take no action at this time. This decision will be documented in a Record of Decision (ROD).

How has the public been involved?

In their October 2007, *Collaboration in the NEPA Process,* the President's Council on Environmental Quality (CEQ) refers to a "Spectrum of Engagement in NEPA Decision-Making" adapted from the International Association for Public Participation's Public Participation Spectrum[4]. The spectrum shows four levels of potential engagement for a lead agency with other governmental and non-governmental entities. Beginning with the level of least shared influence by parties, they are to: Inform, Consult, Involve, and Collaborate (CEQ 2007).

At the ***Inform*** level, the agency informs interested parties of its activities. At the ***Consult*** level, the agency keeps interested parties informed, solicits their input, and considers their concerns and suggestions during the NEPA process. Here the agency consults with parties without necessarily intending to reach agreement with them. At the ***Involve*** level, the agency works more closely with interested parties and tries to address their concerns to the extent possible give the agency's legal and policy constraints. At the ***Collaborate*** level, parties exchange information and work together towards agreement on one or more issues at one or more steps in the NEPA process (CEQ 2007).

We worked at the collaborative level with other governmental and non-governmental entities (Figure S - 2, Table S - 1) to develop the Southwest Jemez Mountains Collaborative Forest Landscape Restoration

[4] Available at http://www.IAP2.org.

Strategy (SWJML) (Valles Caldera Trust, Santa Fe National Forest 2010). This collaboration and strategy served as our basis for developing the purpose and need for action and the proposed action.

Figure S - 2. Collaborative strategic planning workshop, February 2010, Santa Fe, NM

> "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."
> - *Margaret Mead*

Table S - 1. Collaboration participants (Valles Caldera Trust, Santa Fe National Forest 2010)

Local, State, and Federal Government Organizations and Tribes	
Los Alamos County, Fire Department	USGS Jemez Mountains Ecological Field Station
New Mexico Game and Fish	USDA-Forest Service, Santa Fe National Forest
New Mexico State Forestry	USDA-Forest Service, Southwestern Region
New Mexico Surface Water Quality	USDA-Forest Service, Rocky Mountain Research Station
Pueblo of Jemez	USDA-Natural Resource Conservation District
Pueblo of Santa Clara	USDI-BIA, Northern and Southern Pueblos Agency
Sandoval County Emergency Services	USDI-FWS Southwestern Ecological Field Office
Soil and Water Conservation District (Cuba)	USDI-NPS Bandelier National Monument
Los Alamos National Laboratory (USDOE)	Valles Caldera Trust
Mid-Region Council of Governments	Village of Jemez Springs
Non-Government Organizations	
Cuba Regional Economic Development Organization	Northern Arizona University
Forest Guild	Restoration Solutions
Four Corners Institute	Rocky Mountain Elk Foundation
Hawks Aloft	The Nature Conservancy, New Mexico
La Cueva Volunteer Fire Department	Thompson Ridge Home Owners Association
Las Comunidades	Sierra Los Pinos Homeowners Association
National Wildlife Federation	Trout Unlimited, Truchas Chapter
New Mexico Forest and Watershed Restoration Institute	University of Arizona
New Mexico Forest Industry Assc.	University of New Mexico
New Mexico State University	USA Firewise, Greater East Jemez WUI Working Group
New Mexico Trout	WildEarth Guardians
Northern New Mexico College, Forestry Department	Wild Turkey Federation

We committed to engaging the public (you) at the involvement level of the public participation spectrum throughout the NEPA process. Towards this end, we provided you with an extended opportunity to comment on the proposed action following the publication of a Notice of Intent (July 16 – September 29, 2010). We provided you with summarized "easy to read" documents on the existing condition of the preserve's ecosystems as well as detailed specialist reports and background information. We have made these different levels of information available on an interactive web page dedicated to the proposed Stewardship Plan. The web page allowed you to comment and review the comments of others during

the scoping period. We updated the page as alternatives were developed so you could see how your comments shaped the development of the proposed Stewardship Plan; and provide an opportunity for you to review and comment on issues, alternatives and performance requirements. We hosted public meetings during both scoping and alternative development. Due to the delay in planning and decision-making caused by the Las Conchas fire, we provided an update and made early drafts of *Chapter 1 – Proposed Action, Purpose and Need* and *Chapter 2 – Alternatives* available for public review. We also provided updates at other venues including public meetings of the Valles Caldera Trust's Board of Trustees (Valles Caldera Trust n.d.), public meetings regarding the Southwest Jemez Mountains Landscape and meetings held by the newly formed Southwestern Jemez Mountains Collaborative (NMFWRI 2013). The public will have a minimum of 45-days to comment on the Draft EIS.

Affected and interested local, federal, and tribal governments and agencies participated at the collaborative level during the strategic planning for the SWJML and informal consultation was conducted in the spring and early summer of 2011. In 2012 we hosted a public meeting and workshop to provide updated information on the SWJML condition and plans for continued monitoring. Formal consultation with interested tribal governments and the USFWS will be conducted concurrent with the release of the Draft Environmental Impact Statement (DEIS). An expected outcome of formal consultation would be a plan or agreement for continued consultation and involvement throughout the implementation if an action is selected. A complete description of this consultation and the outcomes will be incorporated into the Final EIS as an appendix along with public comments received on the DEIS and our responses.

What types of actions and activities are being proposed?

Under the proposed Stewardship plan we would engage in a variety of actions and activities across the landscape as described in Table S - 2 below. Forest and wildland fire management are the focal actions of the proposed Stewardship Plan

Table S - 2. Restoration actions and connected activities proposed within the 10-year Stewardship Plan

Actions and Activities	Description
Forest Thinning	Selectively cutting trees or shrubs; selection focused on improving the structure, composition and function of the remaining forest and the health and vigor of the remaining trees or shrubs.
Mechanical Thinning	Cutting or pruning smaller diameter trees (0-16" diameter) or shrubs using mechanized heavy equipment
Manual (Chainsaw) Thinning	Thinning individual trees or shrubs manually using a chainsaw.
Pruning	Cutting tops or branches of trees or shrubs (using either manual or even controlled browsing by goats.)
Biomass Disposal	Cutting or pruning trees requires a connected biomass disposal activity.
Biomass Disposal Utilization	Removal for subsequent utilization by: yarding (to pull partially or fully suspended logs or trees) or skidding (to drag or carry logs or trees) biomass to a road or landing point.
Biomass Disposal Mastication	Masticating or chipping and leaving the biomass on site; some equipment is capable of thinning and masticating trees simultaneously.
Biomass Disposal Hand Piling or Machine Piling	Piling biomass for burning under low risk conditions.
Biomass Disposal Lop	Cutting and spreading the biomass to reduce the height, increase the compaction of

Actions and Activities	Description
and Scatter	the fuel bed, and to break up concentrations of fuel.
Biomass Disposal Prescribed Fire	Planned ignitions of wildland fire may be used alone or in combination with any other biomass disposal method.
Wildland Fire Management	Includes the management of both planned and unplanned ignitions to achieve objectives for resource management or protection.
Wildland Fire - Prescribed Fire	Planned ignition of wildland fire under prescribed environmental conditions (prescribed fire) may be used to achieve resource benefits including biomass disposal. Planned ignitions may be used alone or in combination with mechanical treatments.
Wildland Fire – Wildfire	Unplanned ignitions can be suppressed to meet protection objectives or managed for resource objectives or some combination thereof. Only lighting caused fires can be managed for resource objectives and only if environmental and other conditions are appropriate. Unplanned human caused fires are managed with safety and protection5 as the primary objectives.
Road Management	Includes the administrative and physical closure and decommissioning as well as the repair and maintenance of roads.
Administrative Closure	Prohibiting motorized use of a road to encourage natural revegetation. This action may include the placement of barriers. Non-motorized (pedestrian, equestrian, or bicycle) use may be permitted.
Closure and Decommissioning	Physical road rehabilitation to promote natural revegetation. Activities may include the placement of biomass, creating drainage by shaping the alignment or installing culverts, scarify and seeding the alignment.
Temporary road construction	Roads currently closed may be opened or short reaches of road may be built to provide access to areas for thinning, wildfire management or other restoration activity.
Road Maintenance and Repair	Maintenance and deferred maintenance on open roads. Includes road grading, reconstruction of the road prism, and construction of drainage features such as lead out ditches and the placement (or replacement) of culverts. May include realignment to improve safety or protect resources.
Watershed Restoration	Activities (other than road management) to protect or restore riparian and wetland areas or watershed function. Commonly employed activities are planting, placing sod, erecting fences or barriers, placing structures to reduce the energy of flow, heavy equipment may be used to remove man made impoundments, to restore previously diverted stream courses, or address localized erosion in riparian or upland environments.
Riparian Restoration	"Low tech" actions that support natural rehabilitation as well as manipulative actions that directly restore habitats and riparian function.
Wetland Restoration	Restoring wetlands generally requires restoring a source of watering and involve low tech as well as manipulative actions.
Erosion Control	Activities other than road maintenance to prevent, control, or halt erosion.
Noxious Weed Control	Inventory and Eradication of noxious weeds using mechanical or biological methods or herbicides.
Research, Inventory, Monitoring and Evaluation	Measuring structure, composition, and function of various ecosystems at various scales including collecting samples using non-destructive6 and destructive methods, establishing temporary and permanent instrumentation and/or exclosures, and providing temporary and/or limited administrative access.

[5] Protection strategies are based on current and predicted conditions, values at risk, cost effectiveness and other considerations. Public and fire fighter safety is always the first consideration when selecting the appropriate response to any unplanned ignition or the management of any planned ignition.

[6] "Non destructive sampling" means measuring an element such as vegetation, in situ and leaving it intact. Capturing animals and taking measures, attaching collars or transmitters and releasing the animals is non-destructive. "Destructive sampling" generally refers to any action where the element is removed or destroyed and cannot be re-measured. Cutting down snags, capturing and killing or removing animals, removing plants are all destructive methods of sampling.

All the actions and activities would address our purpose and need for action, but the landscape scale restoration of our forests by thinning along with the reintroduction of wildland fire are the focal activities of the plan and will receive the lion's share of our energies and resources.

Are there standards and guidelines for all these actions?

Through our public scoping process and environmental analysis we have identified a suite of mitigating measures that will guide or constrain our management actions. These measures, along with applicable laws and procedures that further guide our actions, are listed in chapter 2 as "performance requirements". These requirements would apply to all activities and alternatives and be adopted as preserve-wide standards and guidelines through the Record of Decision.

The categories of performance required described in chapter 2 are:

- Laws
- Policies
- Procedures
- Mitigating Measures
    - Vegetation Composition and Structure
    - Vegetation Management following unplanned events (fire, insects, disease)
    - Noxious Weed Prevention and Control
    - Herbicide Use
    - Habitats and Biodiversity
    - Soil and Erosion
    - Cultural Resources
    - Water Quality and Riparian Habitats
    - Air Quality
    - Socioeconomic Benefits/Impacts to Local Businesses and Communities
    - Climate Change
    - Wildland Fire Management
    - Managing Preserve Activities
    - Sensory Resources

Would we thin the entire preserve?

We would like to be able to thin all the forests that are overcrowded, damaged, and/or unhealthy but that would not be technically or economically feasible. We have identified the forests that have the greatest degree of ecological departure, the greatest fire behavior potential, and have an average slope less than 25 percent (steeper slopes are not technically or economically feasible to treat at the landscape

scale). These forest stands have been prioritized for thinning over the next 10 years. These forests comprise 21,496 acres in total.

We have proposed to begin treatment in the preserve's southwest corner and then move to the north and east. This is because the area to the south and west of the preserve has a high incidence of fire occurrence, the predominant winds are from the west and southwest, and the slopes face the south and west. This alignment of forest, slope, and wind juxtapositioned with high fire occurrence creates a high risk of fire.

Table S - 3 presents the acres to be thinned within each type of forest on the preserve. The map in Figure S - 3 shows the distribution of the proposed thinning across the landscape as well as the priority areas for treatment.

Table S - 3. Forest types and acres proposed for thinning

Fire Regime and Ecotype	10-Year Treatment
FR I – Ponderosa Pine; Xeric Mixed Conifer	7,860
FR I – Montane Grasslands	3,236
FR III – Mesic Mixed Conifer; Aspen/Mixed Conifer	7,500
FR III – Mesic Mixed Conifer; Aspen-Mixed Conifer	1,500
FR IV – Xeric Spruce-fir; Mesic Spruce-fir	1,200
FRIII – Mixed Montane Woodlands	200
Totals	**21,496**

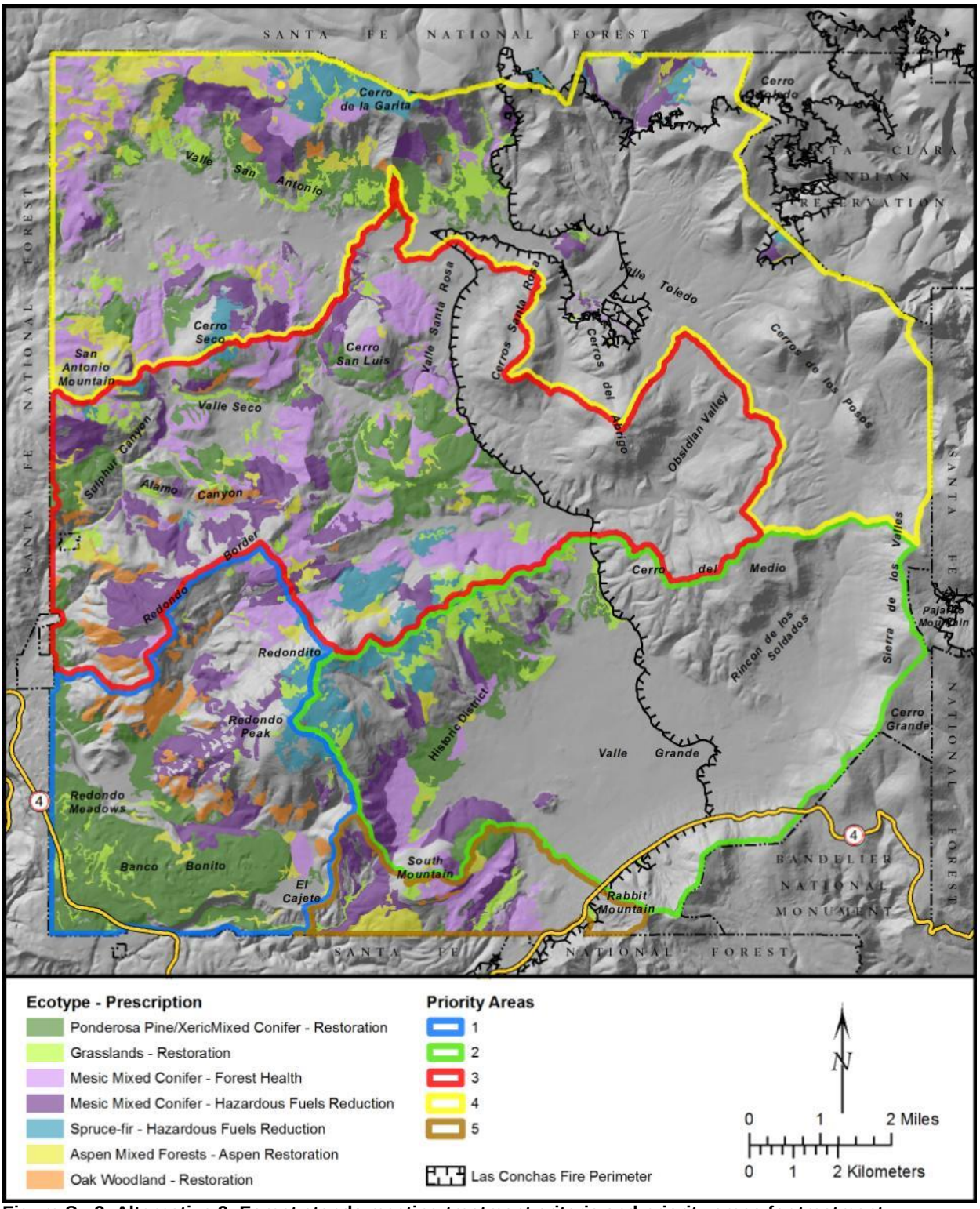


Figure S - 3. Alternative 2: Forest stands meeting treatment criteria and priority areas for treatment

Have we considered any other approaches to landscape restoration?

Actually, the NEPA *requires* us to consider more than one approach to meeting our purpose and need for action. John Paul Stevens, Senior Associate Justice of the U.S. Supreme Court wrote, "Even in high school, a rule that permits only one point of view to be expressed is less likely to produce correct answers than the open discussion of countervailing views" (from: Morse v. Frederick (2007)). NEPA refers to the alternative section as the "…heart of the Environmental Impact Statement"; it is certainly at the heart of good decision-making.

We are considering three alternatives including taking no action. The action alternatives both propose forest thinning, wildland fire management, riparian and wetland restoration, road management, noxious control, and burned area rehabilitation. The action alternatives vary in the selection of *which* forest stands would be selected for thinning across the landscape and the intensity of thinning prescriptions (Figure S - 3 and Figure S - 4 below).

Alternative 1 is the no action alternative and provides the baseline for comparing the environmental consequences of the alternative actions.

Wait! Why would you consider *not* taking action to restore and protect the forests?

In their procedures for implementing the NEPA, CEQ requires the analysis presented in the EIS to "include the alternative of no action". This analysis provides a benchmark, enabling decision-makers to compare the magnitude of environmental effects of the action alternatives.

Alternative 2 is called the "Collaborative Restoration Strategy" and proposes to implement the actions and priorities that were developed in the 2009 collaborative workshop. Under this alternative we would prioritize thinning in forests that were most ecologically departed and had the greatest potential to burn with uncharacteristic severity or scale. Alternative 3 is called "Aspen Restoration". Under this alternative, we would also prioritize the most ecologically departed forests for treatment however, instead of selecting forests to be thinned based on the current degree of fire behavior potential, we would select forests most likely to regenerate aspen trees following treatments.

What is a thinning "prescription"?

Much the same as a doctor prescribes medicine to a patient to treat medical symptoms or diseases; land managers develop a prescription to improve the health and vigor of forests or to alleviate forest health issues.

Under alternative 2, we would apply a more intensive "aspen restoration" prescription only where we were actually thinning in and adjacent to existing aspen clones. Under alternative 3 we would apply the more intensive prescription across stands where aspen regeneration was predicted unless contraindicated by poor access.

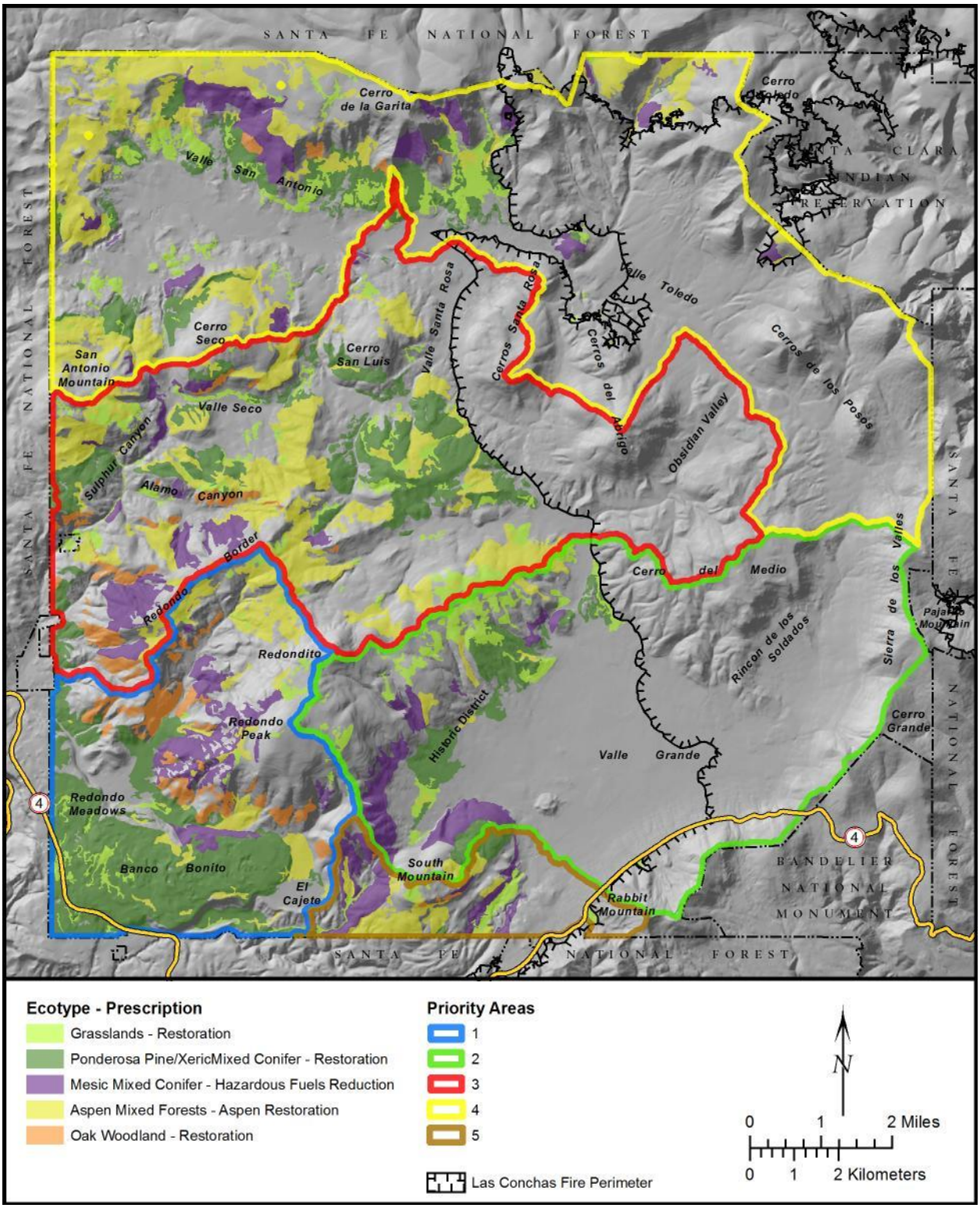


Figure S - 4. Alternative 3: Forest stands meeting treatment criteria and priority areas for treatment

How do these alternatives differ?

Forest types, acres and prescriptions proposed for thinning under the action alternatives are presented below in Table S - 4 (differences are in bold). Aspen Restoration is the most intensive thinning prescription, followed by Restoration, and Forest Health, with Hazardous Fuels being the least intensive thinning prescription. Chapter 2 details the various prescriptions.

Table S - 4. Comparison of thinning proposed under alternative 2 vs. alternative 3

Ecotype	Alternative 2: 10-Year Proposed Acres | Prescription		Alternative 3: 10-Year Proposed Acres | Prescriptions	
FR I Montane Grassland	3236	Restoration	3236	Restoration
FR I Ponderosa Pine Savanna	1032	Restoration	1032	Restoration
FR I Ponderosa Pine Forest	3817	Restoration	3817	Restoration
FR III Xeric Mixed Conifer	2957	Restoration	2957	Restoration
FR III Blue Spruce Fringe	53	Forest Health	53	Forest Health
FR III Mesic Mixed Conifer	5471	Forest Health	5756	Aspen Restoration
FR III Mesic Mixed Conifer (Steep Slopes)	1205	Hazardous Fuels	322	Hazardous Fuels
FR III Aspen/Mixed Conifer	2020	Aspen Restoration	3493	Aspen Restoration
FR III Aspen/Mixed Conifer (Steep Slopes)	295	Hazardous Fuels	0	N/A
FR IV Xeric Spruce-fir	764	Hazardous Fuels	429	Aspen Restoration
FR IV Mesic Spruce-fir	445	Hazardous Fuels	0	N/A
FR III Mixed Montane Shrublands	200	Hazardous Fuels	200	Hazardous Fuels
Totals	**21495**		**21295**	

How do treatment costs compare between the action alternatives?

Table S - 5 below compares the intensity and costs for thinning and prescribed burning for alternative 2 and alternative 3. Alternative 3 is anticipated to cost nearly $3.5 million more over the 10-year planning period due to more intensive mechanical treatment. Dollars are estimates based on direct and indirect (12.5 percent) costs, reflecting current costs and dollars.

Table S - 5. Comparing the intensity and cost of mechanical treatment and prescribed fire (action alternatives only)

	Acres		Cost/Acre ($)	Total Cost ($)	
	Alt. 2	Alt. 3		Alt. 2	Alt. 3
MECH Prescription					
REST – Restoration	11095	11095	800	8,876,000	8,876,000
ASRE – Aspen Restoration	2020	9,677	950	1,919,000	9,193,150
FOHE – Forest Health	5480	0	700	3,836,000	0

	Acres		Cost/Acre ($)	Total Cost ($)	
	Alt. 2	Alt. 3		Alt. 2	Alt. 3
HFRE - Hazardous Fuels	2900	522	600	1,740,000	313,200
Total	21,495	21,295		16,371,000	18,383,150
Prescribed Fire Type					
Biomass Disposal	21,495	23,498	150	3,224,250	3,524,700
Grasslands	12,340	12,340	75	925,500	925,500
Forest/Woodland	15,990	15,990	200	3,198,000	3,198,000
Total	49,825	51,828		7,347,750	7,648,200
Grand Total (Thinning and Burning)				**23,718,750**	**26,031,350**

The proposed Stewardship Plan is intended to benefit the environment, but could there also be adverse impacts?

Yes, chapter 5 - *Environmental Consequences* documents the potential for adverse impacts on nearly every resource area. However, the adverse impacts that could result from the proposed restoration activities are all expected to be localized, minor, and short-term. These adverse impacts include outcomes such as localized ground disturbance, noise, dust, smoke, traffic, and inconveniences to visitors.

Every resource area is predicted to ultimately benefit by the improved condition of the natural systems and the reduced threat from wildfire. These benefits would be long lasting and would extend throughout the planning area and in some cases, extend to the surrounding region. Because the activities have been implemented on the preserve at the project level and are commonly implemented on public lands in general, we have confidence in our analysis and predictions. The mitigation measures are also common practices that are known to be effectives at eliminating or minimizing adverse effects.

The only area of uncertainty is regarding the effectiveness of aspen regeneration following thinning. Aspen has responded robustly within some areas of the Las Conchas fire. However, mechanical treatment combined with fire is a surrogate for fire and available literature reports varying degrees of success. Further, potential browsing by the resident elk herd, climate change, and accompanying potential for drought or outbreaks of insects or disease, adds to that uncertainty.

How will the environmental consequences vary between the alternatives?

Alternatives 2 and 3 only vary in regard to the location and intensity of forest thinning. The outcomes from the two approaches to forest thinning vary with regard to ecological condition, the wildland fire environment, watershed function, air quality, wildlife habitat, cultural resources, scenery, and - as previously described - costs. Following is a summary of the key differences based on the environmental analysis presented in the EIS. (Recall that Table S - 5 above compared the costs for each alternative.)

Ecological Condition

Chapter 4 - Affected Environment, describes in detail the method used for assessing ecological condition and departure, which can be expressed as a *Vegetative Condition Class* rating or VCC. The ratings are: 0-30 = No Departure (*Good*), 31-65 = Moderately Departed (*Fair*), 66+ = Significantly Departed (*Poor*).

Table S - 6 below, compares the expected VCC under the no action and both action alternatives. The red indicates a VCC of *Poor*, orange, yellow, and yellow-green all fall within the range of *Fair.* The color variances emphasize the degree of variation i.e. one point off Poor is orange and one point off Good yellow-green. No forest types either are, or would likely become, within the range of *Good* at the landscape scale (while restoration treatments would create more open forests, only time can create forests dominated by older, larger trees). Alternative 3, by treating so much of the aspen forests, creates an over abundance of mid-age, open forests, actually reducing the condition rating in the near-term.

Table S - 6. Alternative comparison; vegetative condition class

Forest Type	No Action VCC	Alt. 2 VCC	Alt. 3 VCC
Ponderosa Pine Savanna	65	65	65
Ponderosa Pine Forest and Woodland	79	64	64
Xeric Mixed Conifer	82	65	65
Mesic Mixed Conifer	56	31	31
Aspen Mixed Conifer	58	55	64
Xeric Spruce-fir	74	65	65
Xeric Spruce-fir	65	65	65

Wildland Fire Behavior Potential

It is important to note that it is not our intent to exclude fire from the natural systems of the preserve. The EIS includes a detailed description of the important and beneficial role of fire in these ecosystems and the occurrence of fire as an inevitable event. It is our intent to reduce the severity at which a wildfire would burn across the landscape, to improve the capacity of the system to continue a natural succession of growth and development following a fire, and to increase the safety of the public and firefighters who live and work in the wildland fire environment.

We looked at the effect to the fire behavior potential in two ways. First, we applied the fire behavior potential as a static attribute based on forest stand characteristics modeled under a single set of environmental parameters. Fire behavior attribute for each forest stand was applied using a Fire Intensity Scale (FIS) classification as described in Table S - 7.

Table S - 7. Fire Intensity Scale (FIS) classification of fire behavior (Scott November 2006)

Fire Intensity Class (FIS class)	Description of fire behavior
I	Very small, discontinuous flames, usually less than 1 foot in length; very slow spread rate; no spotting.
II	Small flames, usually less than two feet long; small amount of very short-range spotting possible.

Fire Intensity Class (FIS class)	Description of fire behavior
III	Flames up to 8 feet in length; short-range spotting is possible.
IV	Large flames, up to 30 feet in length; short-range spotting common; medium-range spotting possible.
V	Very large flames up to 150 feet in length; copious short-range spotting, frequent long-range spotting; strong fire-induced winds.
VI	Extraordinary flame size, greater than 150 feet in length; copious spotting; very strong fire-induced winds.

Second, we modeled fire behavior potential under various weather scenarios. In this discussion of fire behavior potential it is our objective to have more of the forest fire behavior potential resemble Figure S - 5 left and less resemble Figure S - 5 center and right.

Figure S - 5. Surface fire (left; FIS III), passive crown fire (center FIS IV), active crown fire (right FIS V-VI)

Alternative 2 targets mixed conifer, aspen mixed conifer, and spruce-fir stands based on the degree of fire behavior potential, while alternative 3 selects stands based on the potential to regenerate aspen. Therefore, it is not surprising the alternative 2 results in treating the most acres with the highest degree of fire behavior potential (Figure S - 6).

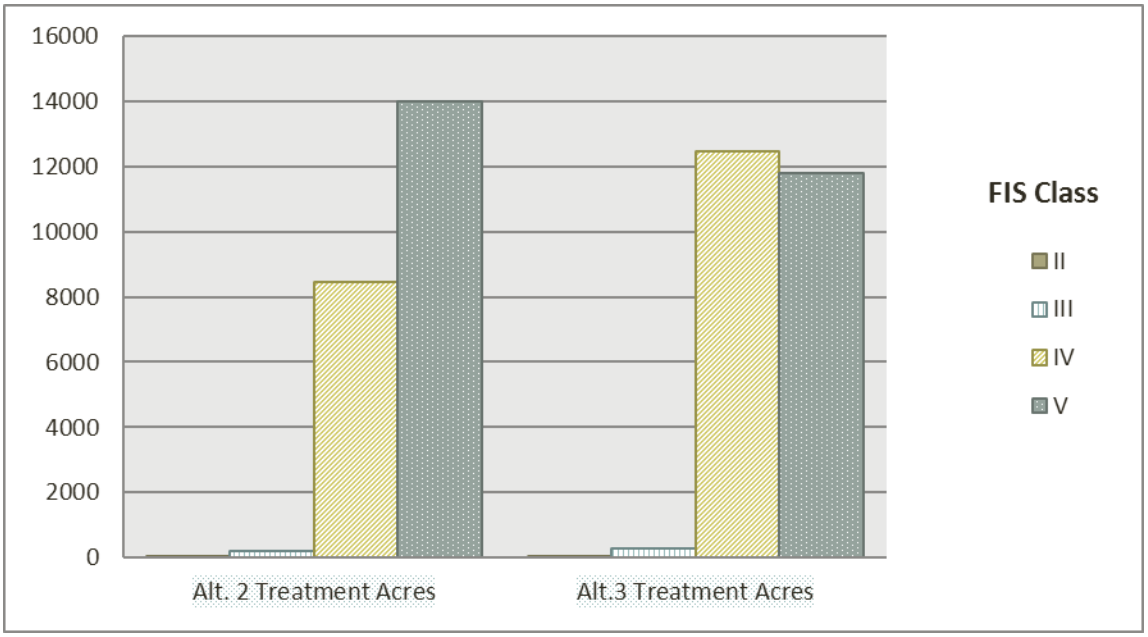


Figure S - 6. Acres treated by FIS Class. V = the greatest fire behavior potential (Scott November 2006)

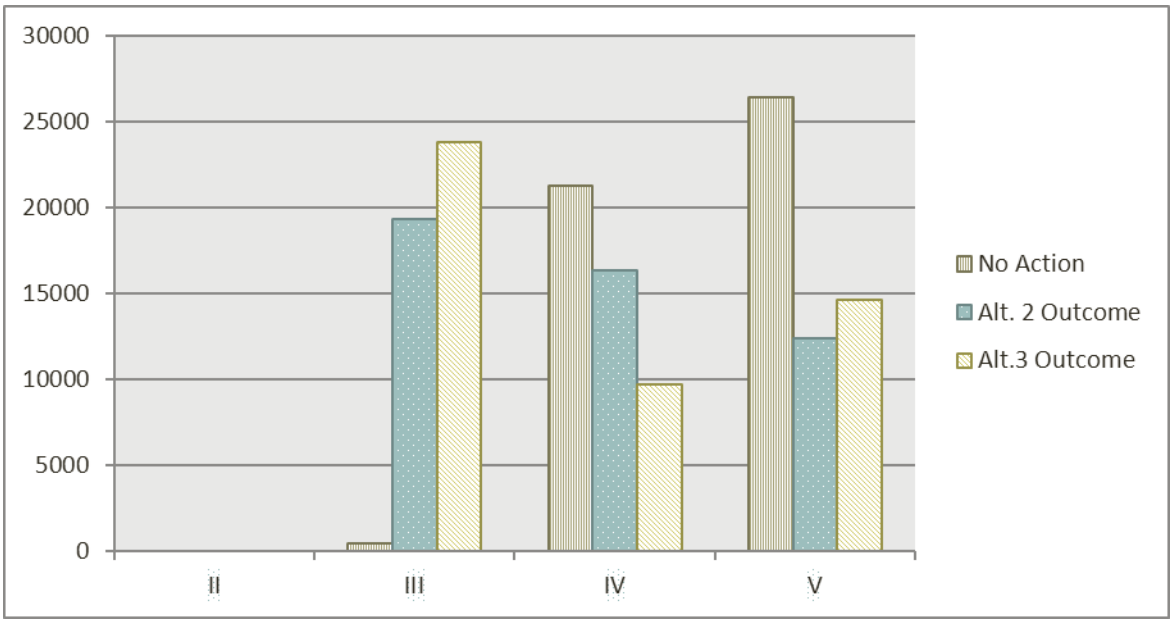
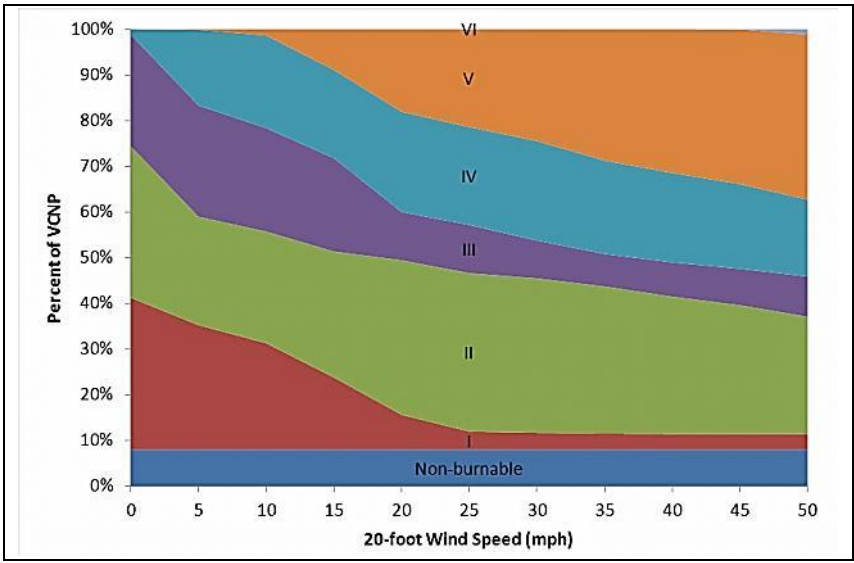


Figure S - 7. Distribution of treatment acres by FIS Class; no action and action alternatives

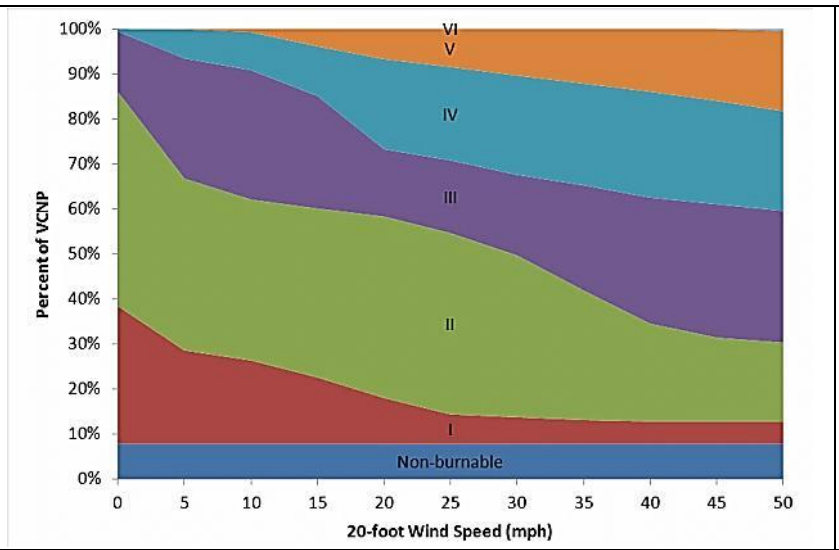
The fire behavior potential of the forest stands is related to the forest structure (dense young trees, interlocking crowns and the height of the crown base). Forest thinning and removing or otherwise disposing of the biomass, reduces the amount of fuel available to energize the fire and changes arrangement of the fuels including the vertical and horizontal continuity as shown in Figure S - 8.

Figure S - 8. Forest stand in the preserve's southwest corner before thinning (left), after thinning, but before biomass disposal (center), and after both thinning and biomass disposal are complete (right)

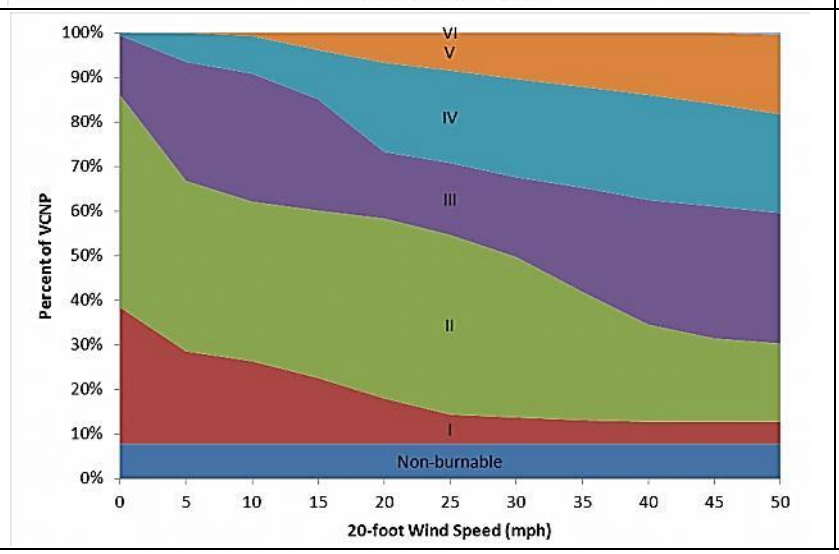
Figure S - 9 below shows the wildland fire behavior potential across the preserve under hot and dry conditions, and various wind speeds for the no action and each alternative action. As shown, the percent area across the preserve with the potential to burn in FIS classes IV and V (characterized by active crown fire and severe impacts to productivity and forest succession) are reduced preserve-wide by either of the action alternatives while the percent with the potential to burn in FIS class III is increased.



Alternative 1
No Action
FIS Class as a percent under various weather scenarios



Alternative 2
Collaborative Restoration Strategy
FIS Class as a percent under various weather scenarios



Alternative 3
Aspen Restoration
FIS Class as a percent under various weather scenarios

Figure S - 9. Percent of VCNP predicted to burn at various FIS classes under various wind speeds for each alternative (FIS Class II is represented by the grasslands)

Watershed Capture, Storage, Yield

Both action alternatives may have minor localized impacts to soil and water due to disturbance from use and access by equipment. Over all both approaches to forest restoration would measurably improve the watershed condition on the preserve. Alternative 3 is predicted to cause a greater increase in water capture, storage and yield (Table S - 8).

Table S - 8. Increase in annual flow for the action alternatives. Calculations based on an assumed increase of 15 percent snow depth.

	Alternative 2			Alternative 3		
Watershed	**Watershed Area with Xeric Forest and Aspen Emphasis (%)**	**Annual Yield Increase (%)**	**Annual Yield Increase (Acre Ft)**	**Watershed Area with Xeric Forest and Aspen Emphasis (%)**	**Annual Yield Increase (%)**	**Annual Yield Increase (Acre Ft)**
E F Jemez	6.5	1.0	89	8.7	1.3	118
San Antonio	8.6	1.3	106	13.8	2.1	171
Redondo	24.8	3.7	12	33.0	4.9	17
Sulphur	17.0	2.6	13	28.0	4.2	22

Air Quality

Both action alternatives have the potential to cause localized, short-term impacts to air quality from prescribed burning and dust from operations but would reduce the potential for more extensive intrusions from severe burning. Alternative 3 proposes slightly more intensive thinning that may lead to heavier fuel loads i.e. greater smoke production.

Wildlife and Terrestrial Habitats

Both action alternatives could cause minor, short-term adverse impacts to terrestrial species and habitats from disturbance. However both alternatives would ultimately benefit wildlife species by protecting habitats and individual animals from severe burning.

Alternative 2 proposes less thinning and less intensive prescriptions within the mesic mixed conifer and aspen mixed conifer preferred by Jemez Mountains Salamander than alternative 3. Mitigation measures intended to reduce or eliminate impacts to the salamander apply to all action alternatives, but the less intensive treatments proposed under alternative 2 have less potential to adversely affect the salamander and its habitat.

Cultural Resources

Both action alternatives would have the potential to cause localized, minor, impacts to individual sites. Overall both alternatives would benefit cultural resources by reducing the potential for severe burning and by completing extensive inventory of the cultural resources on the preserve. However, with its greater emphasis on treatments within forests where aspen is present, alternative 3 would propose a greater likelihood of impacting aspen carvings. However, performance requirements to locate and avoid or otherwise mitigate potential impacts to cultural resources apply to both action alternatives.

SocioEconomic Impact

Table S - 9 below shows the potential economic benefits based on information from the similar Collaborative Forest Restoration Program. They are similar for the ten-year period as both alternatives propose to treat a similar amount of acreage.

Table S - 9. Predicted employment and labor income impacts for the SWJM Restoration Strategy (Valles Caldera Trust, Santa Fe National Forest 2010)

Types of Projects	Total part and full-time jobs	Total Labor Income (2009 $)
Commercial Forest Products	407.2	$15,794,877
Other Project Activities	135.5	$4,314,888
Forest Service Implementation and Monitoring	32.8	$1,971,194
Total Project Impacts	**575.5**	**$22,080,960**

Source: USDA Forest Service, TREAT

Scenery

Under alternative 3 more intensive thinning would occur in the aspen forests. These forests add diversity to the forested landscapes, especially in the fall Figure S - 10. Although the intent is stimulating more cover by aspen, the short-term negative effect to scenery would be more pronounced under alternative three. Further, there is uncertainty as to the successful stimulation of aspen and its recruitment into the canopy overtime. The presence of elk, as well as the current climate trends is the source of this uncertainty.

Figure S - 10. Autumn morning scenery – aspen forest over frosted grass

How do all these actions and impacts combine to affect the environment?

The NEPA requires agencies to look beyond the direct effect of taking action. It requires us to look at indirect effects from our actions, or those effects that occur as a result of our actions but occur later in time or at a different location. It also requires that we consider the cumulative effects of our actions. Cumulative effects are the effects of our actions combined with other past, present and reasonably foreseeable future actions.

The EIS considers indirect effects and the cumulative effects of all the activities proposed in the Stewardship Plan in the environmental consequences section devoted to each impact area. The cumulative effects of past, present and reasonable foreseeable future actions other than those proposed in the Stewardship Plan are discussed in a separate section and organized into three headings: Ecological Condition, Socioeconomic, and Safety.

In general, indirect and cumulative effects of the proposed Stewardship Plan are beneficial and these benefits would extend beyond the areas actually treated to the planning area and beyond. These benefits are a result of reducing the potential for severe wildfires, improving the health and vigor of the forest, stabilizing streams, improving water quality, controlling the spread of noxious weeds, reducing erosion by stabilizing roads and rehabilitating and re-vegetating the area burned in the Las Conchas fire. These benefits carry over to protecting and improving wildlife and fisheries habitats, protecting air quality, recreation, and sensory resources, identifying and protecting cultural resources, and creating economic opportunities in the local area.

The EIS identifies past and present as well as the reasonably foreseeable future actions (actions that have actually been proposed or initiated) in and around the preserve, the have either affected would be likely to affect the human environment when combined with the proposed Stewardship Plan. In general, the affects are expected to be beneficial. This is to be expected as the action is designed to protect and improvement environment.

Are there any potential adverse indirect or cumulative impacts?

Through out the Environmental Consequences section of the EIS we disclose the potential for localized adverse impacts that are likely to occur as a result of the proposed stewardship plan including: smoke from prescribed burning, increased localized traffic, dust, and noise from operations, localized noise and disturbance to wildlife, temporary closures and restrictions to public access, and/or temporary impacts to visual quality.

There are other localized adverse impacts that are less certain to occur but are possible and even probable including: isolated impacts to cultural resources, isolated losses of important biodiversity characteristics (down logs and snags), injury or even death to individual animals or birds, and/or localized areas of severe burning or soil disturbance.

These potential short-term, minor, and localized adverse impacts are identified for almost every resource area. Without exception they are offset by longer term minor to moderate beneficial outcomes that would occur at the project, landscape or regional level. These impacts would be minimized or avoided all together by the application of performance requirements as standards for implementation. Further, we do not expect to incur any loss in the long-term productivity of the land and do not propose any irretrievable commitment of resources.

What if the outcomes are different than what you expected?

The trust's NEPA procedures include a system of *adaptive management* supported by the identification of goals, objectives and monitored outcomes. Adaptive management means: "…adjusting stewardship actions or strategic guidance based on knowledge gained from new information, experience, experimentation, and monitoring results, and is the preferred method for managing complex natural systems." (Federal Register 2003).

Chapter 2 identifies the goals, objectives, and monitored outcomes along with the target outcomes and time frames for measurement. Based on the evaluation of our monitored outcomes, we continue, adjust, or terminate an action or activity. We could also propose a new action or revise our targets or objectives. Considering a new action or a change to our targets and objectives would require additional review under NEPA.

Adaptive management as a process (Figure S - 11 below) views management actions as experiments rather than solutions. It is a formal and systematic approach to learning from the outcomes of our stewardship actions; accommodating change, and improving management. The following quote on learning credited to Martina Horner, President of Radcliff College, embodies the spirit of adaptive management: "What is important is to keep learning, to enjoy challenge, and to tolerate ambiguity. In the end there are no certain answers."

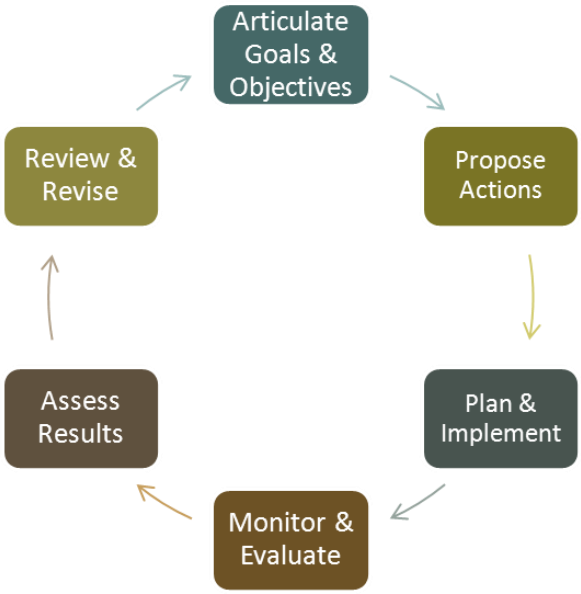


Figure S - 11. Process diagram illustrating adaptive management

Based on this analysis, is there a preferred alternative?

Yes, our preferred alternative is alternative 2, the collaboratively developed restoration strategy. Alternative 2, was designed specifically to meet our purpose for action – including reducing the potential for severe burning and to improving ecological condition across the landscape. Therefore, it is no surprise that it is predicted to best accomplish the purpose for action. Alternative 3 brings forward aspen restoration as a priority. While restoring aspen is not mutually exclusive to our purpose, it does not address fire behavior potential or ecological condition across the landscape to the same degree. Further, while alternative 3 could potentially improve watershed function to a greater degree, there is more uncertainty about the ultimate outcome and the degree to which aspen would be successfully recruited into maturity.

The more intensive treatments proposed in alternative 3 would be in the mesic mixed conifer forest and intermountain aspen-mixed conifer forests, which also represent habitat for the Jemez Mountains salamander. We were concerned that the more intensive treatments in this habitat could lead to greater drying and could adversely affect this species and that these impacts could extend to the mid- or even long-term, especially if the desired response by aspen is not successful.

Alternative 3, due to more intensive thinning would also be likely to have more of the direct, albeit short-term and minor, adverse impacts typically associated with forest thinning and prescribed burning (smoke, ground disturbance, noise, effects on scenery, etc.)

Alternative 2 does include some aspen restoration. Implementing this more intensive prescription on a smaller scale would allow us to measure the success and impacts under the current climate trends. We can also measure the success of aspen regeneration in the Las Conchas burn area. In the future, we could use this information to address restoration of our aspen forests with greater certainty in the outcomes. This conservative approach is consistent with the purpose and need for action and the management principles of the trust including, “We will exercise restraint in the implementation of all programs, basing them on sound science and adjusting them consistent with the principles of adaptive management;” (Federal Register 2003)

Who prepared the EIS?

The EIS was prepared and reviewed by an interdisciplinary team of specialists from the Valles Caldera Trust and the USFS (Table S - 10). The planning, decision-making, and any subsequent implementation are under the authority and supervision of the Executive Director. Valles Caldera Trust staff, researchers, students and volunteers under the supervision of experts, using standard and accepted protocols, have collected the information and data used to support this analysis. Methods, data, models, used are included in the applicable sections of the EIS.

Table S - 10. List of preparers

Name	Organization	Title	Resource Area
Dennis Trujillo	VCT	Executive Director	Responsible Official

Name	Organization	Title	Resource Area
Marie Rodriguez	VCT	Director, Planning and Natural Resources Division	Project Leader, Lead Author
Bob Parmenter	VCT	Director, Scientific Services Division	Data and Literature Review, ESA Consultation
John Swigart	VCT	GIS Specialist	Spatial Analysis and Display
Ana Steffen	VCT	Cultural Resource Coordinator	Cultural Resources
Kristin Whisennand	USDA – Forest Service, TEAMS Enterprise Unit	Technical Writer/Editor	Writer/Editor
Vince Archer	USDA – Forest Service, Above and Beyond Enterprise Team	Soils Scientist	IDT Lead, Soils, Treatment Prescriptions
Anton Jackson	USDA – Forest Service, Above and Beyond Enterprise Team	Range Specialist	Understory, Noxious Weeds
Eric Moser	USDA – Forest Service, Above and Beyond Enterprise Team	Hydrologist	Hydrology
Brooke DeVault	USDA – Forest Service, TEAMS Enterprise Team	Fisheries Biologist	Fisheries and Aquatic Habitats
Don Helmbrecht	USDA – Forest Service, TEAMS Enterprise Team	Fuels Specialist/Geospatial Analyst	Wildland Fire Environment, Treatment Prescriptions, Fire Behavior, Vegetative Condition Class
Janet Moser	USDA – Forest Service, TEAMS Enterprise Team	Wildlife Biologist	Terrestrial Wildlife and Habitats
Neil McCusker	(Formerly) USDA – Forest Service, TEAMS Enterprise Team	Silviculturist	Forestry, Existing Condition
Larry Amell	USDA – Forest Service, TEAMS Enterprise Team	Silviculturist	Forestry, Vegetation Simulation Modeling
Joshua Wilson	(Formerly) USDA – Forest Service, TEAMS Enterprise Team	Economist	Socioeconomic, Affected Environment
Erich Dodson	(Formerly) USDA – Forest Service, Pacific Northwest Research Station	Silviculturist	Forest Condition, Treatment/ Prescriptions, Forest Pest/Disease
Collaborators	Participants in the 2010 Workshop		Purpose and Need, Proposed Action

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Chapter 1. Proposed Action, Purpose & Need

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

"[Restoration] Treatments must be flexible enough to recognize and accommodate: high levels of natural heterogeneity; dynamic ecosystems; wildlife and other biodiversity considerations; scientific uncertainty; and the challenges of on-the-ground implementation. Ecological restoration should reset ecosystem trends toward an envelope of ''natural variability,'' including the reestablishment of natural process"

- *Ecological Restoration of Southwestern Ponderosa Pine Ecosystems: A Broad Perspective*

1.1 Introduction

This chapter is a summary of our proposed plan for the restoration and stewardship of the natural resources of the Valle Caldera National Preserve. This chapter presents the overarching *purpose* (goal), for the plan, and the *need* or the problems or issues we are intending to address and the laws and policies that indicate a need to take action; and describes the *scope* of our analysis. Scope includes the range of actions and activities we are considering, the level of analysis and documentation we will be completing, what decision(s) we will ultimately make, and degree of public involvement.

1.2 Proposed Action

We (the Valles Caldera Trust) are proposing to design and implement a 10-year Landscape Restoration and Stewardship Plan for managing and restoring the natural systems of the Valles Caldera National Preserve[7]. The proposed Landscape Restoration and Stewardship Plan includes forest management, wildland fire management, wetland and riparian restoration, road management, and noxious weed prevention, control and eradication; and burned area rehabilitation. These activities would occur preserve-wide and are aimed at restoring the structure, composition, and function of the preserve's forest, grassland and riparian resources. From this point forward we will refer to the proposed Landscape Restoration and Stewardship Plan as simply the "Stewardship Plan."

1.2.1 Collaborative Forest Landscape Restoration

In 2009 and 2010 over 60 individuals representing 30 different organizations and agencies met through field trips and working meetings, culminating in a 3-day workshop; to propose a strategy for the restoration of 210,000 acres in the southwestern region of the Jemez Mountains. This collaborative restoration strategy entitled: The Southwestern Jemez Mountains Landscape Restoration Strategy was submitted as a proposal for funding through the Collaborative Forest Landscape Restoration (CFLR) program[8] and subsequently awarded 10-years of funding for restoration on the VCNP and Santa Fe National Forest (SFNF). The proposed stewardship plan is a tactical plan for implementing that collaborative strategy. The proposed stewardship plan consists of a suite of integrated stewardship actions designed to restore the resilience[9] and adaptive capacity of the preserve's forest and grassland systems, protect and improve wildlife habitats, increase soil, riparian, and wetland resilience; reduce soil erosion, and restore watershed function. These actions fall within five categories:

[7] Detailed information on the physical and socioeconomic setting of the preserve and the administrative setting of the trust is provided in *Chapter 3 – Setting.*

[8] The CFLR program was created under the Omnibus Public Land Management Act of 2009, Title IV (Pub. L 111-11, H.R. 146) passed by the 111th United States Congress and signed into law by President Barak Obama on March 30, 2009.

[9] For the purpose of this EIS "resiliency" means the ability of a system to remain within, or return to, its natural path of growth and development (succession) in the event of disturbances including fire, insects, disease and/or climatic events and/or changing climate.

- Forest Management – Thinning small diameter trees and disposing of the associated biomass.
- Wildland Fire Management – Using prescribed fire in association with forest thinning as well as a stand-alone tool and managing wildfire (unplanned) to protect people and property and enhance management objectives.
- Road Management and Erosion Control - closing, decommissioning, and maintaining roads; rehabilitating geothermal exploration areas, log landing sites, aggregate pit source sites;
- Riparian and Wetland Restoration - revegetating and otherwise stabilizing stream banks; restoring historic wetland flows; and
- Burned Area Rehabilitation – Stabilizing areas impacted by wildfire.

All activities include research, inventory, and monitoring actions.

Our proposed Stewardship Plan is based on the collaborative forest landscape restoration strategy developed for the Southwest Jemez Mountains Collaborative Forest Landscape Restoration Strategy (SWJML) (Valles Caldera Trust, Santa Fe National Forest, 2010) and incorporates New Mexico Forest Restoration Principles[10] and Ecological Restoration of Southwestern Ponderosa Pine Ecosystems: A Broad Perspective (Allen, et al. 2002).

1.3 Purpose and Need for Action

The National Environmental Policy Act (NEPA) requires a clear statement of purpose and need for any proposed federal action. The purpose is the end goal towards which our efforts are directed. The need is the reason why we are proposing to take action here and now. The need should identify the problems we are seeking to address and the laws, plans, or policies with which we must comply.

A clearly defined purpose and need for action is essential to define the scope of the analysis including the range of actions proposed and the alternatives that we will consider.

1.3.1 Purpose

The purpose of the proposed action is to improve the resilience and adaptive capacity of the preserve's natural systems, protect people and resources from destructive wildfire, and to rehabilitate areas that were severely burned during the Las Conchas wildfire.

The 10-year Stewardship Plan is intended to:

- Move the structure, composition and function of the preserve's natural systems towards the reference condition.
- Reduce the potential for unusually severe or extensive wildfire.
- Reintroduce fire as a natural disturbance and beneficial process on the landscape.

[10] A team of dedicated professionals representing conservation organizations, land management agencies, industry, and independent scientists collaboratively developed these principles. These principles for restoration should be used as guidelines for project development and they represent the “zone of agreement” where controversy, delays, appeals, and litigation are significantly reduced (New Mexico Biomass Evaluation Taskforce n.d.).

- Improve the characteristics of terrestrial and aquatic wildlife habitat.
- Improve water quality and watershed function.
- Repair and rehabilitate areas adversely affected by historic infrastructure, wildfire and post fire flooding and erosion.
- Enhance the objectives on surrounding lands and benefit local communities and businesses.

1.3.2 Need

Currently the natural systems of the preserve are significantly departed from the reference condition and are at risk to a variety of threats especially high severity wildfire (along with post fire flooding and erosion that are frequently associated with high severity burning) but also forest pests and disease. We need healthier[11] and more resilient natural systems if we are to achieve the goals and purposes for which the preserve was established as well as the goals and purposes of the laws, policies and plans, which guide its management. These include:

- The Valles Caldera Preservation Act (U.S.C., 2000).
- The National Environmental Policy Act procedures specific to the VCNP (Federal Register, 2003).
- Strategic management goals for the preserve adopted by the trust (Valles Caldera Trust, 2012).
- Federal Wildland Fire Management Policy and federal guidance for implementing the policy (NWCG, 2009).
- The Collaborative Forest Landscape Restoration Program (CFLRP) established under section 4003(a) of Title IV of the Omnibus Public Land Management Act of 2009.
- Southwestern Jemez Mountains Landscape Restoration Strategy (Valles Caldera Trust, Santa Fe National Forest, 2010) developed in response to the CFLRP.
- National Cohesive Strategy for Wildland Fire Management (USDA and USDI, 2011)

These laws, policies, and plans all provide direction for a collaborative approach to management, which involves all interested and affected governments, agencies, organizations, and individuals, and considers all affected lands. For us to meet the intent of the collective laws and policies which guide the management of the preserve and those which guide forest restoration and the management of wildland fire on federal lands, we need a collaborative plan that considers the entire landscape – the preserve as a whole, the objectives on surrounding lands, and the communities and businesses around us.

1.3.3 Background

Since we assumed management of the preserve in 2002, we have been working to quantify and characterize the current condition of the preserve's natural systems. This allows us to measure, describe, and define the differences between the existing condition and the condition that we know to be sustainable and resilient in response to natural disturbances such as fire. We call this the *reference*

[11] For the purpose of this EIS the adjective “healthy” means a condition similar in structure, composition and function to the reference condition.

condition and use it as a baseline to measure the degree of departure in terms of the physical and biological components and conditions of the existing ecosystems. Based on our research, it is clear that there is a significant degree of ecological departure between the existing condition of the preserve's natural systems and the reference conditions. In other words, the preserve's ecosystems are completely out of whack!

The most noticeable departure is the forest vegetation. The structure of our forests should vary across the landscape and should be dominated by large and old trees (USDA - Forest Service, USDI, 2008; Swetnam and Baisan, 1996; Allen, 1989). However, nearly all of the forests in the preserve are dominated by young, dense forests of small diameter trees where large and old trees are scarce or absent.

In 2007 a team of resource specialists evaluated data from over 700 vegetation plots and measures of water quality and stream condition. The team developed a system to summarize condition at a localized level and to systematically combine these measures to determine condition at various scales.

These data were collected over a period of years and were used to quantify the composition, structure and function of the riparian and grassland ecosystems and also to look for any trend in condition.

The following standards were applied as condition attributes:

- High: 70 - 100 percent of the values were within 30 percent of the optimum or reference condition.
- Moderate: 30 - 70 percent of the measures were within 30 percent of the optimum or reference condition.
- Low: Less than 30 percent of the measures were within 30 percent of the optimum or reference condition.

The overall degree of departure of the grassland and riparian systems measured by water quality, stream morphology, as well as vegetative cover and diversity has been described as moderate with an upward trend (Valles Caldera Trust, 2007; TEAMS Enterprise Unit, 2007). However, our fieldwork and environmental analysis has found the morphology of the stream has changed profoundly over the past century. Historically, the streams of the valles were dominated by wetlands and multi-threaded stream channels. Today, the valles are characterized by single-channel streams buffered by ribbons of wet meadows with fewer wetlands.

The degree of ecological departure is a cumulative result of excluding fire as a natural disturbance in combination with historical management activities, including intensive logging and grazing, geothermal exploration, and the development of infrastructure to support these activities. Infrastructure development included building approximately 1200 miles of logging roads with clearings (landings) for staging equipment and stockpiling logs; excavating 30 geothermal well pads, 10 gravel pits and 39 earthen watering tanks and dams, and establishing gathering locations and building corrals for concentrating sheep and cattle.

Based on the existing condition reports we prepared in 2009/10, we determined that the preserve's forests would likely burn with uncharacteristically high intensity and severity in the event of a wildfire and would not be resilient in the event of wildfire, drought, or other disturbance. The 2011 Las Conchas wildfire confirmed this projection. This fire, the largest in New Mexico's history at the time, burned over 156,000 acres including 30,000 acres of the preserve. Although the grasslands actually benefitted from the burn, the forested area burned with high severity leading to long term impacts to the structure, composition and function that define these forests and the associated habitats. The fire, as well as the post fire flooding, impacted all resources and habitats, causing a near 100 percent kill of brown trout in San Antonio creek adjacent to the burn area and irretrievable losses to cultural resources.

Figure 1-1. Crown fire burning during the 2011 Las Conchas wildfire

The forest systems and habitats in their current state are degraded. Ecosystem services are inhibited including the capture, storage, and yield of water (watershed function); and the capture and sequestration of carbon. The degraded existing condition of these systems leaves them vulnerable and unable to adapt to current and predicted climatic trends, which are likely to be warmer and drier into the foreseeable future (The Nature Conservancy, 2009). The current condition of the preserve's natural systems does not support the attainment of the purposes and goals from the Valles Caldera Preservation Act especially: "…the protection and preservation of the scientific, scenic, geologic, watershed, fish, wildlife, historic, cultural, and recreational values of the Preserve" (U.S.C., 2000).

1.4 Scope

Scope is the extent of the proposed actions and the extent of potential impacts in time and space during the planning period. Scope also refers to how the plan and environmental analysis be will be documented, and how the public will be engaged.

Our analysis will consider the expected short-term (1-3 yr.), mid-term (3-10 yr.), and long-term (>10 yr.) direct, indirect, and cumulative environmental consequences resulting from implementing one of the alternative courses of action or taking no action at all. The analysis will consider activities and impacts at the project and landscape level.

1.4.1 Documentation

We are documenting this analysis in an Environmental Impact Statement (EIS) consistent with the NEPA process developed specifically for managing the VCNP (Federal Register, 2003). Some, if not most, of the management actions we are proposing (forest thinning, prescribed fire, road maintenance, inventory

and monitoring) can be categorically excluded from documentation in an EA or EIS (Federal Register, 2003) at the project level; and some (wetland and riparian restoration, noxious weed eradication) are already covered to some extent under current NEPA documents (Valles Caldera Trust, 2004,2006,2009; Valles Caldera Trust, 2009; Valles Caldera Trust, 2003, Reviewed 2008, 2010). However, by including all actions under the stewardship plan we can ensure that the interactions and cumulative effects of all proposed as well as past, present and reasonably foreseeable future actions are adequately considered. In addition, this enables us to evaluate all actions under a systematic monitoring program in support of adaptive management.

1.4.2 Decision to be Made

The Executive Director of the Valle Caldera Trust is the Responsible Official, who will oversee the planning and implementation of the proposed Stewardship Plan. Based on the environmental impact analysis presented in this EIS, and input from the public, tribes and other agencies, the Executive Director will decide whether to select and implement one of the action alternatives as the long-term Stewardship Plan for the VCNP or to take no action at this time. This decision will be documented in a Record of Decision (ROD).

1.4.3 Public Involvement

In their October 2007, *Collaboration in the NEPA Process,* the President's Council on Environmental Quality (CEQ) refers to a "Spectrum of Engagement in NEPA Decision-Making" adapted from the International Association for Public Participation's Public Participation Spectrum[12]. The spectrum shows four levels of potential engagement for a lead agency with other governmental and non-governmental entities. Beginning with the level of least shared influence by parties, they are to: inform, consult, involve, and collaborate (CEQ, 2007).

At the ***Inform*** level, the agency informs interested parties of its activities. At the ***Consult*** level, the agency keeps interested parties informed, solicits their input, and considers their concerns and suggestions during the NEPA process. Here the agency consults with parties without necessarily intending to reach agreement with them. At the ***Involve*** level, the agency works more closely with interested parties and tries to address their concerns to the extent possible give the agency's legal and policy constraints. At the ***Collaborate*** level, parties exchange information and work together towards agreement on one or more issues at one or more steps in the NEPA process (CEQ, 2007).

We worked at the collaborative level with other governmental and non-governmental entities (Figure 1-2, Table 1-1) to develop the Southwest Jemez Mountains Collaborative Forest Landscape Restoration Strategy (SWJML) (Valles Caldera Trust, Santa Fe National Forest, 2010). This collaboration and strategy served as our basis for developing the purpose and need for action and the proposed action.

[12] Available at http://www.IAP2.org.

Figure 1-2. Collaborative strategic planning workshop, February 2010, Santa Fe, NM

Table 1-1. Collaboration participants (Valles Caldera Trust, Santa Fe National Forest, 2010)

Local, State, and Federal Government Organizations and Tribes	
Los Alamos County, Fire Department	USGS Jemez Mountains Ecological Field Station
New Mexico Game and Fish	USDA-Forest Service, Santa Fe National Forest
New Mexico State Forestry	USDA-Forest Service, Southwestern Region
New Mexico Surface Water Quality	USDA-Forest Service, Rocky Mountain Research Station
Pueblo of Jemez	USDA-Natural Resource Conservation District
Pueblo of Santa Clara	USDI-BIA, Northern and Southern Pueblos Agency
Sandoval County Emergency Services	USDI-FWS Southwestern Ecological Field Office
Soil and Water Conservation District (Cuba)	USDI-NPS Bandelier National Monument
Los Alamos National Laboratory (USDOE)	Valles Caldera Trust
Mid-Region Council of Governments	Village of Jemez Springs
Non-Government Organizations	
Cuba Regional Economic Development Organization	Northern Arizona University
Forest Guild	Restoration Solutions
Four Corners Institute	Rocky Mountain Elk Foundation
Hawks Aloft	The Nature Conservancy, New Mexico
La Cueva Volunteer Fire Department	Thompson Ridge Home Owners Association
Las Comunidades	Sierra Los Pinos Homeowners Association
National Wildlife Federation	Trout Unlimited, Truchas Chapter
New Mexico Forest and Watershed Restoration Inst.	University of Arizona
New Mexico Forest Industry Assoc.	University of New Mexico
New Mexico State University	USA Firewise, Greater East Jemez WUI Working Group
New Mexico Trout	WildEarth Guardians
Northern New Mexico College, Forestry Department	Wild Turkey Federation

We committed to engaging the public (you) at the involvement level of the public participation spectrum throughout the NEPA process. Towards this end, we provided you with an extended opportunity to comment on the proposed action following the publication of a Notice of Intent (July 16 – September 29, 2010). We provided you with summarized “easy to read” documents on the existing condition of the preserve’s ecosystems as well as detailed specialist reports and background information. We have made these different levels of information available on an interactive web page dedicated to the proposed Stewardship Plan. The web page allowed you to comment and review the comments of others during

the scoping period. We updated the page as alternatives were developed so you could see how your comments shaped the development of the proposed Stewardship Plan; and provide an opportunity for you to review and comment on issues, alternatives and performance requirements. We hosted public meetings during both scoping and alternative development. Due to the delay in planning and decision-making caused by the Las Conchas fire, we provided an update and made early drafts of *Chapter 1 – Proposed Action, Purpose and Need* and *Chapter 2 – Alternatives* available for public review. We also provided updates at other venues including public meetings of the Valles Caldera Trust Board of Trustees (Valles Caldera Trust, n.d.) and public meetings regarding the Southwest Jemez Mountains Landscape and meetings held by the newly formed Southwestern Jemez Mountains Collaborative (NMFWRI, 2013). The public will have a minimum of 45-days to comment on the Draft EIS.

Affected and interested local, federal, and tribal governments and agencies participated at the collaborative level during the strategic planning for the SWJML and informal consultation was conducted in the spring and early summer of 2011. In 2012 we hosted a public meeting and workshop to provide updated information on the SWJML condition and plans for continued monitoring. Formal consultation with interested tribal governments and the USFWS will be conducted concurrent with the release of the Draft Environmental Impact Statement (DEIS). AN expected outcome of formal consultation would be a plan or agreement for continued consultation and involvement throughout the implementation if an action is selected. A complete description of this consultation and the outcomes will be incorporated into the Final EIS as an appendix along with public comments received on the DEIS and our responses.

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Chapter 2. Issues & Alternatives

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

"Even in high school, a rule that permits only one point of view to be expressed is less likely to produce correct answers than the open discussion of countervailing views."

- John Paul Stevens, Senior Associate Justice of the U.S. Supreme Court
Morse v. Frederick (2007)

2.1 Introduction

In their procedures for implementing the National Environmental Policy Act (NEPA) the Council for Environmental Quality (CEQ) directs agencies to "…study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources…" and refers to the alternatives section as "…the heart of the Environmental Impact Statement. " Considering reasonable alternatives to a proposed action is certainly at the heart of the type of critical thinking that embodies good decision-making.

This chapter includes:

- Issues – A list and description of the issues and concerns associated with the proposed action. Issues provide the basis for the development of mitigating measures and alternative actions, and help to focus the analysis.
- Performance Requirements – The laws, policies, procedures, and mitigating measures that guide or constrain management activities.
- Alternatives – Including:
  - Alternatives Eliminated from Detailed Analysis – Alternatives that we have eliminated from further consideration and a brief explanation for their elimination.
  - The "No Action" Alternative – required by NEPA, this alternative establishes a basis for comparing the costs and outcomes of taking no action with those of any action alternative.
  - Action Alternatives – A detailed description of the action alternatives.
- Adaptive Management – Goals, objectives and monitored outcomes that we plan to use to evaluate our progress, measure the effects and effectiveness of our actions, and indicate any needed adjustments.
- Alternatives presented in a comparative form – This section presents treatments, costs and outcomes that vary between the alternatives.

2.2 Issues and Key Issues

Issues are the possible conflicts that may arise between the proposed use and allocation of resources or potential (adverse) environmental impacts that are likely to result from the proposed action.

Identifying issues is the basis for developing performance requirements that guide or constrain management practices to avoid potential adverse impacts. Issues that cannot be adequately addressed by performance requirements are considered *key* issues. Identifying key issues is the basis for developing alternatives to the proposed action and helps us to focus the analysis. Issues are also an important element for developing monitoring plans and thresholds for adjusting future actions (adaptive management).

2.2.1 Issues

Identifying issues early on helps us to focus the analysis on the subject matter most relevant to the decision(s) to be made. Issues related to the proposed Stewardship Plan were identified through interdisciplinary analysis and public involvement. Table 2-1 below presents the issues, including key issues, and indicates whether the issue is addressed through the proposed action, performance requirements, alternative development, a focus of the environmental analysis, or through adaptive management.

Table 2-1. Issues

Issues * Indicates Key Issue	Issue Statement	Response
Composition and Structure		
Mortality from prescribed fire	In some areas fire adapted species composition (ponderosa pine, Douglas-fir) transitioned to fire intolerant composition (white fir, blue spruce). In these stands, the proposed use of wildland fire may cause uncharacteristic levels of mortality.	Proposed action Performance requirements
*Successful aspen regeneration	Aspen may regenerate successfully following treatments, but browsing by elk may limit its recruitment into the overstory.	Alternative action Performance requirements Adaptive management
White pine blister rust	White pine blister rust, an exotic rust fungus, has been found near the preserve.	Performance requirements
Introduction of noxious weeds	Activities and equipment used in restoration can introduce or spread noxious weeds/invasive plants.	Proposed action Performance requirements
Spread of noxious weeds	Treatments adjacent to current populations of weeds could create opportunities for weeds to spread into forest and grasslands.	Performance requirements
Effects from herbicides	Proposed use of herbicides have the potential to directly and indirectly affect composition	Performance requirements Environmental analysis
Climate Change		
Effects to climate	Wildland fire and vegetation management can create greenhouse gases (GHG) and affect the movement and sequestration of carbon.	Proposed action Performance requirements Environmental analysis Adaptive management
Response to climate change	Restoration activities can affect how an ecosystem responds to climate change – both trends and events.	Proposed action Performance requirements Environmental analysis Adaptive management

Issues * Indicates Key Issue	Issue Statement	Response
Habitats and Biodiversity		
*Jemez Mountain salamander habitat	Snags and downed logs provide essential habitat for the Jemez Mountains Salamander (candidate species for listing under the ESA) and many other animals. Restoration treatments provide opportunities protect these features and to increase overall habitat heterogeneity and biodiversity. However, these features are conversely susceptible to destruction from restoration treatments, especially fire.	Performance requirements Adaptive management
Northern goshawk	Prescription guidelines thought to protect or optimize forest structure for the Northern goshawk are complex and difficult to communicate to contractors.	Performance requirements Adaptive management
Direct effects to neotropic migratory birds, northern goshawk, Mexican spotted owl	Forest thinning or prescribed fire activities, aimed at improving and protecting habitat for the species, may pose short-term, negative impacts to individual birds when implemented in the spring.	Performance requirements Environmental analysis
Herbicide use	Herbicides may negatively affect non-target species and aquatic habitats.	Performance requirements Environmental analysis
Soils		
Ground disturbance	Treatment or removal of biomass can affect soils leading to erosion or changes in productivity.	Performance requirements
Fire effects	Fire can affect soils directly and indirectly.	Performance requirements Environmental analysis
Cultural Resources		
Ground disturbance	Restoration activities proposed include direct and indirect actions that may potentially affect cultural resources including the use of fire and ground disturbing activities.	Performance requirements Adaptive management
Fire effects	Burning could damage fire-sensitive cultural resources such as field houses, shrines, and wooden structures and corrals, or alter culturally meaningful forest configurations or other traditional cultural properties.	Performance requirements Adaptive management
Hydrology		
Increased sediment	The proposed action could have short-term impacts to stream condition and water quality, even when long-term benefits are ultimately achieved.	Performance requirements Adaptive management Environmental analysis
Biomass Disposal		
Markets	Market conditions fluctuate creating uncertainty regarding utilization.	Proposed action Adaptive management
Mastication	Long-term impacts of mastication are not well understood.	Performance requirements Adaptive management
Cost Benefit Ratio		
*Costs vs. benefits over time	Costs and benefits vary between treatments	Alternatives
Biomass Disposal	Costs and benefits (monetary and non-monetary) vary between biomass disposal options.	Performance requirements Environmental analysis

Issues * Indicates Key Issue	Issue Statement	Response
Wildland Fire Management		
Smoke	Smoke from prescribed burning has the potentially to affect individuals and communities.	Performance requirements
Firefighter and public safety	Fire and smoke can present a hazard to the public and fire fighters.	Performance requirements
Risk management	Any use of fire includes the risk of escape and wildfire.	Performance requirements
Management actions	Actions used to control fire including construction of control lines and use of hand tools are sometimes unplanned and are ground disturbing.	Performance requirements
Use of chemicals	Aerial retardant used as an emergency control method (unplanned) can affect fish and wildlife, cultural, features, scientific instruments, facilities, and infrastructure. A variety of substances including diesel, gasoline, potassium permanganate, ethylene glycol, as used in incendiary devices and could affect human health.	Performance requirements, environmental analysis
Preserve Operations		
Livestock grazing	Livestock grazing either before or following treatments may negatively affect the success of restoration efforts.	Performance requirements
Public access	Public access and use may negatively affect restoration or monitoring activities.	Performance requirements
Public access	Permanent and temporary monitoring equipment and instrumentation may be vulnerable to theft and vandalism.	Performance requirements
Sensory Resources	Restoration activities may affect the sights and sounds of the preserve.	Performance requirements Environmental analysis
Sensory Resources	Monitoring activities including exclosures and instrumentation may have long-term negative visual effects.	Performance requirements Environmental analysis

2.2.2 Key Issues

As indicated (*) in Table 2-1, we have identified three key issues that were used to develop alternatives and focus our analysis

Successful Aspen Regeneration

There is uncertainty regarding aspen management including whether aspen is declining in the southern Rockies, the precise combination of factors for successful regeneration, and the scale of treatment necessary to overcome browsing by elk.

Under the proposed action, the priority for treatments would be ecosystems adapted to frequent, low intensity fire and forests with the greatest fire behavior potential. While some forests likely to regenerate with aspen would be treated, treatment for the purpose of regenerating aspen would not be prioritized. An alternative restoration strategy is also being considered where the priority for treatments would be ecosystems adapted to frequent, low intensity fire, and forests most likely to respond with aspen regeneration. While some forested areas with higher fire behavior potential would be treated, fire behavior potential would not drive prioritization.

The environmental analysis will take a hard look at the tradeoffs between these two approaches to landscape restoration.

Critical Habitat Characteristics

Snags and downed logs provide essential habitat for many animals, but these features are susceptible to destruction from restoration treatments, especially fire. However, restoration treatments would protect these features from wildfires and provide opportunities to increase habitat heterogeneity and biodiversity.

While mitigation measures are being proposed to reduce the loss of these critical habitat features, some loss of individual features is nearly certain. In a natural forest setting, one would expect moderate degrees of loss to be replaced by future recruitment. However, on the preserve, large and old live trees are nearly as rare as large down logs and snags. Without hazard reduction and restoration actions, recruitment of large and old trees is unlikely and the potential for complete loss of these characteristics to occur in localized context from wildfire continues.

The environmental analysis will predict the potential loss associated with each alternative and monitoring and evaluation actions will be used to verify our predictions and as a basis for adjusting our actions as necessary.

Cost/Benefit

Costs versus benefits received vary between treatments. The environmental impact analysis will provide a prediction of costs and outcomes that will be evaluated through adaptive management.

2.3 Performance Requirements

Performance requirements include laws, policies, procedures, and mitigation measures that guide or constrain our actions. Mitigation measures are best management practices intended to eliminate or reduce the context or intensity of potential adverse impacts on resources or values. Performance requirements apply to all action alternatives.

2.3.1 Laws

- Omnibus Public Lands Management Act of 2009
- Valles Caldera Preservation Act of 2000 as amended
- Endangered Species Act of 1973
- Clean Water Act of 1972 as amended
- Clean Air Act of 1970 as amended
- National Environmental Policy Act of 1969 as amended
- National Historic Preservation Act of 1966 as amended

- The Migratory Bird Treaty Act, signed in 1918, amended in 1936, 1974 and 1989

2.3.2 Policies

- Federal Wildland Fire Management Policy and Implementation Guidelines Interagency (Revised 2009)
- Prescribed Fire Planning and Implementation Guide (Revised 2009)
- NWCG 310-1Wildland Fire Qualifications System Guide (Revised 2009)
- VCT Wildland Fire Management Policy

2.3.3 Procedures

- The National Environmental Policy Act Procedures for the Valles Caldera Trust, Federal Register, July 2003
- VCT Cultural Resource Clearance Process (VCT internal protocol, unpublished)
- VCT Interdisciplinary Clearance Process (VCT internal protocol, unpublished)

2.3.4 Mitigations

The following mitigating measures are designed to reduce the context and intensity of potential adverse impacts or, to optimize potential benefits. The measures are organized by area of impact. Upon the selection of any action alternative, these mitigation measures will be adopted as preserve-wide standards and guidelines.

Vegetation Composition and Structure

- Silvicultural prescriptions and contract specifications for thinning shall include selection (leave tree or cut tree) based on tree form, species, size, and forest structure.
- Sample mechanically treated areas, photos, or sample marked areas can be used to communicate structural objectives regarding “groups” and “clumps”. Other techniques may be incorporated.
- Prescriptions shall emphasize the retention of large[13] and old trees (characteristic bark and crown). Large trees can only be cut if their presence would negatively impact future health and vigor due to genetics or host status (poorly formed, fire intolerant, diseased, mistletoe infected[14], insects); or the location presents a threat to facilities or public safety (hazard trees). If a large tree is cut for these reasons, at minimum 12 feet (measured from the large end) will be left in the woods for habitat.

[13] “Large” is a measure of tree diameter. This EIS defines a large tree (standing live or dead) as having a diameter greater than 16 in. when measured 4.5 feet above the ground on the uphill side (diameter at breast height or dbh); a large log is defined as having a diameter greater than or equal to 12 in. measured at the large end.

[14] Mistletoe infection may be used as criteria for selecting individual trees. We are not proposing to eradicate mistletoe infected trees under the proposed or alternative actions.

- Large trees may be designated for cutting in prescriptions but all such trees must be marked with paint or other impervious method for removal.
- Trees greater than 16” and less than 24” may be marked for removal along roads or landing locations as needed.

❖ Prescriptions shall emphasize the retention of large snags and down logs. A large snag can only be cut if it presents a threat to facilities, or to public or worker safety (hazard trees), or would contribute to control problems during prescribed fire activities. If a large snag is cut for the above reasons, it shall be retained as large down log.

❖ Mechanical and prescribed fire treatments can be implemented in two entries in significantly departed forests based on soils to reduce the intensity of impacts.

❖ Healthy limber pine shall be favored as leave trees. This will ensure the greatest degree of genetic diversity is retained within the limber species and offer protection from white pine blister rust.

❖ Mid- to long-term, small, or large elk exclosures can be erected to allow aspen to mature or facilitate monitoring following treatments.

❖ Monitoring treatments in aspen forests shall include:
- Restoration in aspen forests in stands heavily overtopped by conifers.
- Restoration in pure aspen stands that are dying.
- Restoration in diseased aspen stands.

Vegetation Management Following Unplanned Events (insects, wind throw, wildland fire, disease)

❖ All performance requirements shall apply to areas treated in response to an unplanned event.

❖ The following, additional requirements will also apply:
- On slopes less than or equal to 30 percent where mastication or removal of killed trees is occurring, five large (or largest available) logs per acre shall be left for wildlife.

Noxious Weed Prevention and Control

❖ For all projects resulting in ground disturbance, the ICP document, contract, or agreement must identify noxious weed control measures that must be undertaken during project implementation.

❖ Measures taken to avoid the spread of noxious weeds through operations would include but may not be limited to:
- When the risk of spread is moderate or high (Appendix B), noxious weed treatment would be required prior to project implementation.
- The occurrence of noxious weeds either within or in close proximity to a project area shall be identified during operational planning.
- All ground disturbing activities in areas known to have current or recent populations of non-native thistles shall take place before flower buds appear on the plants so seeds are not spread by the wind.
- Establish plant cover and increase recovery on all heavily disturbed areas as needed such as decommissioned roads, landings, and main skid trails by the following methods: (1) Seed

with native grass seed and non-persistent/non-allopathic cereal grains, (2) place fine and coarse slash material as mulch, and/or (3) increase soil porosity by ripping.

- To prevent the spread of noxious weed species, construction equipment shall be cleaned of dirt and mud that could contain weed seeds, roots, rhizomes, or other plant propagative parts. The tracks, feet, tires, and undercarriage shall be carefully washed, and special attention shall be paid to axles, frame, cross members, motor mounts, underneath steps, running boards, and front bumper/brush guard assemblies.
- Prior to entering the preserve, equipment shall be inspected to ensure they are free of any dirt or mud that could contain weed seeds, and any plant propagative parts.
- Other construction vehicles (e.g. pick-up trucks) that shall be frequently entering and exiting the site shall be inspected and washed on an as-needed basis.
- Equipment cleaning shall be included in contracts, agreements, and other operational plans in order to reduce introduction of weeds to and transport from the project area by removing dirt, plant parts, and material that may carry weed seeds.
- Vehicles and equipment used in known weed infested areas shall be washed before leaving the work area.
  - Cleaning stations would use either high-pressure water or air to remove dirt and mud from equipment and vehicles.
  - Use certified weed free sources of seeds and other plant material for revegetation and erosion control. Use local seed when possible.
  - Gravel used for road maintenance (if needed) shall be weed free. Use local gravel sources when possible.
  - Certify all mulching agents such as hay or straw as weed free. Create mulch from on-site material when possible.
  - Use weed free sources of feed for preserve horses.
  - Livestock that shall graze on the VCNP should be held in a single pasture for at least three days so that any weed seeds within their digestive systems may pass in a contained area before livestock are turned out to pasture (Rounds 1998).
- Livestock to be housed and grazed on the preserve shall be fed feed that is certified as weed free for at least three days prior to entry.
- Only certified noxious weed free feed shall be used on the VCNP.
- Certified noxious weed free hay must be identified by one of the following:
  - State certification tag attached to the bale string;
    - Forage Tag Minimum Requirements:
    - The words “North American Weed Free Forage Certification Program".
    - A number system (for tracking purposes).
    - Province/state of issue.
    - Province/state telephone number (responsible official).
    - A statement that the product is "Certified to the North American Standards".
  - At least one strand of purple and yellow (intertwined) bale twine encircling the bale; blue and orange (intertwined) bale twine encircling the bale; or other colored twine encircling the bale that is used to designate certified forage.

- Certified noxious-weed-free compressed forage bales are identified by yellow binding (strapping) material with the statement "ISDA NWFFS" and the manufacturer's name printed in purple.
- Certified noxious-weed-free forage in bags is identified by a stamp, sticker, or printing on the bag identifying it as certified forage.

Herbicide Use

- Use only U.S. EPA-approved herbicides, following all label directions and “advisory” statements for application, transport and storage.
- Select and apply herbicides products to minimize additional impacts from degradates, adjuvates, inert ingredients and tank mixtures.
- Herbicide applications shall target only classified noxious weeds.
- Target plants are to be sprayed by wetting exposed surfaces and avoiding non-target plants.
- Only licensed personnel may apply herbicides.
- Contract and Federal workers are required to meet Federal Worker Protection Standards (40 CFR Part 170) and existing State of New Mexico Regulations, including the use of protective clothing. Safety procedures and Material Safety Data Sheets must be reviewed by personnel prior to herbicide applications.
- Procedures for spill cleanup and emergencies must be established by the project leader and conveyed to each applicator prior to fieldwork.
- When no aquatic label is available, an herbicide shall not be applied in a wet or riparian area or where it could be washed into a wet or riparian area.
- All storage, mixing, or backpack refilling of herbicides must be located away from open water in a central location.
- Individual spray containers must be filled from a single source and may be transported to the weed infestation sites by motor vehicle if secured in transport.
- If an “area” as opposed to an individual plant is sprayed or if herbicide is applied to a trail or similar area where access by people is likely then human access to the treatment area will be restricted until the spray solution has completely dried.
- Avoid spraying on windy days.
- Record application – both spatial and operational data.

Habitats and Biodiversity

- Best Management Practices for the protection of Jemez Mountains Salamander (JMS) are being collaboratively developed. Once finalized, these practices shall be incorporated as performance requirements.
- Designated habitat for JMS shall be considered occupied for the purpose of implementing performance requirements.
- A portion of coniferous logs at least 12 in. in diameter at the large end felled during thinning, particularly Douglas fir will be left on site.

- Existing logs at least 12 in. diameter at the large end which are in contact with the soil in varying stages of decay from freshly fallen to nearly fully decomposed will be left on site.
- Heavy equipment use will be avoided within:
  - Structural features, such as rocks, bark, and moss mats that provide the species with food and cover will be avoided with heavy equipment.
  - Underground habitat in forest or meadow areas containing interstitial spaces provided by:
    - Igneous rock with fractures or loose rocky soils;
    - Rotted tree root channels; or
    - Burrows of rodents or large invertebrates.
- Prescription parameters shall leave canopy closure at greater than or equal to 50 percent in designated habitat.
- Use of heavy equipment/ground disturbing activities shall be curtailed in designated JMS habitat during the summer monsoonal season.
- Prescribed burn plans shall include the following to protect large down woody debris including stumps and snags.
  - Prescription parameters that minimize consumption of large down woody debris.
  - Lighting techniques that reduce the ignition of large down woody debris and snags.
  - Pre-burn treatments such as removing concentrations of fuel surrounding large woody debris and snags.
  - Pile burning shall be curtailed when JMS could be directly impacted i.e. piles are on likely salamander locations, within designated habitat, conditions are saturated, and salamanders could be active (spring, summer, or early fall).
- A 300-foot aerial retardant avoidance buffer shall be applied to waterways, wet meadows, and wetlands. The only exception to the application of aerial retardant within the mapped avoidance area is for the protection of firefighter or public safety (USDA - Forest Service, 2012).
- Proposed management activities planned within suitable nesting/breeding habitat for Mexican spotted owls and northern goshawk should occur October 1 through February 28 to avoid disturbance during breeding season. If surveys (goshawk, Mexican spotted owl), according to protocol, are done in May/June and were negative for response, and no nests are discovered, then management activities can proceed with no seasonal restrictions.
- Appropriate seasonal restrictions for wildlife (Jemez Mountains Salamanders, Mexican spotted owls, neotropic migratory birds, northern goshawk) shall be considered and documented within the interdisciplinary clearance process for project activities.
- Plans to capture birds, reptiles, rodents, fish, and mammals for research, inventory, or monitoring shall identify mitigation measures to ensure actions are humane.

Soil and Erosion

- Action alternatives identify activities appropriate on various soil types and slopes based on mapping. Any finer scale assessment that would permit a treatment on an area mapped otherwise unsuitable must be documented in the ICP.
- Hazard reduction or other less intensive thinning prescriptions shall be used in lieu of restoration prescriptions on steeper slopes and sensitive soils.

- Effects resulting from on-site mastication are not well known – may be adverse and/or beneficial.
  - Where practical, remove a portion of the biomass prior to mastication.
  - Thinning intensity may be limited to reduce the amount of biomass created.
  - Where practical, masticate only a portion of the biomass (i.e. only tops and branches or only material under 6 in. diameter).
  - Mulching or masticating equipment should be set to operate no closer than 3”to the ground surface.
  - Where practical, move biomass to roadbed or other currently unproductive site for mastication.
  - Incorporate new mitigating measures, as new information is available.
- Only tops and branches or material less than or equal to 6 in. diameter at the large end should be burned in piles.
- No heavy equipment is to be operated on slopes greater than 30 percent.
- Requests for proposals and contract award criterion shall favor awards to practices and equipment that reduce impacts to soils where practicable.
- Biomass removal performance requirements:
  - Skidding or dragging logs and slash should be minimized; thinned material should be elevated off the ground where practicable.
  - Contracts shall provide for the designation of trails and roads and other mitigations to limit the context and intensity of equipment impacts.
  - Contracts shall include parameters for curtailing equipment use based on moisture and soils including limiting operations to dry or frozen ground when appropriate.
- Prescribed fire burn plans shall include prescription parameters to reduce impacts to soils
  - Prescriptions to limit consumption of duff
  - Prescription parameters to limit hydrophobicity
  - Removing or rearranging (lopping and scattering) fuels prior to prescribed burning
  - Ignition patterns to reduce fire intensity and consumption
- Road management activities shall include BMP’s (best management practices) to limit short term impacts to soils including:
  - Erosion control plan
  - Timing of construction activities
  - Road slope stabilization
  - Control of road drainage
  - Maintenance of roads
  - Control of sidecast material
  - Traffic control during wet periods
  - Timely erosion control measures on incomplete roads and water crossings
  - Road Surface Treatment to prevent loss of materials
  - Construction of stable embankments (fills)
  - Restoration of borrow pits and quarries

Cultural Resources

- The VCT Cultural Resources Compliance Process (CRCP) shall be completed prior to on-the-ground implementation of any ground disturbing activity (any scale).
  - Identify and implement Tribal consultation requirements
  - Identify and implement inventory requirements.
  - Identify and implement site-specific protection measures in addition to performance requirements.
- The following general recommendation shall be applied to all mechanical treatment unless otherwise stated in the CRCP:
  - Significant sites shall be avoided by: ground based equipment (hand thinning would be permitted), piling or stockpiling logs or slash, skid trail identification, mechanized removal of forest products, parking or driving vehicles, staging equipment.
  - Trees shall be directionally felled away from sites features.
  - Thinned material shall be carried off site.
  - Site boundaries shall be clearly marked with while tape, white flagging, or t-posts.
  - All activities shall be restricted to the areas surveyed and cleared. Changes to a project boundary must be surveyed and cleared prior to implementation.
- The following general recommendations shall be applied to all planned ignitions of wildland fire unless otherwise stated in the CRCP:
  - Surveys shall identify fire sensitive cultural resources
  - CRCP completed for planned ignitions shall address connected activities (parking, staging of vehicles and equipment, construction of control lines or fuelbreaks etc.)
  - Briefings shall include necessary maps and information to ensure personnel can avoid activities in or on sites.
  - Prescriptions shall be developed to limit consumption of duff where subsurface artifacts are likely.
  - Removing or rearranging fuels within cultural resource sites prior to burning to reduce fire severity.
  - Ignition patterns to reduce fire severity.
- Known cultural resources likely to be damaged by the aerial delivery of retardant have been included on the mapped avoidance areas (Appendix XX) as points where the direct delivery of retardant should be avoided.

Water Quality and Riparian Habitats

- Use hand tools including chainsaws in lieu of heavy equipment in riparian areas.
- Where heavy equipment is being used to restore stream channels, create water-crossings, decommission roads, create exclosures, or other beneficial restoration work, project plans shall specify access, rehabilitation, and short-term actions to minimize erosion.
- When closing, maintaining, or decommissioning roads on hill slopes or former wet meadows the roadbed should be out sloped to allow water to drain evenly across the road.
- Bar ditching and use of culverts to drain the uphill sides of roads should be avoided and replaced by outsloping, and using rolling dips to improve drainage.
- Road management activities shall include best management practices to limit short term impacts to soils including:

- Erosion control plan
- Timing of construction activities
- Road slope stabilization
- Control of road drainage
- Maintenance of roads
- Control of sidecast material
- Traffic control during wet periods
- Timely erosion control measures on incomplete roads and water crossings
- Road Surface Treatment to prevent loss of materials
- Construction of stable embankments (fills)
- Restoration of borrow pits and quarries

❖ Where streamside vegetation is likely to burn in a prescribed fire, the prescribed burn plan shall include mitigating measures such as:
  - Prescription parameters for live fuel moisture content or "greenness" of riparian vegetation.
  - Ignition patterns to limit spread of fire in riparian areas.
  - Buffers to keep fire outside of riparian areas.

❖ The application of aerial retardant in or within 300 feet of waterways, wet meadows, or wetlands will only be permitted when human life or safety is threatened and the application of aerial retardant is reasonably likely to alleviate that threat.

Air Quality

❖ Planned ignitions of wildland fire shall include prescription parameters designed to reduce the consumption of large woody debris and duff.

❖ Biomass piled for burning shall limit the size of piled material to a maximum of 6 in. diameter at the large end.

❖ Prescribed burn notifications will be distributed seasonally or two weeks prior to ignition.

Socioeconomic Benefits/Impacts to Local Businesses and Communities

❖ Requests for proposals and contract bids shall incorporate methods to value benefits to local businesses and communities as practical, lawful, and consistent with over all competitiveness and efficiencies.

❖ Mechanical treatments should consider suitability for removal in selecting treatment areas.

❖ Consider opportunities for public firewood use and Christmas tree removal prior to prescribed burning.

❖ Collaboration with the SWJML and other governmental and non-governmental entities should continue in order to expand outreach regarding potential utilization opportunities.

❖ Access and egress through Elk Valley subdivision (i.e. Sulphur Gate) will be avoided; contracts will require access and egress through either Redondo Meadows, Banco Bonito, or Valle Grande entrances.
  - Exceptions may occur where other points of access are not practicable. Such exceptions will include the following mitigations:
    - Notice

    - Limited times/days
    - Dust abatement if warranted
    - Road maintenance if warranted
    - Climate Change
- Environmental consequences and comparisons are based on current information and assumptions and reasonable predictions. The ICP shall be used to affirm that new information does not significantly alter the assumptions of this analysis.
- Prescription parameters addressing structure, composition, prescribed fire season, and environmental parameters shall consider changing climate and incorporate new information.

Wildland Fire Management

- Prescribed fire shall be planned and implemented in compliance with the Interagency Prescribed Fire Planning and Implementation Guide (USDA/USDOI, 2008).
- Prescribed burn plans shall include the following elements:
    - Description of the prescribed fire area and maps
    - Environmental prescription and parameters
    - Burn objectives and fire behavior prescription and parameters
    - Complexity analysis
    - Personnel organization, qualifications, and assignments
    - Communications plan
    - Ignition plan
    - Monitoring plan
    - Holding Plan
    - Contingency Plan and Assignments
    - Safety and Medical Plan
    - Wildfire Conversion
    - If aerial ignition devices shall be used, include an aerial ignition plan

Managing Preserve Activities

- Livestock grazing may be restricted in time and place to promote the success of restoration and monitoring activities.
- Public access may be restricted in time or place to promote the success of restoration and monitoring activities or to protect equipment and instruments.
- Public access may be restricted in time or place to provide for public safety.
- The public shall be informed about ongoing restoration activities that may affect the quality of their recreation experience.
- Restoration activities may be restricted on holidays, weekends, or special events when they would adversely affect the quality of visitors' experience or impact public safety.

Sensory Resources

- Mitigate visual impacts of prescribed fire in major views:
    - Limit patches of mortality by using mechanical treatments in combination with prescribed fire or by adjusting ignition patterns.

- Burn in the fall when second order fire effects are less likely to lead to mortality in mature trees (USDA - Forest Service, 2000).
- Provide information to the public to explain the intensity and expected duration of visual effects from prescribed fire.

❖ Mitigate visual impacts to the landscape from forest thinning:
- Edges of treatment units will be shaped and/or feathered to avoid abrupt changes between treated and untreated areas.
- Where the treatment unit is adjacent to denser forest (treated or untreated), the percent of thinning within the transition zone (150-250 feet) will be progressively reduced toward the denser edges of the unit.
- Similarly, where the treatment unit interfaces with an opening (including savannah and grassland treatments, and natural openings) the transition zone will progressively increase toward the open edges of the unit.
- Treat up to the edges; do not leave a screen of trees. Favor groups of trees complying with the prescribed treatment that visually connect with the unit's edge to avoid an abrupt and noticeable change.
- Treatment boundaries should extend up and over ridgelines to avoid the "Mohawk" look.
- Thinning treatments shall include biomass disposal.
- Stump height will not exceed 6" measured from the ground on the uphill side or 4" above natural obstacles. This height should be further reduced along trails or scenic routes. The cut side of a stump should be angled away from roads or trails.
- Landing locations will be rehabilitated using slash and logs scattered in an irregular pattern; local grass seed can be collected and scattered as needed.

❖ Locate monitoring exclosures and instrumentation to minimize impacts to views.

❖ Concentrate instrumentation and exclosures of monitoring in a single footprint where possible.

❖ Provide information to the public regarding the purpose of exclosures and instrumentation.

❖ Off-road vehicle access shall occur only under dry or frozen conditions.

❖ Minimize any off-road vehicle access to monitoring sites to what is necessary to transport supplies and equipment.

❖ Utilize ramps or bridges for any necessary water crossings by vehicles or equipment.

2.4 Alternatives Considered but Eliminated from Detailed Analysis

A wide range of actions were considered but then eliminated from detailed analysis based on technical or economic feasibility and whether or not they met the purpose and need for action. A brief description of these alternatives and the rationale for eliminating them from detailed analysis is provided below.

2.4.1 Wildland Fire Management Only

We considered wildland fire management as the only tool for restoration and management of the forest, grassland, and woodland ecosystems. Based on detailed assessments of the current condition, we

determined that this alternative was not technically feasible and would not meet the purpose and need for action.

In the current condition, there would be such a narrow set of environmental parameters where it would be safe and effective to ignite prescribed fire or manage natural fire that it would be unlikely that the use of fire alone would measurably move the current condition towards the reference condition in a ten-year period. Further, while managing fire-adapted forests with prescribed fire is often the least expensive option to reduce hazardous fuels[15] when utilization opportunities are limited, there are many areas and times where prescribed fire cannot be used. High fuel loadings, air quality restrictions, short windows of appropriate weather, and risk of escaped fire are some of the factors that limit application of prescribed fire (USDA - Forest Service, 2005).

2.4.2 Less Mechanical Treatment

We considered limiting mechanical treatments just to the degree necessary to improve the safety of wildland fire management. This alternative may be less costly (USDA - Forest Service, 2005) and would address concerns from the public such as, "*Mechanical thinning sounds like logging companies being allowed to come in under the guise of "thinning" the trees*" (Martinez, 2010).

We determined that this alternative would not meet the purpose and need for action in forest types adapted to frequent fire regimes (ponderosa pine and dry-mesic mixed conifer). Fire alone can improve the resilience of these forests and reduce hazardous fuels but would not move the structure towards the reference condition. Further, less intensive thinning can reduce the intensity of fire behavior but is not effective at reducing crown fire potential at the landscape scale (Fiedler, et al., 2001).

2.4.3 More Intensive Use of Mechanical Treatment

We considered emphasizing mechanical treatments in all forest types, slopes, and elevations to more precisely restore forest structure. This alternative was not considered to be economically feasible at a cost of $50,000,000[16] over 10 years depending on slope, access and forest condition) relative to the benefits received.

2.4.4 Salvage Logging Following Fire, Insects, and Disease Events

There is a very short window following high severity fires where the dead and dying trees can be valuable as wood products. Following the Las Conchas fire, we looked at the potential to salvage the potential economic value in the burned area as well as establishing guidelines for salvaging timber in the future. The purpose of salvage logging is to capture potential economic value; the purpose of the proposed LRMP is to restore ecosystem structure and function and to reduce current and future threats. Mechanical treatment in a burned area for the purpose of restoration is included in the proposed action. Burned area restoration would not cut and remove large trees except where needed for the protection

[15] Hazardous fuels are live and dead vegetation that could be difficult to control if ignited.

[16] Assuming treatment costs of $600-$1200 per acre

of people and infrastructure. Removing hazard trees near roads, trails, or facilities are examples of where larger trees may be cut.

Any salvage logging in the Las Conchas or any future burned area for the purpose of recovering any potential economic value, would be considered as a separate action and require additional analysis under NEPA.

2.4.5 Capping the Diameter of Cut-trees

Because forest inventories found few large and old trees it was reasonable to consider a diameter cap on trees to be cut to ensure that any remaining large and old trees are protected. However, a diameter cap could limit our ability to achieve both hazard reduction and forest health[17] objectives.

Removal of seedlings and saplings is important to reduce ladder fuels and reduce the potential for crown fire to initiate. However, thinning only small material does little to reduce crown fire spread (Ohara, 2009; USDA - Forest Service, 2005; Fiedler, et al., 2001; Keyes and O'Hara, 2002). Fiedler and others (2001) found that a comprehensive selection treatment, removing some trees from all diameter classes, had a more significant effect on reducing measures of crown fire potential than removing only small trees.

We determined that large and old trees could be protected by the application of mitigating measures, which limit the circumstances where trees over 16 in. diameter would be cut. In addition, all proposed treatments aim to protect large and old trees and increasing their abundance on the landscape over time.

2.4.6 Removing Limitations to Cutting Large Trees

As previously stated, comprehensive prescriptions which include all class sizes have been found to have more significant effect on reducing measures of crown fire potential than removing only small trees (Fiedler, et al., 2001). We defined large trees and placed limitations on the circumstances where they could be cut for two reasons:

1. Our inventories showed consistently that 16 in. diameter was the breaking point at which the number of trees per acre dropped off dramatically, and that the 9-16 in. diameter class was the dominant cover class in all forest types. Having this cut-off allows us to primarily describe (as opposed to physically marking) the trees to be left versus those to be cut and increases the technical and economic efficiency of treating large heterogeneous areas.

2. Protecting large and old trees is a requirement of the restoration strategy (Valles Caldera Trust, Santa Fe National Forest, 2010), the Collaborative Forest Landscape Restoration Program (CFLRP) established under section 4003(a) of Title IV of the Omnibus Public Land Management Act of

[17] For the purpose of this EIS, "forest health" is used to indicate a forested area where trees are growing vigorously and for the most part are well formed and not excessively impacted by insects, disease, or competition.

2009, and perhaps most importantly, the New Mexico Forest Restoration Principles (New Mexico Biomass Evaluation Taskforce, n.d.).

These principles were collaboratively developed by a team of dedicated professionals representing conservation organizations, land management agencies, industry, and independent scientists. The intent was that these principles for restoration should be used as guidelines for project development and they represent the "zone of agreement" where controversy, delays, appeals, and litigation are significantly reduced. The principles included that, *"It is generally advisable to maintain ponderosa pines larger than 41 cm (16 inches) diameter at breast height (dbh) and other trees with old-growth morphology regardless of size (e.g. yellow-barked ponderosa pine or any species with large drooping limbs, twisted trunks or flattened tops).*"

We believe that applying 16 in. diameter as a cut-off for limiting when a tree could be cut provides us with adequate flexibility to adjust prescriptions at the stand level while ensuring that collaborative agreements are kept and jointly developed principles are adhered to at the landscape level.

2.4.7 Eradication of Non-native Plants Other than Classified Noxious Weeds

Approximately 10 percent of all herbaceous species found on the preserve are non-native European pasture grasses, which affect the overall resiliency of the grasslands (Valles Caldera Trust, 2009). While we considered eliminating non-native grasses, this alternative is not technically feasible. Any measures to eradicate these species would likely be equally detrimental to native species. All action alternatives manage for the benefit of native species and include native species cover and diversity as monitored outcomes.

2.4.8 Using Only Non-chemical Methods to Eradicate Noxious Weeds

Biological, mechanical, and chemical methods are all commonly used to eradicate noxious weeds. Public comments indicated a concern regarding the application of herbicides in wildland environments. In the development of the proposed action, we considered mechanical and biological methods along with chemical treatments.

Eliminating chemical methods would not meet the purpose and need for action. Some weeds such as Canada thistle and other rhizomes actually spread when treated mechanically (hoeing, grubbing, herbivory, etc.). The use of biological controls, such as insects and or pathogens, has not proven to be an effective method of controlling or eradicating Canada, musk, or bull thistle (Valles Caldera Trust, 2003, Reviewed 2008, 2010).

Two insects are available to control Canada thistle, *Ceutorhyncus litura* and *Urophora cardui* and are available from the Colorado Department of Agriculture. These insects may be quite effective in croplands where they could be combined with cultural practices such as planting alfalfa or other highly competitive crops (practices that are limited on native rangelands). They are generally not effective when used as a sole control (Duncan and Brown, 2001).

The rosette weevil is can be effective on bull thistle but requires 10-12 years to reach a population level that can be considered effective (Beck, 2011).

While grazing or mowing in the early spring or late fall can effectively reduce cheatgrass, the location of cheatgrass on the preserve is primarily limited to road cuts. Concentrating cattle along these isolated areas is not feasible. Further, livestock grazing on the preserve begins later in the season than is recommended for effective reduction of cheatgrass.

Action alternatives emphasize the use of non-chemical treatments where they can be effective and include performance requirements to eliminate or mitigate any adverse effects from herbicides.

2.4.9 Wildlife Management Actions

Several fisheries and wildlife species have been extirpated from their range in the preserve and/or Jemez Mountains or had their range significantly reduced over the last century. These species include (but are not limited to) New Mexico meadow jumping mouse *Zapus hudsonius luteus*, Mexican gray wolf (*Canis lupus baileyi)*, Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), northern leopard frog (*Lithobates pipiens)*, and American beaver (*Castor canadensis)*. Further, the current population of elk, a result of reintroduction, is thought to be significantly higher than any historic population and is affecting both vegetation and riparian conditions (Valles Caldera Trust, 2009). While the IDT considered actions to directly manage wildlife populations, recreating historic (reference) faunal assemblages is outside the scope of this action which focuses on restoring and managing the terrestrial and aquatic habitats for all species. However, it is likely and desirable that extirpated species such as beaver would naturally return to the preserve as habitats are created and sustained. While such reintroduction is outside the scope of this analysis, the reintroduction of any species could be considered on a case-by-case basis following the appropriate level of environmental analysis and public involvement. For example, introductions of New Mexico meadow jumping mouse and northern leopard frog could be incorporated into habitat monitoring and evaluation and would be within the scope of this analysis. The introduction of species such as Rio Grande cutthroat trout could be done on a limited basis as part of habitat monitoring, however alternations of habitat such as constructing fish barriers and/or eradicating other trout species would require additional analysis and documentation under NEPA.

Figure 2-1. Wildlife species extirpated from the preserve shown clockwise from top, left: New Mexico meadow jumping mouse, Mexican grey wolf, northern leopard frog, American beaver, Rio Grande cutthroat trout

2.5 No Action Alternative

The NEPA requires that the "no action" alternative be analyzed in detail. It serves as a baseline for measuring the environmental consequences, costs, and benefits of the action alternatives and ensures that federal actions, and the associated investments, are warranted.

Under Alternative 1 – *No Action* there would be no decisions regarding landscape restoration or management of the preserve's natural resources. Actions covered under existing Stewardship Registers (http://www.vallescaldera.gov/stewardship/vctdevmain.aspx) would continue including:

- Ongoing thinning and follow-up prescribed burning.

- Annual inventory and eradication of Canada, musk and bull thistle; and oxeye daisy.
- Riparian and wetland restoration in San Antonio and Sulphur watersheds and repair of earthen tanks and other historic range infrastructure.
- Routine road maintenance and repair preserve-wide, and road management currently proposed in San Antonio and Sulphur watersheds.

2.6 Action Alternatives

Besides *Alternative 1 – No Action*, two action alternatives are being considered and compared in the detailed impact analysis. *Alternative 2 – Collaborative Forest Restoration* – selects forest stands for treatment based on the degree of ecological departure and current fire behavior potential. *Alternative 3 – Aspen Restoration* – selects forest stands for treatment based on the degree of ecological departure and the potential for treatments to stimulate aspen regeneration.

2.6.1 Restoration Activities Common to All Action Alternatives

Both alternatives propose a similar suite of restoration activities including forest thinning, wildland fire management, riparian and wetland restoration, post wildfire rehabilitation, road closure, decommissioning, and maintenance and erosion control; noxious weed eradication, and research, inventory, and monitoring. Descriptions of the proposed restoration activities that comprise the action alternatives are presented in Table 2-2 below; narrative descriptions follow.

Table 2-2. Restoration Activities

Activity	Code	Description
Forest Thinning		Directly managing forest and woodland vegetation
Mechanical Thinning	MECH	Cutting or pruning smaller diameter trees (0-16" diameter) using mechanized heavy equipment
Manual (Chainsaw) Thinning	MANU	Thinning individual trees manually using a chainsaw.
Non-mechanical Thinning	NOME	Using non mechanical methods means to thin forest and woodland vegetation such as goats.
Biomass Disposal		Cutting or pruning trees requires a connected biomass disposal activity.
Biomass Disposal Utilization	BDUT	Removal for subsequent utilization by: *yarding* (to pull partially or fully suspended logs or trees) or *skidding* (to drag or carry logs or trees) biomass to a road or landing point.
Biomass Disposal Mastication	BDMA	Masticating or chipping and leaving the biomass on site; some equipment is capable of thinning and masticating trees simultaneously.
Biomass Disposal Hand Piling	BDHP BDMP	Piling biomass (hand piling, HP or machine piling, MP) for burning under low risk conditions.
Biomass Disposal Lop and Scatter	BDLS	Cutting and spreading the biomass to reduce the height, increase the compaction of the fuel bed, and to break up concentrations of fuel.
Biomass Disposal Prescribed Fire	BDPF	Planned ignitions of wildland fire may be used alone or in combination with any other BD method.
Wildland Fire Management		Includes the management of both planned and unplanned ignitions to achieve objectives for resource management or protection.
Wildland Fire - Prescribed Fire	WFPF	Planned ignition of wildland fire under prescribed environmental conditions (prescribed fire) may be used to achieve resource benefits including biomass disposal. Planned ignitions may be used alone or in combination with mechanical treatments (see BDPF above).
Wildland Fire – Wildfire	WFWF	Unplanned ignitions can be suppressed to meet protection objectives or managed for resource objectives or some combination thereof. Only lighting caused fires can be managed for resource objectives and only if environmental and other conditions are appropriate. Unplanned human caused fires are managed with safety and protection[a] as the primary objectives.
Road Management		Includes the administrative and physical closure and decommissioning as well as the repair and maintenance of roads.
Administrative Closure	RMAC	Prohibiting motorized use of a road to encourage natural revegetation. This action may include the placement of barriers. Non-motorized (pedestrian, equestrian, or bicycle) use may be permitted.
Closure and Decommissioning	RMCD	Physical road rehabilitation to promote natural revegetation. Activities may include the placement of biomass or may require creating drainage or installing culverts.

Activity	Code	Description
Road Maintenance	RMRM	Maintenance and deferred maintenance on open roads. Includes road grading, reconstruction of the road prism, and construction of drainage features such as lead out ditches and the placement (or replacement) of culverts. May include realignment to improve safety or protect resources.
Watershed Restoration		Activities (other than road management) to protect or restore riparian and wetland areas or watershed function. Commonly employed activities are planting, placing sod, erecting fences or barriers, placing structures to reduce the energy of flow, heavy equipment may be used to remove man made impoundments, to restore previously diverted stream courses, or address localized erosion in riparian or upland environments.
Riparian Restoration	WRRR	"Low tech" actions that support natural rehabilitation as well as manipulative actions that directly restore habitats and riparian function.
Wetland Restoration	WRWR	Restoring wetlands generally requires restoring a source of watering and involve low tech as well as manipulative actions.
Erosion Control	ERCO	Activities other than road maintenance to prevent, control, or halt erosion.
Noxious Weed Control	NWCO	Eradicating noxious weeds using mechanical or biological methods or herbicides.
Research, Inventory, Monitoring and Evaluation	RIME	Measuring structure, composition, and function of various ecosystems at various scales including collecting samples using non-destructive[b] and destructive methods, establishing temporary and permanent instrumentation and/or exclosures, and providing temporary and/ or limited administrative access.

a – Protection strategies are based on current and predicted conditions, values at risk, cost effectiveness and other considerations. Public and fire fighter safety is always the first consideration when selecting the appropriate response to any unplanned ignition or the management of any planned ignition.
b - "Nondestructive sampling" means measuring an element such as vegetation, in situ and leaving it intact. Capturing animals and taking measures, attaching collars or transmitters and releasing the animals is non-destructive. "Destructive sampling" generally refers to any action where the element is removed or destroyed and cannot be re-measured. Cutting down snags, capturing and killing or removing animals, removing plants are all destructive methods of sampling.

Forest Thinning

This EIS considers the direct, indirect, and connected activities associated with forest thinning as well as the various prescription guidelines that would determine the intensity and design of forest thinning. Prescription guidelines are applied based on forest type and site-specific objectives.

Forest Thinning – Direct Indirect and Connected Activities

Forest thinning is primarily a mechanical endeavor involving heavy equipment as well as chainsaws. Forest thinning also includes additional, connected activities in order to access the project area and to dispose of the biomass created by the thinning. The activities that can be connected to mechanical treatment include:

- Cutting trees using a chainsaw operated by hand or mounted on specialized equipment
- Cutting trees using heavy equipment.
- Yarding or skidding trees from the forest to a landing site for removal (as chips, logs, firewood, etc.)
- Masticating standing trees or pushing over and masticating trees on the ground
- Leaving the material on site
- Removing the chipped material
- Lopping off and piling or spreading tops and branches of trees
- Removal as firewood by individuals with pickups
- Stockpiling logs or slash for removal or disposal (burning or chipping)
- Constructing fenced exclosures to protect restored areas from impacts by elk or livestock.
- Camping by crews or contractors
- Improving or maintaining roads for temporary access
- Construction of up to 1320’ of new temporary roads
- Closing and rehabilitating temporary roads and/or skid trails

Forest Thinning – Prescription Guidelines

Mechanical treatments can be used in various prescriptions (intensity and design) to achieve the desired outcome. Proposed prescriptions have been developed based on fire regime, vegetation type, current fire behavior potential[18], current structure and composition, slope, soils, and climate and/or the desired outcome following treatment. Prescriptions and guidelines for mechanical treatment are presented in Table 2-3.

[18] Each forest stand is attributed with a fire potential rating based on a scale of 1-6. See *Chapter 4 – Affected Environment.*

Table 2-3. Prescriptions and guidelines for forest thinning

Prescription	Code	Guidelines
Restoration	REST	Reduce canopy closure to 30-60 percent over a landscape area with a target Basal Area (BA) of 40-75 $ft^{2.}$ Leave groups and clumps representing all age classes. Select trees based on size, species, and vigor.
Aspen Regeneration	ASRE	Target conifer species growing in and adjacent to aspen trees. Removal of individual trees and group selection with a target BA of 40-60 $ft^{2.}$ May include openings ranging from ½ to 3 acres.
Forest Health	FOHE	Reduce tree densities, remove suppressed, damaged, or diseased trees; and reduce hazardous fuels (remove ladder fuels, break up surface and canopy fuel continuity, raise canopy base height) with a target BA of 50 -80 $ft^{2.}$
Hazardous Fuels Reduction	HFRE	Remove ladder fuels[a], disrupt the continuity of canopy and surface fuels, and raise canopy base height with a target BA of 60-95 $ft^{2.}$
Wildland Fire Control	Wildland Fire Control	Reduce canopy closure to 30 to 50 percent in a localized area; size of treatment area based on slope and fuels and may vary in intensity. Strategically located to provide an anchor for wildland fire management.

a - Ladder fuels are small trees, brush, or slash that provide a "ladder" for fire to move from the ground to the forest canopy.

Forest Thinning – Prescriptions by Ecotype

"Prescription" is the term used to refer to the descriptive parameters for selecting trees to be cut versus those to be left. The trust is proposing a series of basic prescriptions based on fire regime and ecotype. These thinning prescriptions would be classified silviculturally, as *variable density thinning*, where cut trees are selected primarily from the lower crown classes with other characteristics (species, form, vigor) also given consideration (Hunter, et al., 2007). These prescriptions may be adjusted based on site-specific considerations including access, slope, and soils as these factors may limit our ability to remove or otherwise dispose of biomass. Where our ability to remove biomass is limited, a less intensive prescription and/or multiple entries may be used.

Fire Regime I - Ponderosa Pine Woodland and Savanna, Dry Mixed Conifer

REST - This prescription leaves the largest and healthiest trees in groups with 10-20 feet between tree canopies and 25-50 feet between groups of trees (see Figure 2-2). The largest (> 16 in. diameter) and most vigorous ponderosa pine and Douglas-fir as well as inclusions of aspen would be favored for retention. Based on field-sampled data, white fir and ponderosa pine would be targeted for removal; the majority of the white fir trees are under 7 in. diameter.

Figure 2-2. A closed mid-aged ponderosa pine forest thinned using a restoration prescription. Residual stand is an open mid-aged forest.

Fire Regime I - Montane Grasslands

REST - A restoration prescription would be assigned where ponderosa pine ponderosa pine trees are encroaching into the grasslands. Prescriptions would call for retaining small well-spaced groups (60-100 feet between groups) of the largest (> 16 in. diameter), and healthiest trees (see Figure 2-3 below). Where blue spruce trees are encroaching, trees average from 7-9 in. diameter. The blue spruce would be lightly thinned in an irregular pattern to reduce the susceptibility to wind throw and protect soils, while enhancing watershed function.

Figure 2-3. Before (left) and after (right) grassland restoration

Fire Regime III - Aspen and Mesic Mixed Conifer

FOHE, ASRE, HFRE - Forest health, aspen regeneration, and hazardous fuels reduction prescriptions would be assigned to these forests emphasizing the removal of ladder fuels[19], trees impacted by insects, trees with visible signs of damage or disease, and fire intolerant species (white fir, blue spruce, Engelmann spruce.

Figure 2-4. Aspen-mixed conifer forest

Based on measures taken in the field, conifers, especially white fir and spruce, less than 9 in. diameter would be targeted for removal. Some stands contain over 1000 aspen trees per acre, most under 5 in. diameter. In these stands, the emphasis would be to remove overstory conifers that shade the aspen. The largest (> 16 in. diameter most vigorous aspen, Douglas-fir, and ponderosa pine, would be favored for retention. Limber pine would also be retained[20]. Openings of ½ to 1 acre would be created.

Fire Regime IV - Mesic and Dry Spruce-fir

Figure 2-5. Dense young spruce-fir forest and heavy slash

HFRE - Hazardous fuels reduction prescriptions would be used to reduce the potential intensity and severity of wildland fire across the landscape. Planned prescription parameters would select small, disease or damaged trees for removal. The largest (>16 in. diameter), healthiest trees of all species would be favored for retention. Fuelbreak prescriptions would be used strategically to improve the safety and effectiveness of wildland fire management.

Based on measures taken in the field, trees targeted for removal would be white and subalpine fir less than 5 in. diameter and Engelmann spruce less than 7 in. diameter. Healthy Engelmann spruce, Douglas-fir, and aspen would be favored for retention.

Typical conditions (dense small trees and heavy slash from historic logging) are shown right in Figure 2-5. The figure shows slash laid out as a track for pulling out the large tree from the center.

[19] "Ladder fuels" refer to trees small to medium sized trees arranged to create a "ladder" of fuel that would allow fire to move from the surface into the crowns of the larger trees.

[20] White pine blister rust is present along the northern boundary of the preserve adjacent to Santa Clara Pueblo's boundary, therefore limber pine should be retained to ensure the greatest degree of genetic heterogeneity is present.

Fire Regime III Mixed Montane Woodlands

FOHE, HFRE - prescriptions would be used to create patches and corridors of various size classes emphasizing the retention of mature shrubs and trees.

Conifers less than 9 in. diameter would be targeted for removal; healthy large conifers and oak trees and shrubs would be retained.

A mixed montane woodland where the thinning of small conifers could improve wildlife habitat is shown right in Figure 2-6.

Figure 2-6. Mixed montane woodland

All Fire regimes/ecotypes - Hazardous Fuels Reduction on Steep Slopes

Figure 2-7. Hazardous fuels reduction and handpiling on slope

HFRE - On steep slopes with a very high fire behavior potential, mechanical treatments may be implemented employing a hazardous fuels reduction prescription. This prescription focuses on removing ladder fuels (small trees, brush, and slash) and breaking up the continuity of the fuels. Biomass is generally hand piled (as shown in Figure 2-7) or lopped and scattered for later burning.

REST, FOHE - Small tree yarding systems, which fully or partially suspend trees, could also be used allowing us to apply more intensive prescriptions based on the forest type.

All Fire regimes/ecotypes - Responding to Natural Events

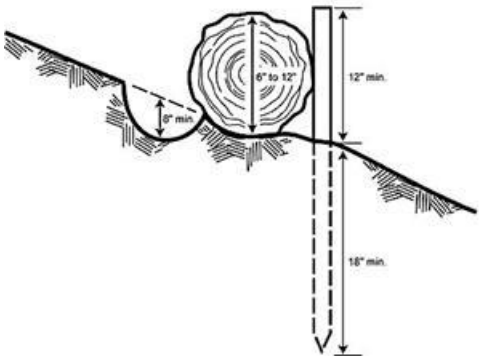


Figure 2-8. Contour felling diagram

Under the proposed Stewardship Plan we would use mechanical treatments to restore and rehabilitate burned areas or areas impacted by insects and disease as follows:

source: (Montana - NRCS, n.d.)

- To reduce secondary risks created by dead and dying trees we would implement any of the prescription options for mechanical treatment – all performance requirements would apply.
- To stabilize areas following a loss of vegetation from wildfire we would cut trees, and either lop and scatter or masticate biomass to provide surface cover. On steep slopes, the boles of trees could be anchored horizontally along the slope to capture soil and reduce erosion as illustrated in Figure 2-8.
- To reduce the spread of insects or disease infected trees may be removed or isolated if it is determined that such treatment can be timely and effective – all performance requirements shall apply.

All Fire regimes/ecotypes - Wildland Fire Management Control

WFCO - Localized thinning or fuelbreak construction may be used in association with control lines or to protect cultural or natural features from fire.

Wildland Fire Management

Figure 2-9. Valle Toledo Prescribed Fire, November 2005

We are proposing to manage wildland fire, both planned ignitions (*prescribed fire)* and unplanned ignitions, as a restoration and management tool in forests, montane grasslands, and woodlands. We are proposing to use prescribed fire alone and in combination with mechanical treatments.

Wildland fire management would be consistent with, but not necessarily imitative of, the fire regimes that have influenced the structure, composition, and function of the preserve's ecosystems prior to European settlement.

Any unplanned human caused ignitions would be managed for protection and we would select the safest, most cost effective means to extinguish such fires. However, under any action alternative we would consider managing any lightning caused wildland fires to enhance our management objectives. The management of these fires would be limited initially due to the current fire behavior potential but could be expanded over time as more of the forests were treated and the fire behavior potential was reduced. Consistent with the *Guidance for the Implementation of the Federal Wildland Fire Management Policy*, reviewed and updated in 2009 (NWCG, 2009) and the *Interagency Prescribed Fire Planning and Implementation Guide*, reviewed and revised in 2008 (USDA/USDOI, 2008), any use of wildland fire would consider current climate trends, expected weather, potential fire behavior, the impacts of wildland fire on other activities on the preserve, and the amount and duration of smoke impacts in

surrounding communities. The primary objective for managing any planned or unplanned wildland fire is safety; the safety of our firefighters, the public, as well as employees, volunteers, contractors, or others.

Wildland Fire - Direct, Indirect and Connected Activities

Wildland fire management activities include direct and indirect actions to prepare, ignite, control, or otherwise manage wildland fire:

- Construction of control lines (clearing all vegetation and debris to expose only bare dirt or rock) using hand tools or mechanized equipment.
- Igniting fire by hand using a gasoline-diesel fuel mix.
- Mixing and dispensing of the fuel mixture.
- Use of aerial ignition devices.
- Management of aircraft (helicopters) including staging and refueling.
- Use of approved foaming agents or water to retard the spread of fire or to protect sensitive features.
- Use of approved foaming agents or water in combination with digging and scraping to extinguish fire.
- Reducing concentrations of fuel adjacent to control lines or surrounding sensitive features by hand or using equipment.
- Using areas to store or stage water tanks and vehicles
- Staging, parking, and turning vehicles and equipment
- Establishing camps for short term staging of vehicles and personnel and project management
- Forest thinning as previously described.

Wildland Fire – Prescription Guidelines

Prescription parameters including air temperature and humidity, fuel, soil, and plant moistures, wind speed and direction, time of year and other factors will be developed for each ignition of prescribed fire. These parameters will be designed to achieve various objectives including reducing the loading and continuity of forest fuels.

Table 2-4. Prescriptions and guidelines for wildland fire – planned ignitions

Prescription	Guidelines
Low Severity	Primarily low intensity fire (less than 4 ft. flame lengths). Mortality in mid-age and mature trees less than 10 percent. Maximum consumption of fine fuels and ladder fuels, minimum consumption of large logs and organic material
Mixed Severity	Primarily low intensity fire as described above with some areas of moderate intensity fire (4-8 ft. flame lengths) and passive crown fire. The target for higher severity fire would generally be for less than 30 percent of the burn area. Within these areas, mortality of mid-age trees could be targeted at up to 30 percent within a range of accepted deviation – higher or lower. Mature trees could be killed but would not be targeted.

Wildland Fire - Prescriptions by Ecotype

Ponderosa Pine Woodland and Savanna, Dry Mixed Conifer, and Montane Grasslands

Prescribed fire would be used in these forest types alone or following appropriate mechanical treatments. Prescriptions parameters would emphasize low severity and intensity fire (Figure 2-9) burning continuously (>50 percent) across the landscape to reduce hazardous fuels, restore composition and structure, or dispose of biomass resulting from mechanical treatment.

Aspen and Mesic Mixed Conifer Forests

Wildland fire would be used in these forest types alone or following appropriate mechanical treatments. Prescriptions would promote low to mixed severity and intensity fire with patchy (<50 percent) continuity to reduce hazardous fuels, restore structure and composition, and dispose of biomass resulting from mechanical treatments.

Gambel Oak-Mixed Montane Woodlands

Wildland fire would be used to enhance structural diversity and wildlife habitat improvements initiated by mechanical treatments. Prescriptions would promote low severity and intensity, patchy and discontinuous burning (<50 percent) across the landscape to restore structure and composition and dispose of biomass resulting from mechanical treatment.

Dry and Mesic Spruce-fir Forests

Wildland fire would be used in these forest types alone or following mechanical treatments. Prescriptions would promote low to mixed severity and intensity fire with patchy (<50 percent) continuity to reduce hazardous fuels restore structure and composition and dispose of biomass resulting from mechanical treatment.

Road Closures, Rehabilitation and Maintenance

Figure 2-10. Old logging road,

administratively closed naturally revegetating

We are proposing to move the current road density from an average of 9 mi/mi^2 to 1.5 mi/mi^2. Meeting this objective would require closing and/or decommissioning about 1000 miles of road over 10 years. Based on soils and hydrology, road closure and decommissioning would primarily be achieved through administrative closure and natural rehabilitation Figure 2-10.

Approximately 100 - 150 miles of road have been identified as needing physical decommissioning and rehabilitation. Most of this would occur at localized points, less than 500 linear feet, where active erosion is occurring.

Approximately 52 miles of the 200 miles of roads to be maintained for ongoing use are in need of deferred maintenance to restore hydrology or halt ongoing erosion. Deferred maintenance activities include:

- Reshaping and resizing the existing road prism
- Realignment to alter grades or reduce erosion
- Constructing lead-outs, or installing or replacing culverts to improve drainage
- Replacing fill
- Extracting, hauling and placing aggregate material (gravel, rock, dirt, etc.)
- Staging equipment

Currently differed maintenance activities are ongoing on open roads in the VCNP and this would continue. Existing roads were developed to support of past logging, hunting, ranching and geothermal development. Other infrastructure features associated with the roads include well pads, log landing, or livestock gathering areas. Rehabilitation of these localized features would generally include erosion control (placement of logs, rocks, or fabricated features to halt erosion), construction of contours or placement of culverts to provide drainage, or soil scarification to promote the establishment of native grasses.

Maintenance and repair to VC05 (see location in Figure 2-14) is the first priority for beginning new maintenance activities. VC05 is characterized by ongoing severe erosion (Figure 2-11), that is currently affecting cultural resources and watershed condition, and is valued as a key administrative and interpretive route. Ongoing erosion has since been significantly exacerbated by post fire run-off following the Las Conchas wildfire.

Figure 2-11. Road VC05 was severely impacted by erosion from the Las Conchas fire

The priority for physically decommissioning and rehabilitating roads would be site-specific areas rather than landscape areas. Road alignments which are directly affecting water quality, diverting wetlands, increasing overland flow, or impacting cultural resources (Figure 2-12 left) would be the first priority, as opposed to more stable areas of localized erosion (Figure 2-12 right). The priority for

completing deferred maintenance would be based on current condition, level of use and current resource impacts.

Figure 2-12. Road causing active resource damage on right compared with relatively stable roads on left

Points where intermittent perennial water courses intersect with roads (Figure 2-13. are often sources of point erosion and comprise the areas requiring physical decommissioning actions on roads being administratively closed or maintenance on roads being maintained for public or administrative use.

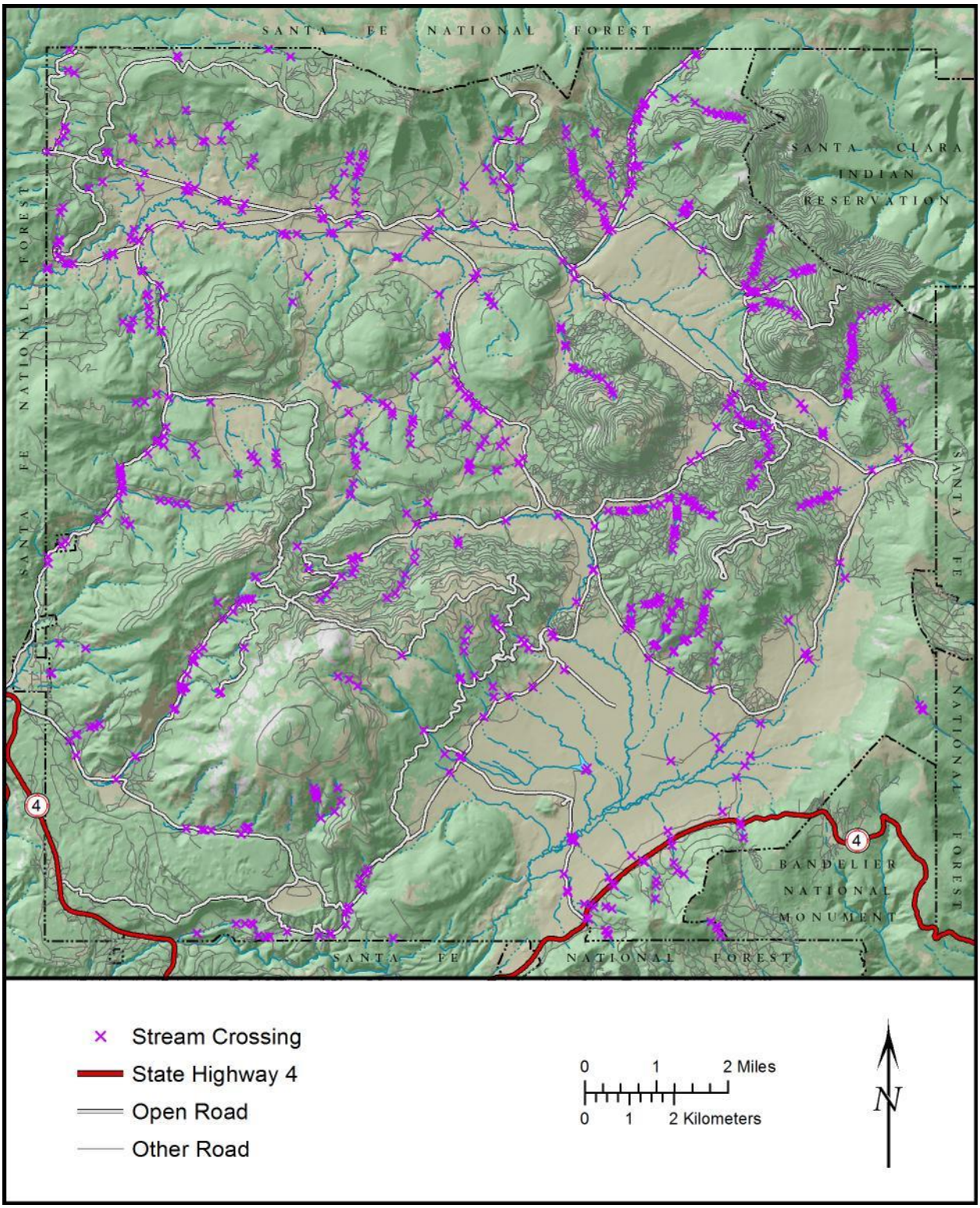


Figure 2-13. Points where intermittent or perennial flows intersect roads

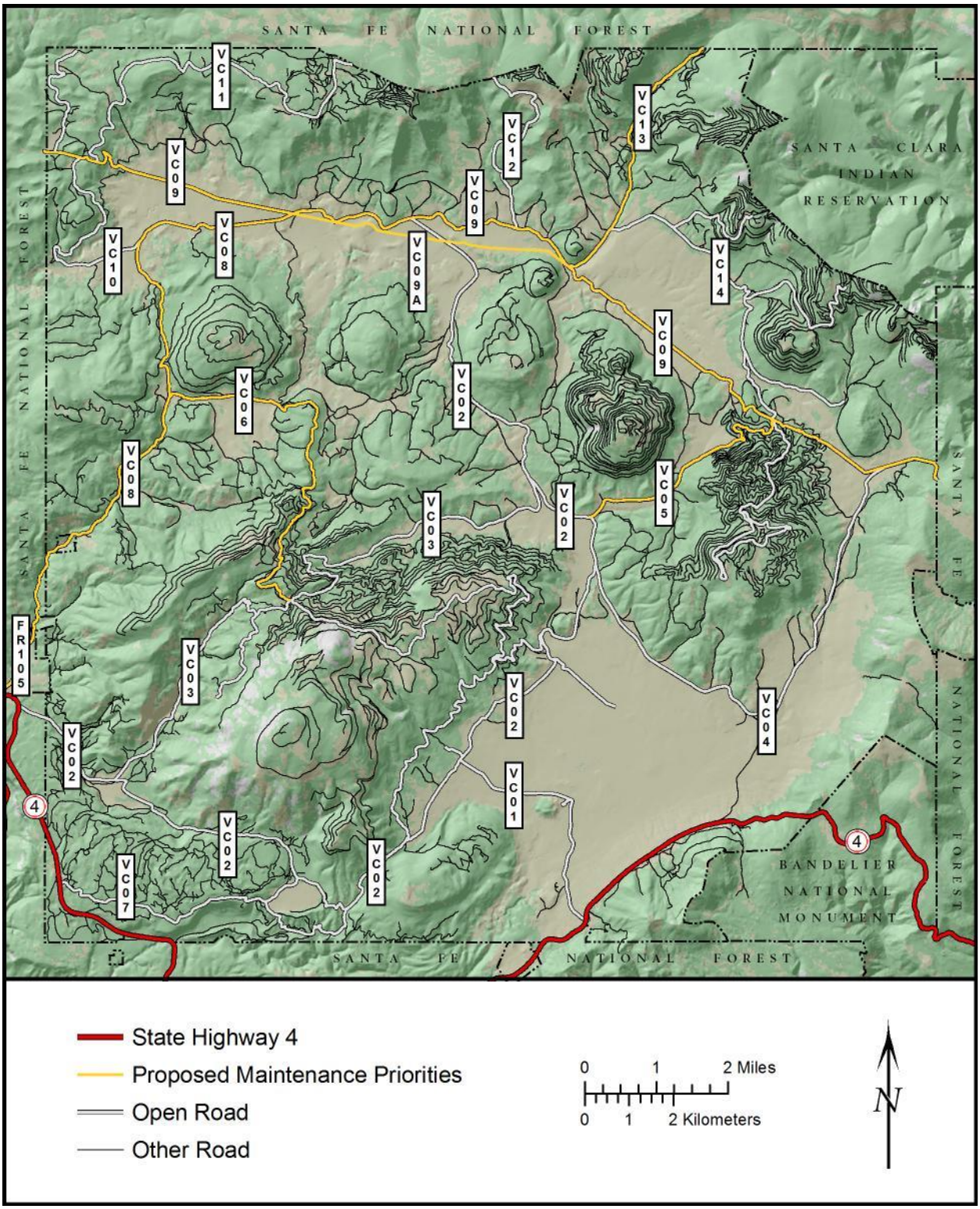


Figure 2-14. VCNP road network

Riparian and Wetland Restoration

In combination with road management actions as described above, we are also proposing to restore wetland and riparian areas throughout the preserve. The objectives of this restoration work are to optimize interflow, minimize overland flow, increase base flow, reduce sediments, dissolved oxygen and other water quality impairments; and reduce stream temperatures. The wetland and wet meadow systems containing the preserve's riparian areas and streams comprise just over 6,800 acres, mostly within the open valle systems. Restoration activities would include:

- Streambank and channel restoration to address site-specific erosion.
- Planting trees and shrubs (Figure 2-15).
- Placement of rock or log and fabric dams, or Zuni bowl techniques to protect and restore wetlands and mitigate ongoing erosion (Figure 2-15).
- Removal of road and water control features to restore wetlands.
- Repairing or decommissioning earthen tanks and dams.
- Installing weirs or channel modifications to slow the development or reduce the consequences of meander cutoffs (Figure 2-15).

Many water quality and stream condition issues are addressed through the treatment of forests, grasslands, and road management actions. The priority for riparian restoration is to continue ongoing restoration in San Antonio, Sulphur, and Redondo Creeks within the San Antonio and Sulphur 6th code watersheds (see Figure 2-16) especially post Las Conchas fire rehabilitation in Indios and San Antonio creeks. As additional funding is available, the trust would begin restoration actions in the Jaramillo and the East Fork of the Jemez River

Figure 2-15. Clockwise from top, left: tree planting, rock dam, Zuni bowl, meander cut-off mitigation (before, during, and after)

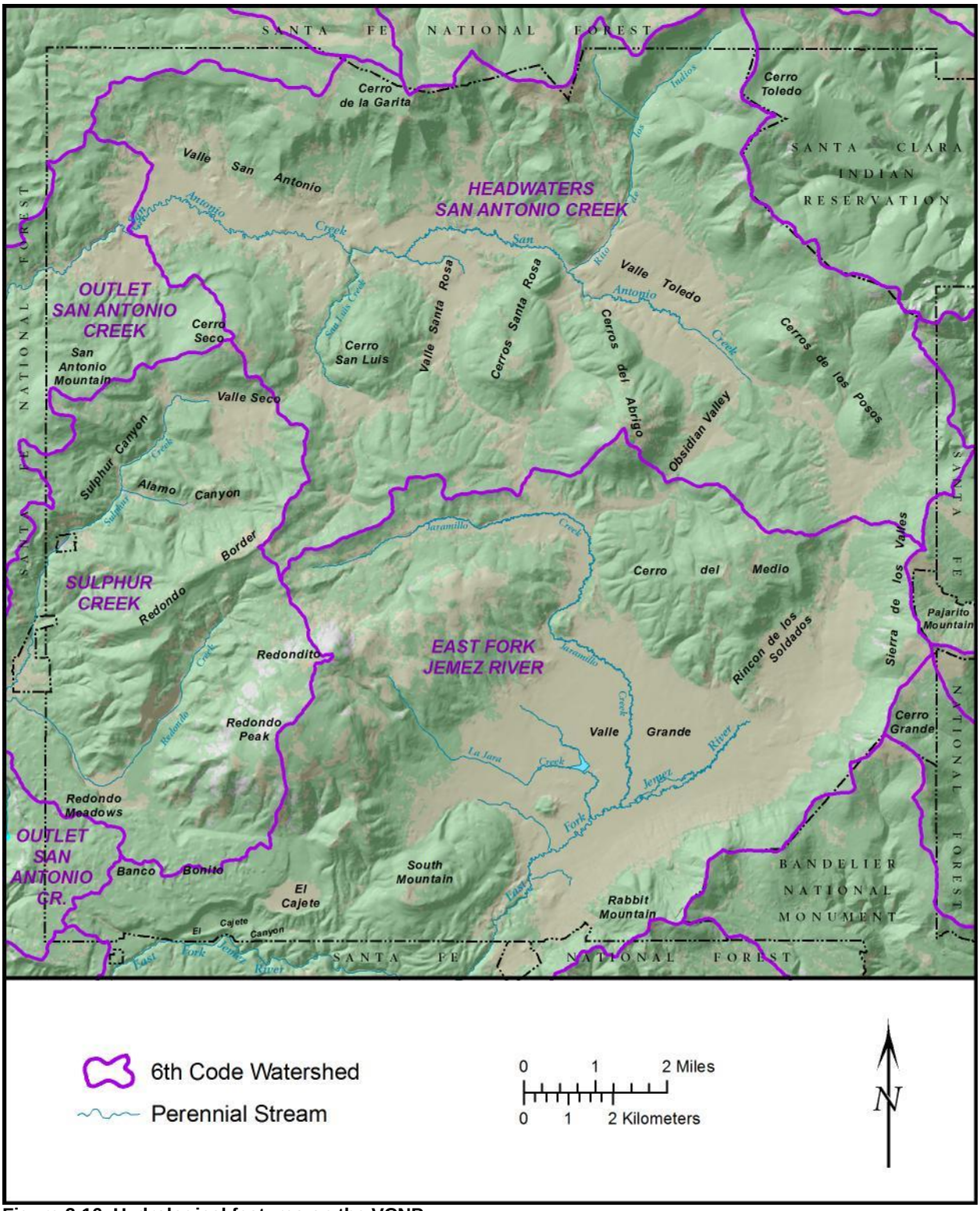


Figure 2-16. Hydrological features on the VCNP

Prevention, Control and Eradication of Noxious Weeds

Noxious weeds are legally defined as any plant designated by a federal, state, or county government to be injurious to public health, agriculture, recreation, wildlife, or any public or private property (Sheley and Petroff, 1999). All ecosystems (rangelands, forests, grasslands, riparian areas, wetlands, lakes, and streams) are vulnerable to invasion by non-native weed species. The State of New Mexico maintains a list of species considered noxious in the state. The list places a weed designated as noxious into one of three categories for treatment:

- Class A species are currently not present in New Mexico, or have limited distribution. Preventing infestations of these species and eradicating existing infestations is the highest priority.
- Class B species are currently limited to portions of the state. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread.
- Class C species are widespread in the state. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation.

Currently we are actively eradicating weeds occurring on the preserve deemed noxious in the state of New Mexico including:

- Canada thistle (*Cirsium arvense)* (Figure 2-17, left) a Class A noxious weed,
- Bull thistle (*Cirsium vulgare)* a Class C noxious weed,
- Musk thistle (*Carduus Nutans*) (Figure 2-17, center) a class B noxious weed,
- Oxeye daisy *(Leucanthemum vulgare)* (Figure 2-17, right), a Class A noxious weed.

Canada and bull thistle as well as oxeye daisy are being treated annually with an herbicide, Clopyralid, (Transline™). Musk thistle is primarily treated by digging up the plant and removing the seed heads.

We are proposing to continue current efforts to eradicate these weeds as well as implementing a long-term strategy to prevent, control, and eradicate noxious weeds. Under this long-term strategy, we would continue current eradication efforts and would begin immediate and aggressive control and eradication of known populations of Cheatgrass *(Bromus tectorum),* shown left in Figure 2-18, using Glyphosate (Roundup™), Imazipic (Plateau™), or the combination of both (Journey™) to control cheatgrass.

We are also proposing to implement a strategy of *early detection, rapid response (EDRR)* to prevent, control, and/or eradicate any weeds found on the preserve in the future. The EDRR strategy would allow treatment of invasive plant infestations located outside of currently identified treatment areas. Infestations outside of existing treatment areas may include sites and species that currently exist on the preserve but have not been located during previous inventories, or new sites and species that arise in the future. For example, Dalmatian toadflax (*Linaria dalmatica*) and yellow toadflax (*Linaria vulgaris*) (Figure 2-18 center and right) are known threats from surrounding areas that would be treated under these rules if they were discovered on the preserve.

Figure 2-17. Canada thistle (left), musk thistle (center), oxeye daisy (right) (Photo ©Al Schneider, www.swcoloradowildflowers.com)

Figure 2-18. Cheatgrass (left), Dalmatian toadflax (center), yellow toadflax (right) (Photo ©Al Schneider, www.swcoloradowildflowers. com)

The intent of EDRR is to allow timely control, so that new infestations can be treated when they are small in order to control their spread, minimize treatment costs, and reduce adverse effects of treatment. EDRR would improve our ability to eradicate new invasive plant species and keep areas currently without infestations noxious weed-free. Newly discovered sites considered for treatment under EDRR must meet certain requirements. They would be reviewed prior to treatment to determine if environmental impacts and treatments would be consistent with those analyzed and disclosed in the LRMP EIS. All of the following requirements must be met in order for new sites to be treated through EDRR:

- The species at the site must be a plant meeting the definition of “noxious weed” and be on the list of species identified as noxious in the state of New Mexico. We are not proposing to eradicate all non-native plants, only those classified as “noxious weeds”. An exception is regarding goatheads (*Tribulus terrestris*) which have been sighted on the preserve. Goatheads are an exotic, invasive, and generally miserable plant although not classified as noxious by the

state of New Mexico. Goatheads would be aggressively eradicated by digging or pulling in combination with the application of Glyphosphate.

- The control is consistent with this plan.

Annually, or as needed, we would identify new sites outside of the known treatment areas for potential treatment under an EDRR strategy. Sites considered for treatment under EDRR would be assigned a priority, objective, treatment method, and restoration strategy consistent with the methodologies described below. Sites would be reviewed by an interdisciplinary team of resource specialists using the ICP to determine appropriateness of treatment under EDRR. Applicable Performance Requirements would then be implemented at each new site.

The review team would screen the new site(s) and complete the ICP demonstrating how treatment would be within the scope of the original NEPA decision. In general, if the anticipated environmental impacts do not exceed those presented in this EIS, treatment would proceed through the normal process. If impacts would exceed those analyzed in the EIS, treatment methods would need to be adjusted, or additional review in compliance with NEPA would be necessary. The completed ICP would be reviewed by the Responsible Official prior to treatment. Proposed treatments under EDRR would be included and disclosed in the stewardship register.

Proposed Treatment Methods for Invasive Species

Once prioritized and assigned treatment objectives, noxious weed populations would be treated i.e. eradicated, confined, or controlled. Selected treatment methods would be based on the experience of staff, invasive plant control experts from local agencies, and herbicide labels, (Bossard, et al., 2000; Sheley and Petroff, 1999). No single management technique is perfect for all invasive plant control situations therefore more than one option is listed for each species where available. Treatments may be used in combination, or change over time as sites become smaller and less dense. We would follow the decision-making process outlined in the appendices, which focuses on site-specific factors and on incorporating an integrated weed management approach in order to achieve effective and practical treatment at each site.

Physical control methods include manual hand-pulling, the use of hand tools, power tools, prescribed fire, mulching, mowing, and solarization. Biological control, within the context of this analysis, involves the use of animals or vegetation to consume or out-compete undesirable plant species. Grazing can be used to selectively control or suppress weed growth, but may also spread certain invaders. The use of desirable or innocuous plants, especially natives, to out-compete alien species is an important consideration in any weed treatment effort and may be used to enhance other types of control measures.

Chemical control is conducted with herbicides that kill or inhibit plant growth and would be used to eliminate the target species. Different herbicides would be selected based on the site-specific factors including:

- Stages of plant growth;
- Preventing herbicide resistance;
- Sensitive plants, riparian areas, open water, or human uses that may be present or occur at a site-specific area.

As previously described the continued use of Clopyralid (Transline), authorized under the 2003 decision, and is proposed in this analysis. Three additional herbicides are also proposed for use as noxious weed treatments on the preserve. They are: Glyphosate (Roundup), Imazapic (Plateau), and Imazapic+Glyphosate (Journey).

Increased inventories have located noxious weed occurrences that were previously unknown. The weed populations occur as individual plants or several plants. In 2012, we treated about 40 individual locations. However, comprehensive mapping efforts have not been conducted and the true extent of invasive species has not been quantified. If existing occurrence size turns out to have been underestimated, if treatment needs increase in response to vegetation treatments, or if emergencies arise in the future (such as response to post- fire invasion) it could be necessary to be able to treat significant areas of the preserve.

Combined herbicide treatments from within existing sites and as a result of EDRR would not exceed 1139 acres per year (~1.28 percent of the preserve's area) during the life of the plan (we currently treat 40-point locations of individual plants and groups of plants). This upper limit is a "cap" derived from considering acres treated in recent years, potential increases in treatment acres resulting from recently discovered weed populations, and potential "worst case" needs based on a comprehensive inventory of high risk locations (such as roadsides and gravel pits).

Realistically, it is expected that actual treatment would be much less than 1139 acres per year. Herbicides would not be used in every instance of treatment, existing weed populations likely cover far less than 1139 acres, and performance requirements are expected to prevent noxious weeds from achieving this extent. In general, relatively small spot treatments similar to historic herbicide application on the preserve are expected. Nonetheless, it is prudent to plan for unforeseen circumstances so that we can be adaptive in our management of the preserve. If this cap proves to be inadequate in the future, additional environmental analysis would be required to implement a decision to treat additional areas.

Site Restoration

Commonly used control methods, such as manual or herbicide treatments may eliminate or suppress invasive species in the short term, but the resulting gaps in vegetation and bare soil create open niches that are susceptible to further invasion by the same or other undesirable plant species. Site restoration or revegetation is an important part of any strategy to reduce invasive plants. The first step is to determine the need for active restoration/revegetation versus passive restoration.

Passive restoration depends on re-colonization from the existing native plant seedbank and from seed dispersed from surrounding sources, as well as growth and reproduction of native species already within the treatment site. Passive restoration is appropriate on sites where relatively little bare ground exists after treatment. Active restoration requires activities such as seeding, raking (by hand or with a harrow pulled by an ATV), mulching, and/or planting native plants. Active restoration would likely be limited to large sites with dense infestations, where considerable bare soil and little native vegetation are present after treatment. None of these areas presently exists.

Passive restoration would be the preferred option at known noxious weed locations within the preserve due to their relatively small size and the fact that they are within or adjacent to native plant

communities capable of providing seeds for re-colonization. Many of the sites have low-density infestations, and growth and reproduction of existing native plants should be sufficient to re-vegetate the sites. Sites where continual disturbance prevents long-term establishment of vegetation (such as parking areas, and gravel pits) would not be actively restored. Foreseeable active management opportunities would include recently disturbed landings and skid trails where restoration would be used as a preventative measure to reduce bare soil, or on roadsides where restoration seeding could be used to vegetate recently treated areas. Active restoration opportunities such as planting or seeding of native species would be implemented on a site specific (project by project/treatment by treatment) basis as they are identified in the future, and according to the principles of adaptive management.

Prevention would be accomplished through the implementation of mitigating measures listed under Noxious Weed Prevention and Control.

The long-term strategy for prevention and control focuses on reducing the establishment of new noxious weeds or spread of existing weeds. Initially we would focus on known occurrences and features such as roads, aggregate sources, mechanical treatment sites, grazing infrastructure and open roads. Additional inventories may correlate other locations or activities as high risk.

Noxious Weed Treatment Priorities

Invasive species sites would be prioritized for treatment based on factors such as the current abundance and distribution of the species, the potential for spread, and the type and values of the site affected Table 2-5 shows criteria for determining high, medium, and low priority for treatment. Other management considerations may also affect treatment priority, and these factors may change over time. For example, sites located in areas proposed for ground-disturbing management activities may be treated prior to project implementation in order to prevent spread. Priority may be given to treatment and restoration of sites where considerable time and money has already been spent. Opportunities for special funding or cooperative projects with other landowners, agencies, and organizations may also be considered.

After invasive plant species locations are prioritized for treatment, each site within the preserve would be assigned a treatment objective defined as follows:

- **Eradicate**: Attempt to eliminate an invasive plant species from a site.
- **Control**: Reduce the infestation over time; some level of infestation may be acceptable.
- **Contain**: Prevent the spread of the invasive plant beyond the perimeter of patches or infestation areas mapped from current inventories.
- **Tolerate**: Accept the continued presence of established infestations and the probable spread to ecological limits for certain species. Try to exclude new infestations through prevention practices.

Objectives vary depending on the potential negative impacts of a given invasive species, the potential for spread, the value, or sensitivity of the treatment site, and the feasibility and costs of treating a site. Different sites of the same species may have different objectives. For example, the objective for a large population of musk thistle in a young forest site may be control or contain, while the objective for a small population of musk thistle in an active gravel pit may be to eradicate. Objectives may also change

over time based on adaptive management factors (experience, new research, new technology, etc.). Additionally the class of weed (A-C) often provides guidance based on state level objectives.

All known populations of noxious weeds on the preserve near high traffic areas are a high priority for treatment. Eradication is the objective of choice for noxious weeds that currently exist on the preserve because all known noxious weed populations are relatively small at this time and/or restricted to roadsides where they can be easily accessed and treated. Roadside populations are a special concern due to their observed tendency to spread rapidly and over great distances in a short period of time (Iskra 2009). The ability of these weeds to be spread by day-to-day operational traffic on the preserve highlights the importance of early and proactive management. It is important that these populations be treated before or concurrent with any ground disturbing activity that is conducted in adjacent areas (Noxious Weed Prevention and Control Mitigating Measures) to avoid spreading them into mechanically treated or burned locations. Additional precautions (per the proposed performance requirements) may also need to be implemented concurrent with or prior to proposed project implementation.

Table 2-5. Criteria for determining the treatment priorities for noxious weeds

Priority	Description
High	Sites of species new or uncommon on the preserve. In active pits and quarries. In areas of high traffic (e.g. roads, high use recreation sites, trailheads, horse camps, fire camps, parking lots, etc.). Sites in recent fire areas where potential for infestation and spread is high. Sites that could affect Threatened, Endangered, or Sensitive plant and animal habitat. Sites in or near unique plant habitats, or areas of high diversity (e.g. meadows, streamsides, wetlands, fens). Sites with potential to spread across ownership boundaries onto lands that are not currently infested. Instances where weed treatment partnerships or funding opportunities are available Areas of high/concentrated livestock or wildlife use
Medium	Control/Containment of existing large infestations of priority species with a focus on the boundaries of the infestation. Roads that have less traffic, but still promote seed dispersal.
Low	Sites of species already widespread on the preserve. Large infestations, where eradication, control, or containment would be costly and difficult to achieve in 10 to 15 years. Sites with low risk of spread that are expected to decline with natural plant community succession.

Research, Inventory, Monitoring, and Evaluation

Inherent in all the proposed actions and activities are the research, monitoring, and evaluation activities in support of adaptive management. These include:

- Routine inventory of floral and faunal habitats using non-destructive as well as destructive[21] methods.
- Limited introduction of species and measures of success[22].

[21] Destructive monitoring includes cutting trees or down logs; digging pits, capturing specimens, or other features to take precise measurements.

[22] Species such as New Mexico meadow jumping mouse, northern leopard frog for the purpose of measuring habitat condition.

- Inventory of wildlife using observation as well as capture and measurement.
- Measure of ecosystem processes including succession, water capture, storage and yield and carbon sequestration using temporary and permanent exclosures and instrumentation.
- Measures of climate and/or weather using permanent instrumentation (Figure 2-19)
- Pre and post activity monitoring
- Long term monitoring of various ecosystems and various scales using temporary and permanent plots and instruments.

Figure 2-19. Existing meteorological monitoring station, Valle Grande

Research, Inventory, Monitoring and Evaluation Priorities

Priorities would be to:

- Install permanent water quality and climate instrumentation, and permanent sites and exclosures for long-term monitoring.
- Collect baseline information for areas and actions proposed for treatment under the Stewardship Plan.
- Evaluate and compile the results of activities implemented under the proposed Stewardship Plan.
- Maintenance of existing monitoring instrumentation and exclosures.
- Landscape scale baseline data on wildlife including, New Mexico meadow jumping mouse and large predators.

Extramural research and inventory (not directly associated with ongoing management activities or long-term monitoring; generally in support to an external project) would be second priority.

2.6.2 Alternative 2 - Collaborative Forest Landscape Restoration

Alternative 2 proposes integrated restoration and management actions including forest thinning, wildland fire management, watershed, riparian, and wetland restoration and management, road closure,

decommissioning and maintenance; and noxious weed eradication and control. Stands being proposed for treatments were selected based on the criteria from the restoration strategy submitted for funding under the collaborative forest restoration program (Valles Caldera Trust, Santa Fe National Forest, 2010) – ecological departure and fire behavior potential.

Alternative 2 - Mechanical Treatment Areas and Acres

To develop a proposed strategy over the next 10 years that would move the forests of the VCNP towards the reference condition at the landscape scale, the IDT evaluated several forest attributes at the stand level: fire regime, vegetation type, structure, composition, fire behavior potential, slope, and soils. Based on these attributes the IDT identified forests stands where mechanical treatments would be the most suitable and effective and assigned the following prescriptions. 27,312 acres were considered suitable and in need of mechanical treatment. Based on our current capacity including staffing and expected levels of funding, we are proposing to treat nearly 80 percent of these forests or approximately 21,500 acres. Table 2-6 below displays the total acres within the ecotypes, the acres suitable for mechanical treatment (footprint for treatment), and the acres we expect to treat over the 10-year planning period.

Table 2-6. Alternative 2: proposed mechanical treatment acres (top); additional treatments as needed and as funded (bottom)

Fire Regime and Ecotype	Treatment Criteria	Potential Treatment Acres	Prescriptions	10-Year Treatment	Potential Utilization
FR I – Ponderosa Pine; Xeric Mixed Conifer	Average Slope[23] ≤ to 25%	9,760	REST	7,860	Yes
FR I – Montane Grasslands	Encroachment by conifer	3,724	REST	3,236	Yes
FR III – Mesic Mixed Conifer; Aspen/Mixed Conifer	Average Slope ≤ 25%, Fire Intensity Class[b24] = IV or V	9,729	ASRE, FOHE	7,500	Yes
FR III – Mesic Mixed Conifer; Aspen-Mixed Conifer	Slope >25%, Fire Intensity Class = V, erosive soils.	4,219	HFRE	1,500	No
FR IV – Xeric Spruce-fir; Mesic Spruce-fir	Slope ≤ 25%, Fire Intensity Class = IV or V	3090	HFRE	1,200	Yes
FRIII – Mixed Montane Woodlands	Gambel oak dominate species	1,235	HFRE	200	No
Totals		**31,757**		**21,496**	

Fire Regime and Ecotype	Treatment Criteria	Potential Treament Acres	Prescriptions	10-Year Treatment	Potential Utilization
All fire regimes, forest types	Not otherwise selected	2364	WFCO[25]	<2000	Yes
All fire regimes, forest types	Burned in the Las Conchas fire	30,100	HFRE		Yes
All fire regimes, forest types	Affected by unplanned events	N/A	HFRE		Yes

[23] – Each forest stand is attributed with an average slope. This attribute was used to identify stands on "generally" operable ground. Performance requirements limit the use of heavy equipment to slopes less than 30 percent. Actual slopes will be used to identify operable ground.

[24] Fire Behavior Potential is indicated by a Fire Intensity Class attribute of 1-VI, with one being the least potential and VI being the greatest.; detailed definaition in Ch. 4

[25] Mechanical treatments in support of prescribed fire preparation to reduce the intensity of prescribed fire or to create or improve control lines.

Alternative 2 – Mechanical Treatment Priorities

The proposed activities are planned over a 10-year period. The plan is based on expected levels of funding, typical costs for treatments, current market conditions, and an assumption that environmental conditions will be favorable. These assumptions and expectations can vary substantially over the planning period therefore, it is important to identify priority treatment activities at the project level to ensure that goals and objectives can be met at the landscape scale.

The IDT considered watershed management units (WMU), which are sub-units of 6th level HUCs. There are 24 WMUs in the VCNP which have been organized into five priorities based on degree of ecological departure, fire risk[26], fire behavior potential, and values at risk (and vulnerable) to damage or loss from fire. Forest stands where treatments are proposed and priority areas are displayed below in Figure 2-20.

Priority 1

The southwestern corner was considered the first priority due to the proximity and alignment to a historically high concentration of human caused fires as well as the current degree of ecological departure.

Priority 2

WMUs within the Valle Grande are the second priority due to ecological departure, fire behavior potential and values at risk (historic wooden cabins and iconic views; both extremely vulnerable to loss or damage from fire).

Priority 3

Sulphur Creek and the middle San Antonio where the forests are ecologically departed and fire behavior potential is high. Post fire impacts (debris flows and flooding) could damage or destroy homes and infrastructure in downstream communities (Sulphur Springs, La Cueva)

Priority 4

The forests aligned with the northern boundary of the VCNP are the fourth priority. Reducing the fire behavior potential in this area would enhance the objectives on the surrounding NFS land.

Priority 5

This area includes the Valle Jaramillo, and the Upper San Antonio WMUs.

Priority 6

South Mountain and East Fork Jemez River WMUs are the sixth priority.

[26] Fire risk considered fire behavior potential as well as proximity and alignment to historic fire occurrence.

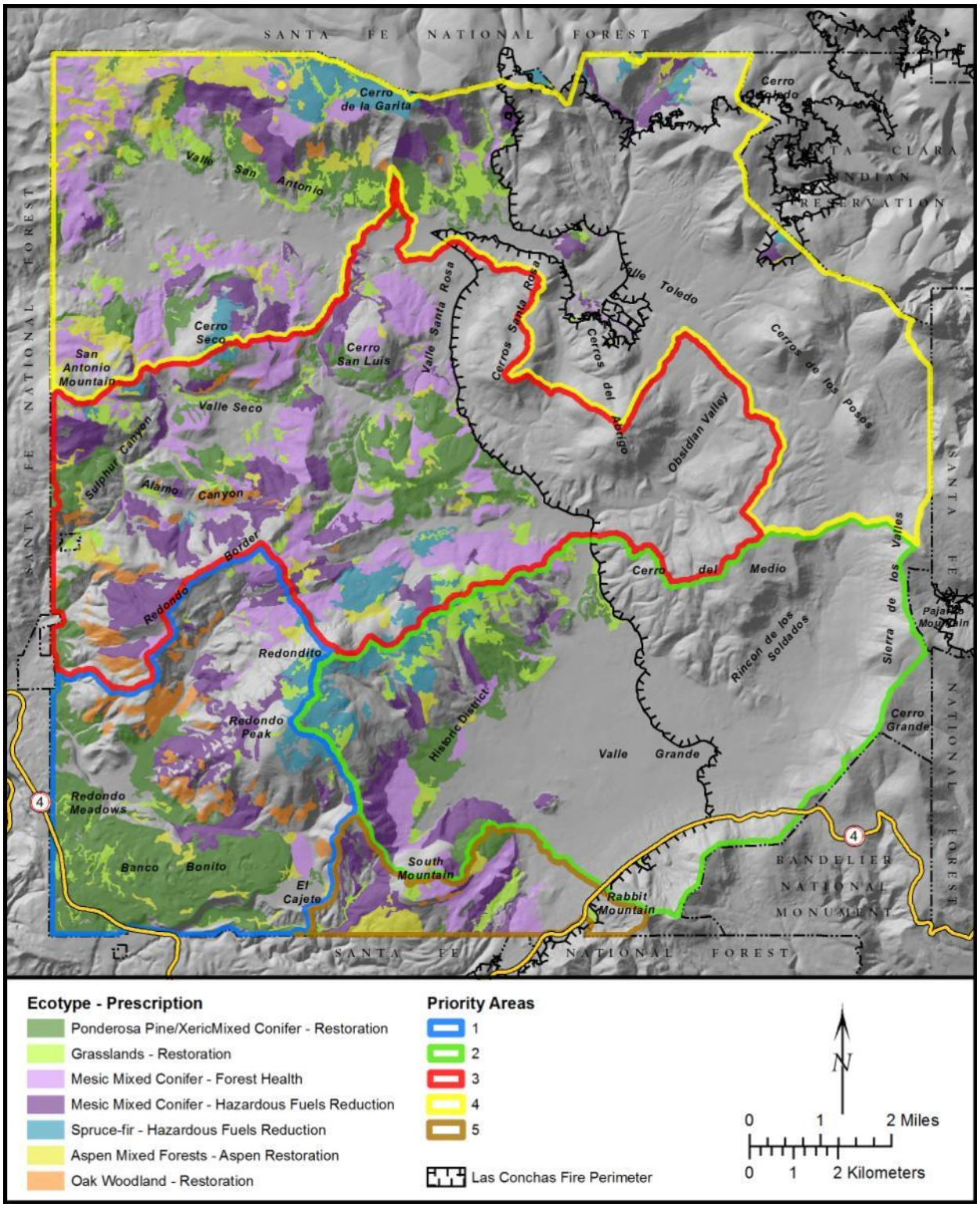


Figure 2-20. Alternative 2: Forest stands meeting treatment criteria and priority areas for treatment

Alternative 2 - Wildland Fire – Acres and Prescriptions

As noted in chapter 1, fire has been an essential process in the landscapes in and around the preserve for the past 10,000 years (Allen, 1989) and in general, wildland fire could potentially be applied beneficially to most ecotypes on the preserve. However, funds and environmental conditions limit the amount of acres proposed for treatment during the planning period. Due to the current fire behavior potential most burning within forest types would follow mechanical treatment. Table 2-7presents proposed prescribed burning over the 10-year planning period.

Table 2-7. Alternative 2: Proposed prescribed burning

Fire Regime	WFPF Only[a]	WFPF in combination with MECH (Table 2-6)	Prescriptions	Total WFPF
FRI	17,415	11,095	LOWS	28,510
FRIII and IV	10,915	10,400	MIXS	21,315
Totals	**28,330**	**21,495**		**49,825**

a - MECH areas would also be treated with prescribed fire following BD activities

Alternative 2 - Wildland Fire Planned Ignition Priorities

Biomass disposal and hazardous fuels reductions would be the highest priority for planned ignitions. Opportunities to implement planned ignitions can be limited by environmental conditions and lack of resources. As mechanical treatments were completed, opportunities to manage wildland fire would increase. Planned ignition projects should be used to treat larger landscapes whenever possible and consistent with desired outcomes.

2.6.3 Alternative 3 – Aspen Regeneration

This alternative varies from alternative 2 in the intensity and location of proposed forest thinning and associated prescribed burning. Other proposed restoration activities would remain the same.

Alternative 3 - Mechanical Treatment Acres and Areas

This alternative proposes more thinning intensive prescriptions within the mesic mixed conifer, aspen-mixed conifer, and dry spruce-fir type forests, where disturbance is likely to stimulate aspen reproduction. This alternative would also vary in biomass disposal. Under alternative 2, we would emphasize the disposal of biomass through utilization, in order to minimize the intensity and severity of prescribed fire. Under alternative 3 we would emphasize the use of fire for biomass disposal. The aim is to use the combined disturbance of mechanical treatment and mixed severity fire to stimulate aspen regeneration. Performance requirements limit heavy equipment operation to slopes less than or equal to 30 percent.

This alternative addresses two issues regarding aspen forests. First, the preserve's resident elk herd is reducing the survival of regenerating aspen to what could be an unsustainable level; field transects measured 95 percent browsing of aspen seedlings. Second, a variety of factors including elk, climate, fire exclusion, forest pests, and diseases are combining to affect aspen at the regional scale and warrant the

consideration of more intensive protection and management of aspen. This alternative could also increase the capture, storage, and yield of water to a greater degree than alternative 2.

Table 2-8 below summarizes the proposed forest thinning activities under alternative 3 organized by fire regime and ecotype and includes a summary of the criteria used to identify the proposed treatment areas as well as the intensity of treatment proposed over the next 10 years. Figure 2-21 displays the areas suitable for mechanical forest thinning and priority treatment areas for alternative 3.

Alternative 3 - Mechanical Treatment Priorities

Under alternative 3, the stands identified for treatment and the prescriptions were based on forest stands most likely to regenerate aspen if disturbed. The general areas treated and the order of treatment for be the same as for alternative 2. Stands identified for treatment and priority areas are shown in Figure 2-21.

Table 2-8. Alternative 3: proposed mechanical treatment acres (top); additional treatments as needed and as funded (bottom)

Fire Regime and Ecotype	Treatment Criteria	Potential Treatment Acres	Prescriptions	10-Year Treatment Acres	Potential Utilization
FR I – Ponderosa Pine Woodland and Savanna; Dry Mixed Conifer	Average Slope ≤ to 25%	9,760	REST	7,860	Yes
FR I – Montane Grasslands	Encroachment by conifer	3,724	REST	3,236	Yes
FR – III and IV Aspen Composition	Slope ≤ 30%, aspen in composition	13,249	ASRE	9,677	Yes
FR III – Mesic Mixed Conifer; Aspen-Mixed Conifer	Slope >30%, FIC V, erosive soils (not included above)	1011	HFRE	322	No
FRIII – Mixed Montane Woodlands	Gambel oak dominate species	1,230	HFRE	200	No
Totals		28,971		21,295	

Fire Regime and Ecotype	Treatment Criteria	Potential Treament Acres	Prescriptions	10-Year Treatment	Potential Utilization
All fire regimes, forest types	Not otherwise selected	2364	WFCO	<2000	Yes
All fire regimes, forest types	Burned in the Las Conchas fire	30,100	HFRE		Yes
All fire regimes, forest types	Affected by unplanned events	N/A	HFRE		Yes

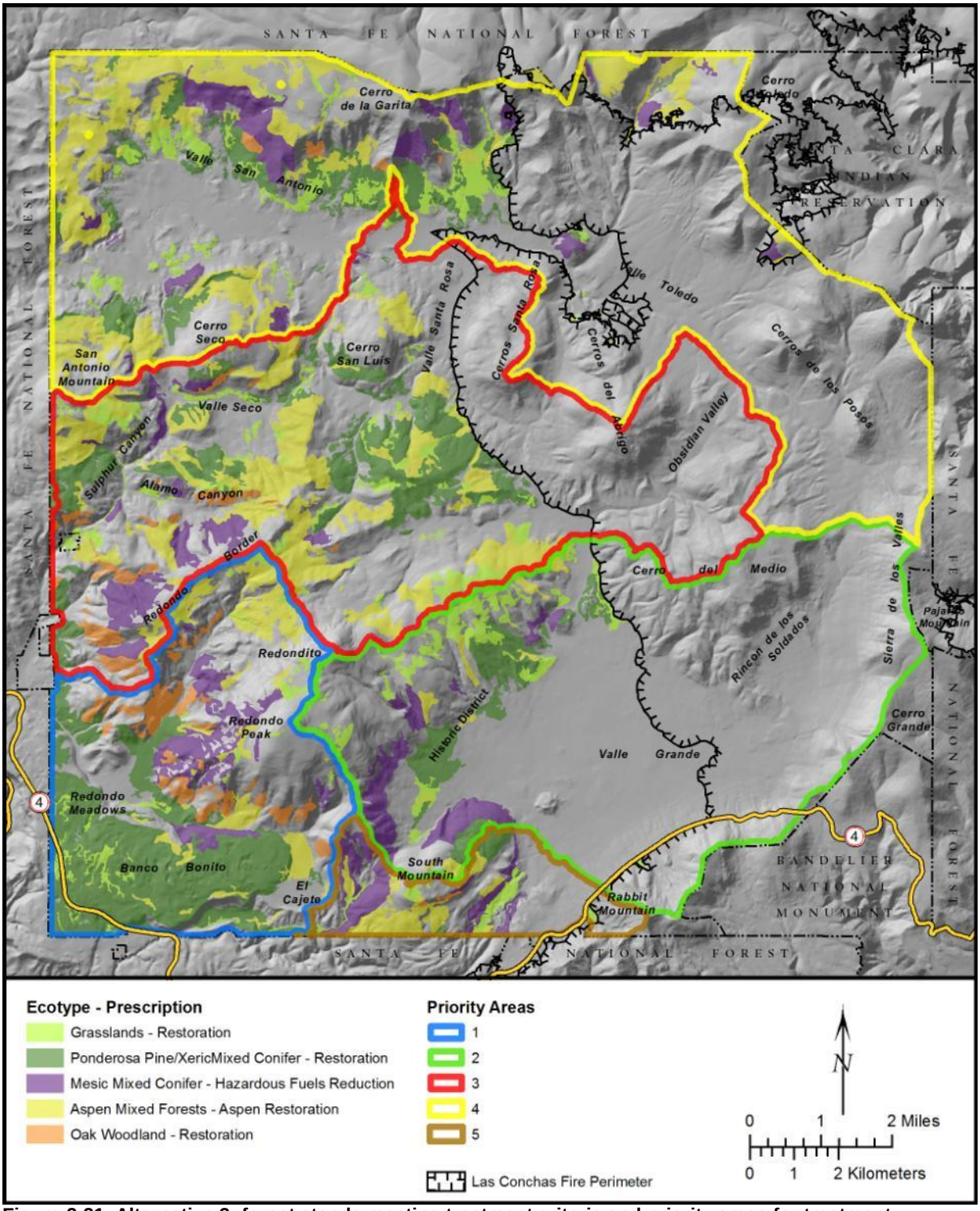


Figure 2-21. Alternative 3: forest stands meeting treatment criteria and priority areas for treatment

Alternative 3 – Wildland Fire – Acres and Prescriptions

Table 2-9 displays proposed planned ignitions of wildland fire management over the 10-year planning period under alternative 3.

Table 2-9. Alternative 3: proposed planned ignitions of wildland fire

Fire Regime	WFPF Only[a]	10-Year Treatment Acres (Table 2-8)	Prescriptions	Total WFPF
FRI	17,415	11,096	LOWS	28,511
FR III and IV	10,915	10,199	MIXS	21,114
Totals	**28,330**	**21,295**		**49,625**

a - MECH areas would also be treated with prescribed fire following BD activities

Alternative 3 - Wildland Fire Planned Ignition Priorities

Biomass disposal and hazardous fuels reductions would be the highest priority for planned ignitions. Opportunities to implement planned ignitions can be limited by environmental conditions and lack of resources. As mechanical treatments were completed, opportunities to manage wildland fire would increase. Planned ignition projects should be used to treat larger landscapes whenever possible and consistent with desired outcomes.

2.7 Adaptive Management

The implementation of any action alternative would incorporate a system for adaptive management. The NEPA procedures of the VCT define adaptive management as "*…adjusting stewardship actions or strategic guidance based on knowledge gained from new information, experience, experimentation, and monitoring results, and is the preferred method for managing complex natural systems*." (Federal Register, 2003). We implement adaptive management by adopting goals and identifying objectives and monitored outcomes in order to measure goal attainment (Figure 2-22 below).

Based on a review of monitored outcomes, mid-course adjustments can be made. Adjustments can be made without further review under the National Environmental Policy act (NEPA) provided the adjustments include actions and potential environmental consequences identified in this EIS. A summary of all actions, monitored outcomes, and adjustments will be presented every five years in the State of the Preserve.

Perhaps adaptive management can be better understood as a set of principles:

- Define explicit and measurable management objectives
- Recognize uncertainty and develop and test hypothesis
- Seek input of interested members of the public and stakeholders
- Monitor and learn through experience
- Adapt management and stewardship actions and decisions based on learning

Adaptive management is a process of viewing management actions as experiments rather than solutions. It is a formal and systematic approach to learning from the outcomes of our stewardship actions, accommodating change, and improving management.

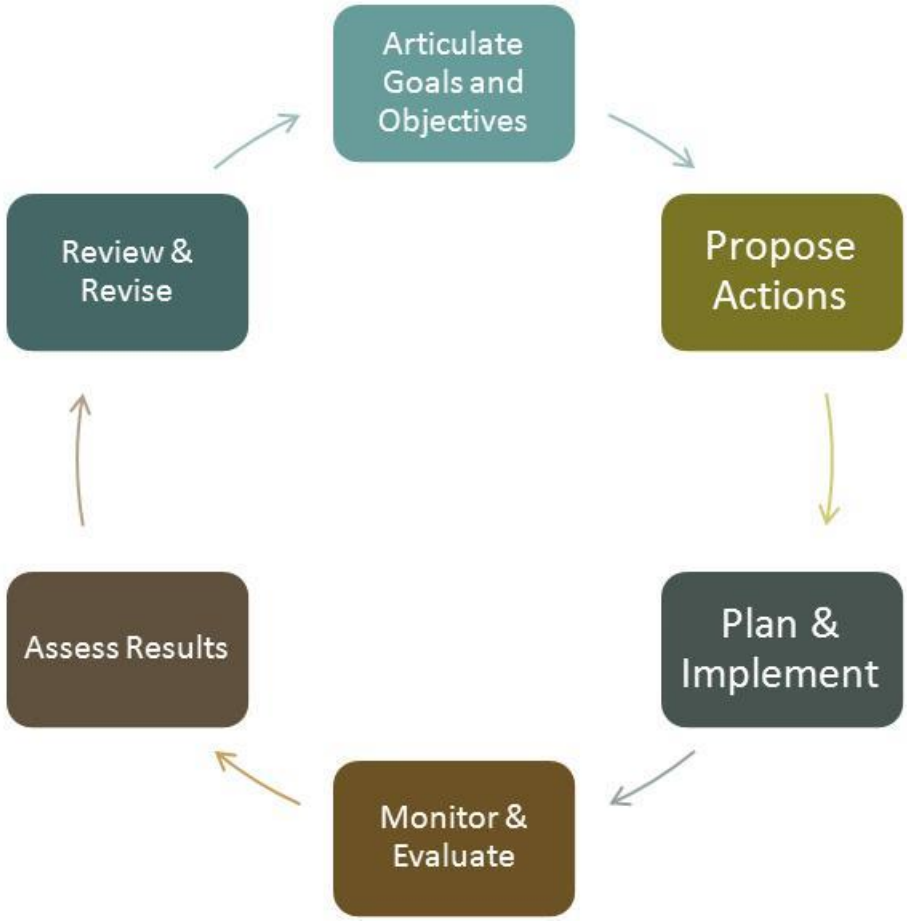


Figure 2-22. Process diagram illustrating adaptive management

> "What is important is to keep learning, to enjoy challenge, and to tolerate ambiguity. In the end there are no certain answers."
>
> - *-Martina Horner, President Radcliff College*

2.7.1 Goals

Our procedures for implementing NEPA define a goal as "*… a desirable condition as sought by the Trust*" (Federal Register, 2003). The procedures include that a goal can be adopted based on a review of a current *State of the Preserve.*

A goal is both qualitative and quantifiable, but is not quantified. Goals stretch and challenge us, but they are realistic and achievable as well as flexible enough to persist over time.

Based on a review of the 2007 *State of the Preserve,* and in pursuit of the central goal for management put forward in the 2004 *Framework and Strategic Guidance for the Comprehensive Management of the Valles Caldera National Preserve*, we adopted the following goal for the ecological condition of the preserve:

"The ecological condition of the preserve would be moving toward the composition of landscape vegetation and disturbance attributes that, to the best of our collective expert knowledge, can sustain current native ecological systems and reduce future risk to native diversity" (Valles Caldera Trust, 2009).

This goal is synonymous with the collaboratively developed goal for the Southwestern Jemez Mountains Landscape: "*Improve the resilience of ecosystems to recover from wildfires and other natural disturbance events in order to sustain healthy forests and watersheds for future generations"* (Valles Caldera Trust, Santa Fe National Forest, 2010).

2.7.2 Objectives

Our NEPA procedures define an objectives as "*… the desired outcome that can be meaningfully evaluated by location and timing within the Preserve*." Measurable objectives are used to evaluate progress towards goal attainment. The objectives proposed for assessing goal attainment for the Stewardship Plan are listed in Table 2-10.

Table 2-10. Proposed objectives, desired outcomes and targets

Objective	Desired Outcome	Target
Improve Forest Structure	Move the structure and composition of the preserve's ecosystems towards the reference condition. Improve the resilience of the ecosystem.	35% of closed forests move to open classes
Improve Forest Function	Improve water capture, storage and yield, carbon sequestration, and succession.	35% of closed forests move to open classes
Reduce Uncharacteristic Wildfire Potential	To reduce the likelihood of disturbances (especially fire, but also including insects and disease) occurring with uncharacteristic intensity, severity, frequency and/or at an uncharacteristic scale.	55% reduction in acres classified FIC IV or V.
Reduce Crown Fire Potential	Reduce the likelihood and extent of crown fire potential.	30% reduction in crown fire potential.

Objective	Desired Outcome	Target
Reintroduce Wildland Fire	Restore fire as a critical process in fire adapted ecosystems.	35,000 acres treated with planned or unplanned ignition in 10 years.
Reduce Road Density	Reduce road densities and associated erosion and water quality impacts.	1000 miles of roads decommissioned
Improve Water Quality	Move the water quality of the preserve towards meeting all designated uses as identified by the New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB).	No exceedance of any TMDL
Restore Stream Function	Move all stream conditions to a fully functioning condition.	Streams rated as "Proper Functioning Condition"
Restore Wetlands	Restore historic wetlands extent	20% increase in acres identified as wetlands[a]
Protect Native Species	Eradicate noxious weeds; maintain and increase native species and diversity.	Eradication of Canada, bull and musk thistle, 70 % reduction in oxeye daisy, 50% decrease in cheatgrass, no new species established.
Improve Wildlife and Terrestrial Habitats	Improve and maintain the quality and diversity of wildlife.	Maintain 70% of large down logs; 35% of closed forest moves to open forest
Improve Fisheries and Aquatic Habitats	Restore the quality, function and disturbance pattern of aquatic habitats	Return of beaver, New Mexico meadow jumping mouse, and northern leopard frog
Protection and preservation of cultural resources	Protect cultural resources from direct or indirect damage from restoration activities	No damage or loss resulting from treatments. 30% of the VCNP is surveyed.
Benefit local economy	Create opportunities for local employment	40 jobs annually[b]

a – Currently wetlands have been identified through the 2006 vegetation map prepared by New Mexico Natural Heritage Museum (Muldavin, et al., 2005).
b - Within the SWJML

2.7.3 Monitored Outcomes

Our procedures for implementing NEPA define monitored outcomes as "*…the result or consequence of a stewardship action that can be meaningfully evaluated by location and time of occurrence*" (Federal Register, 2003). Meaningful evaluation of outcomes ensures that progress is being made towards achieving plan goals and objectives. Such evaluations are used as the basis for adjusting management actions in a timely manner to ensure continued progress. Table 2-11 identifies outcomes selected for monitoring and evaluation and indicates the proposed frequency for measure. Measures may be taken either at the project location or representative long-term monitoring sites. We may also measure the movement and habits of wildlife to measure their response to treatments (Figure 2-23) of Permanent monitoring sites can be used to measure the effects of planned as well as unplanned events (Figure 2-24).

> "An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer."
>
> - *Max Planck*
> *Scientific Autobiography* (1949)

Table 2-11. Objectives, monitored outcomes, and frequency of measure

Objective	Monitored Outcomes	Frequency
Improve forest structure stand level	Tree size, species, and canopy density	1-5 years following treatment
Improve forest structure landscape level	Distribution of successional classes	Summarized every 5-years
Restore forest function	Carbon flux, water capture storage and yield	Continuously, summarized every 5 years
Reduce uncharacteristic fire potential	Crown base height, crown bulk density or canopy closure, surface fuel model	1-5 years following treatment
Reduce road density	Miles of road, closed, rehabilitated, and maintained	Every 5 years
Improve water quality	Temperature, turbidity, dissolved oxygen, pollutants	Continuously during frostfree seasons; summarized every 5 years.
Restore stream condition	Depth to width ratio, vegetative cover	1-3 years following treatments
Restore wetlands	Acres of wetland	3-5 years following treatment
Protect native species	Vegetative cover/diversity, cover /diversity of native species, presence of noxious weeds	1-3 years following treatments, summarized every five years.
Improve wildlife and fisheries habitats	Key characteristics related to forest structure, water quality, and stream condition	1-3 years following treatments, summarized every five years.
Improve wildlife and fisheries habitats	Population health and characteristics	Varies by species
Protect and preserve cultural resources	Damage or loss of features	During implementation or 1-3 years following treatment
Benefit local economy	Utilization of wood products, Days of work	Jobs and Labor Income; reported annually.

Figure 2-23. Monitoring predator population health and characteristics as it relates to habitat

Figure 2-24. Quantifying impacts from the Las Conchas fire to San Antonio Creek

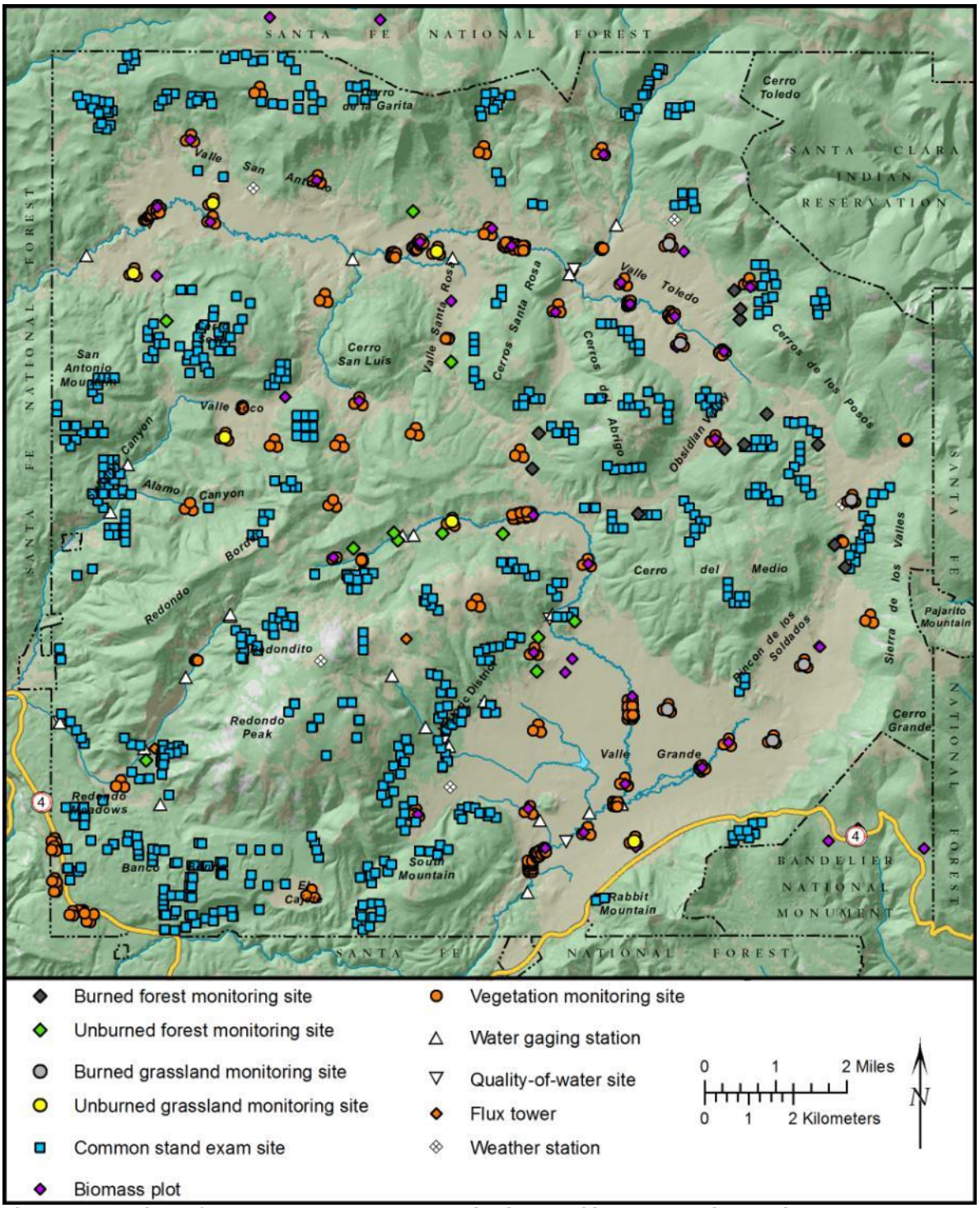


Figure 2-25. Points of resource measurement, study sites, and instrumentation on the VCNP

2.8 Preferred Alternative

Alternative 2 – the collaborative restoration strategy is the preferred alternative. Chapter 5 details the expected environmental consequences of the no action and action alternatives. Alternative 1 (the no action alternative), while having no direct effect, is predicted to have adverse indirect and cumulative impacts to all natural systems and habitats.

While both action alternatives would meet the purpose and need for action, alternative 2 best addresses key issues related to the cost and benefits of treatments and effects to biodiversity. Alternative 2 is estimated to cost less to implement over the ten year period while achieving equal or slightly better outcomes than alternative 3 for most resources considered. In impact areas where alternative 3 is expected to perform better (watershed function and aspen regeneration) there is a degree of uncertainty in our prediction of outcomes.

This uncertainty is related to current and predicted climate trends. If warmer trends continue as predicted, aspen forests and watershed function could respond negatively rather than positively to the more intensive thinning. The more intensive thinning and burning prescribed to stimulate aspen under alternative 3, could potentially cause increased warming and drying of the forest floor in these mesic forests. These impacts could be long-term is aspen regeneration and maturation is not successful. This potential impact to mesic habitats, which include critical habitat designated for the Jemez Mountains Salamander was an important factor in determining our preference.

We believe the more conservative approach to restoration as described under alternative 2 will clearly meet the purpose and need for action. Further, alternative 2 does provide for some level of aspen restoration. This less intensive approach will allow us to monitor the outcomes of our aspen restoration prescriptions. In the future we can evaluate the outcomes of our actions as well as the effects to aspen brought about by the Las Conchas fire and adjust our actions if warranted.

This approach is in keeping with the principles of science based adaptive management and the management principles of the trust including: "*We will exercise restraint in the implementation of all programs, basing them on sound science and adjusting them consistent with the principles of adaptive management.*" (The complete list of the management principles are included in *Chapter 3 – Setting.*)

2.9 Alternative Comparison

This section highlights the actions and outcomes of the action alternatives based on the analysis provided in *Chapter 5 – Environmental Consequences.* It does not summarize that chapter but merely highlights the differences in the alternatives and where these differences were important in identifying the preferred alternative.

2.9.1 Actions

The action alternatives (2 and 3) vary in the acres of mechanical treatment, thinning prescriptions, and the ecotypes treated mechanically , and with follow up prescribed burning (Table 2-12); other restoration actions would be the same.

Table 2-12. Comparing 10-year proposed mechanical treatment acres presented by ecotype (differences between alternatives are in bold)

Ecotype	Alternative 2 10-Year MECH Acres	Alternative 3 10-Year MECH Acres
FR I Montane Grassland	3236	3236
Ponderosa Pine Savanna	1032	1032
Ponderosa Pine Forest	3817	3817
Xeric Mixed Conifer	2957	2957
Blue Spruce Fringe	53	53
Mesic Mixed Conifer	5471	5756
Mesic Mixed Conifer (HFRE)[a]	1205	322
Aspen/Mixed Conifer	2020	3493
Aspen/Mixed Conifer (HFRE)	295	0
Xeric Spruce-fir	764	429
Mesic Spruce-fir	445	0
Mixed Montane Shrublands	200	200
Totals	**21495**	**21295**

a - Hazardous fuels reduction on steep slopes

This section summarizes only the actions and impacts that *vary* between the alternatives including costs, changes to the ecological condition, wildland fire behavior potential, watershed function, wildlife and terrestrial habitats, cultural resources and scenery.

2.9.2 Cost Comparison

Table 2-13 below compares the intensity and costs for thinning and prescribed burning for alternative 2 and alternative 3. Alternative 3 is anticipated to cost nearly $3.5 million more over the 10-year planning period due to more intensive mechanical treatment. Dollars are estimates based on direct and indirect (12.5 percent) costs, reflecting current costs and dollars. It does not reflect potential market value, which today are not significant but we believe could increase as the supply of small diameter material become more reliable. Table 2-14 shows the potential economic benefits based on information from the similar Collaborative Forest Restoration Program. They are similar for the ten year period as both alternatives propose to treat a similar amount of acreage. The higher costs for implementing alternative 3 was a consideration in our identification of alternative 2 as the preferred alternative.

Table 2-13. Comparing the intensity and cost of mechanical treatments (action alternatives only)

MECH Prescription	Acres		Cost/Acre ($)	Total Cost ($)	
	Alt. 2	Alt. 3		Alt. 2	Alt. 3
REST – Restoration	11095	11095	800	8,876,000	8,876,000

ASRE – Aspen Restoration	2020	9,677	950	1,919,000	9,193,150
FOHE – Forest Health	5480	0	700	3,836,000	0
HFRE - Hazardous Fuels	2900	522	600	1,740,000	313,200
Total	21,495	21,295		16,371,000	18,383,150
WFPF Type					
WFBD	21,495	23,498	150	3,224,250	3,524,700
WFPF - Grasslands	12,340	12,340	75	925,500	925,500
WFPF – Forest/Woodland	15,990	15,990	200	3,198,000	3,198,000
Total	49,825	51,828		7,347,750	7,648,200
Grand Total				**23,718,750**	**26,031,350**

Table 2-14. Economic benefits per acre treated for CFRP

	Benefit/acre	Alt. 2	Alt. 3
Acres Treated		21,495	21,295
Output per Acre Treated	$1,397.14	$30,031,524	$29,752,096
Total Value Added per Acre Treated	$832.74	$17,899,746	$17,733,198
Labor Income per Acre Treated	$731.57	$15,725,097	$15,578,783
Number of Jobs per Acre Treated	0.03	644.85	638.85

Source: Starbuck et al. (undated)

2.9.3 Ecological Condition Comparison

Chapter 4, *Affected Environment* describes in detail the method used for assessing ecological condition and departure which can be expressed as a *Vegetative Condition Class* rating or VCC. In summary the ratings are: 0-30 = No Departure (*Good*), 31-65 = Moderately Departed (*Fair*), 66+ = Significantly Departed (*Poor*). Table 2-15 below compares the expected VCC under the no action and both action alternatives. The red indicates a VCC of Poor, orange, yellow, and yellow-green all fall within the range of Fair both fall into a rating of fair. The variances in color emphasize the variation i.e. one point off Poor versus one point off Good. No forest types either are or would like become within the range of *Good* at the landscape scale. While restoration treatments will create more open forests, only time can create forests dominated by older, larger trees. Alternative 3, by treating so much of the aspen forests creates an overabundance of mid-age, open forests, actually reducing the condition rating in the near-term.

Table 2-15. Alternative comparison; vegetative condition class

Forest Type	No Action VCC	Alt. 2 VCC	Alt. 3 VCC
Ponderosa Pine Savanna	65	65	65
Ponderosa Pine Forest and Woodland	79	64	64
Xeric Mixed Conifer	82	65	65
Mesic Mixed Conifer	56	31	31
Aspen Mixed Conifer	58	55	64
Xeric Spruce-fir	74	65	65
Xeric Spruce-fir	65	65	65

2.9.4 Wildland Fire Behavior Potential

Alternative 2 targets mixed conifer, aspen mixed conifer, and spruce-fir stands based on the degree of fire behavior potential, while alternative 3 selects stands based on the potential to regenerate aspen.

Therefore, it is not surprising the alternative 2results in treating the most acres with the highest degree of fire behavior potential (Figure 2-26).

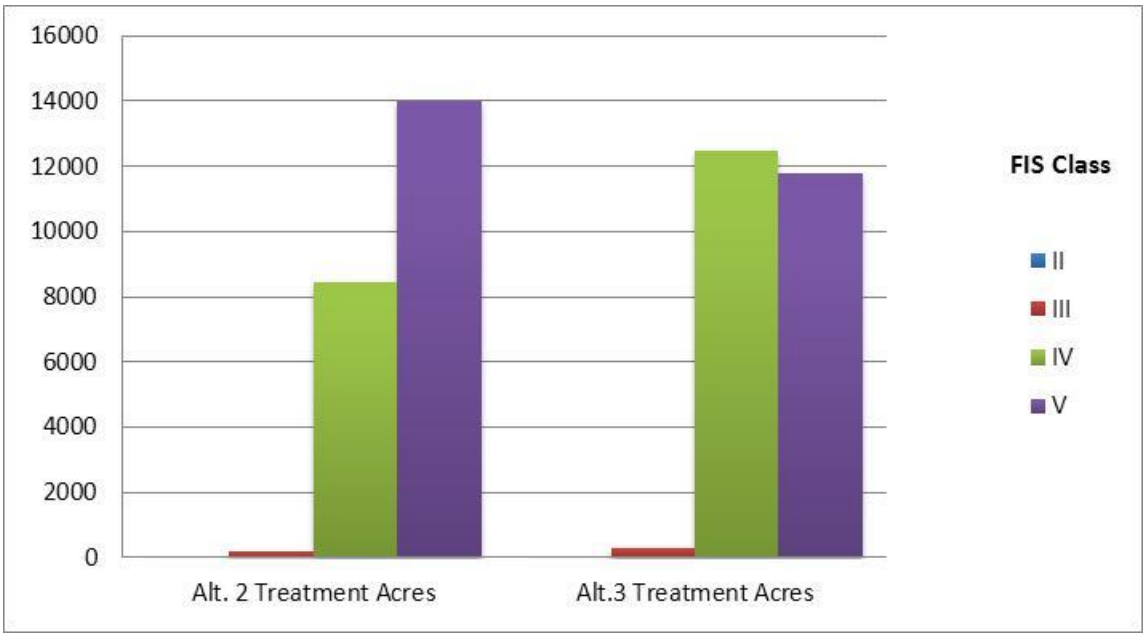


Figure 2-26. Acres treated by FIS Class. V = the greatest fire behavior potential (Scott, November 2006)

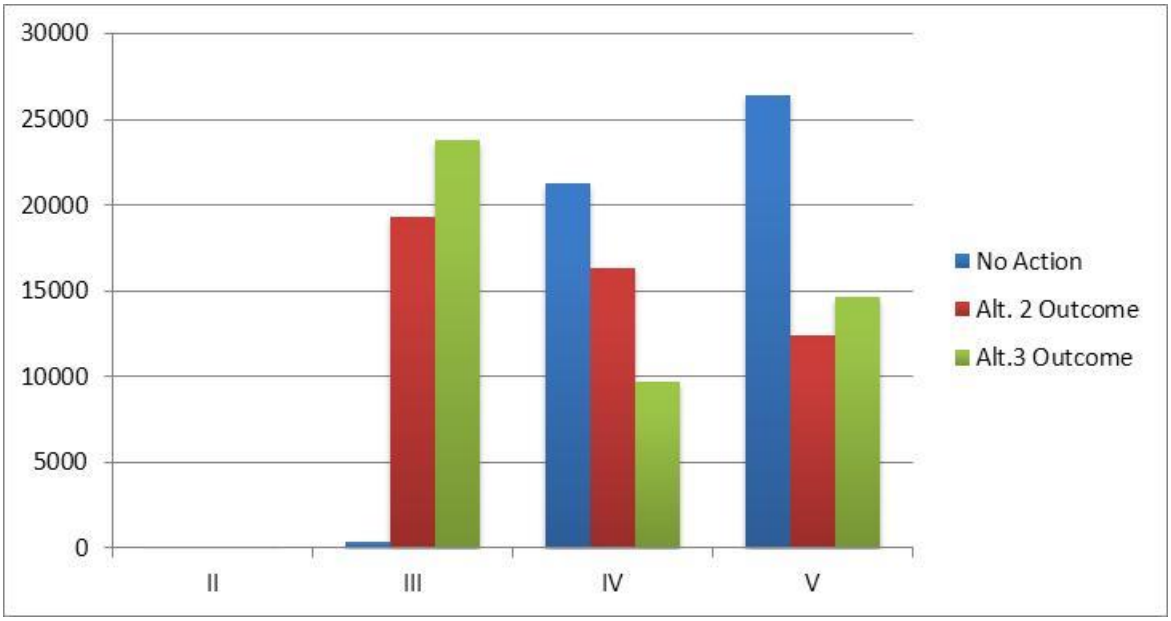
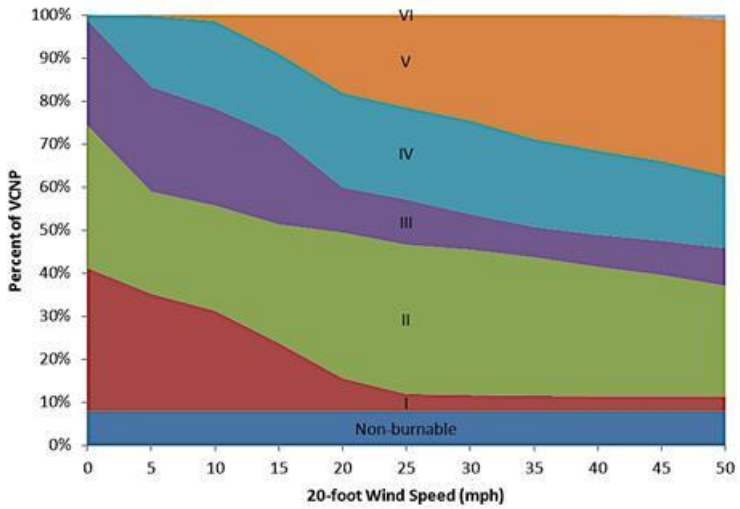
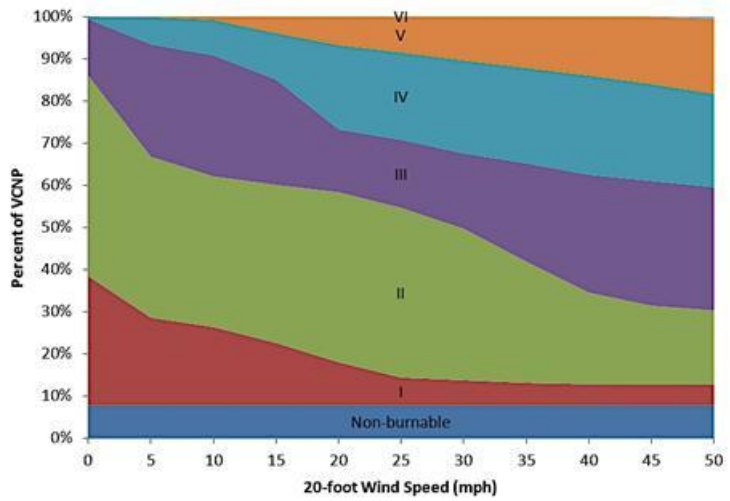


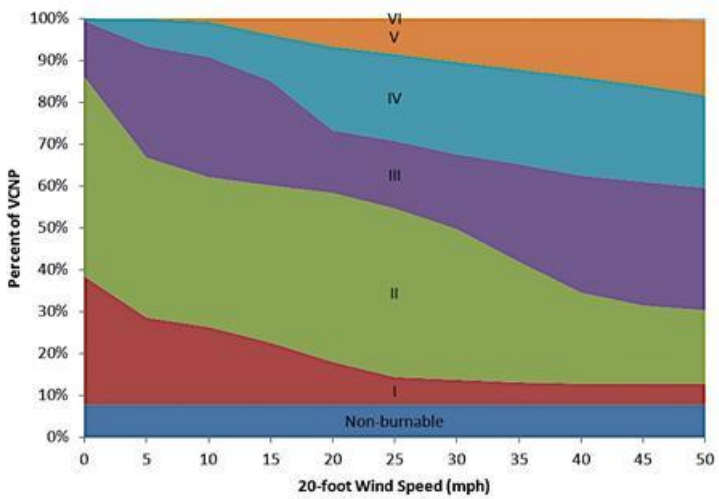
Figure 2-27. Distribution of treatment acres by FIS Class; no action and action alternatives

We also analyzed the treatments under various weather scenarios. Figure 2-28 below shows the wildland fire behavior potential across the preserve under hot and dry conditions, and under various wind speeds for the no action and each alternative action. As shown, the percent area across the preserve with the potential to burn in FIS classes IV and V (characterized by active crown fire and severe

impacts to productivity and forest succession) are reduced preserve-wide by either of the action alternatives while the percent with the potential to burn in FIS class III is increased.

	Alternative 1 No Action FIS Class as a percent under various weather scenarios
	Alternative 2 Collaborative Restoration Strategy FIS Class as a percent under various weather scenarios

Note: Figure continues on following page



Alternative 3
Aspen Restoration
FIS Class as a percent under various weather scenarios

Figure 2-28. Percent of VCNP predicted to burn at various FIS classes under various wind speeds for each alternative

2.9.5 Watershed Capture, Storage, Yield

Both action alternatives may have minor localized impacts to soil and water due to disturbance from use and access by equipment. Overall both approaches to forest restoration would measurably improve the watershed condition on the preserve. Alternative 3 is predicted to cause a greater increase in water capture, storage and yield (Table 2-16).

Table 2-16. Increase in annual flow for the action alternatives. Calculations based on an assumed increase of 15 percent snow depth

	Alternative 2			Alternative 3		
Watershed	Watershed Area with Xeric Forest and Aspen Emphasis (%)	Annual Yield Increase (%)	Annual Yield Increase (AF)	Watershed Area with Xeric Forest and Aspen Emphasis (%)	Annual Yield Increase (%)	Annual Yield Increase (AF)
E F Jemez	6.5	1.0	89	8.7	1.3	118
San Antonio	8.6	1.3	106	13.8	2.1	171
Redondo	24.8	3.7	12	33.0	4.9	17
Sulphur	17.0	2.6	13	28.0	4.2	22

2.9.6 Air Quality

Both action alternatives have the potential to cause localized, short term impacts to air quality from prescribed burning and dust from operations but to reduce the potential for more extensive intrusions from severe burning. Alternative 3 proposes slightly more intensive thinning that may lead to heavier

fuel loads i.e. greater smoke production. This potential weighed into our identification of alternative 2 as the preferred alternative.

2.9.7 Wildlife and Terrestrial Habitats

Both action alternatives could cause minor, short term adverse impacts to terrestrial species and habitats from disturbance. However both alternatives would ultimately benefit wildlife species by protecting habitats and individual animals from severe burning.

Alternative 2 proposes less thinning and less intensive prescriptions within the mesic mixed conifer and aspen mixed conifer preferred by Jemez Mountains Salamander than alternative 3. Mitigation measures intended to reduce or eliminate impacts to the salamander apply to all action alternatives, but the less intensive treatments proposed under alternative 2 have less potential to adversely affect the salamander and its habitat.

This potential weighed into our identification of alternative 2 as the preferred alternative.

2.9.8 Cultural Resources

Both action alternatives would have the potential to cause localized, minor, impacts to individual sites. Overall both alternatives would benefit cultural resources by reducing the potential for severe burning and by completing extensive inventory of the cultural resources on the preserve. However, with its greater emphasis on treatments within forests where aspen is present, alternative 3 would propose a greater likelihood of impacting aspen carvings. However, performance requirements to locate and avoid or otherwise mitigate potential impacts to cultural resources apply to both action alternatives.

2.9.9 Scenery

Under alternative three more intensive thinning would occur in the aspen forests. These forests add diversity to the forested landscapes, especially in the fall Figure 2-29. Although the intent is stimulating more cover by aspen, the short term negative effect to scenery would be more pronounced under alternative three. Further, there is uncertainty as to the successful stimulation of aspen and its recruitment into the canopy overtime. The presence of elk, as well as the current climate trends is the source of this uncertainty. This potential weighed into our identification of alternative 2 as the preferred alternative.

Figure 2-29. Autumn, aspen over frosted grassland (photo by Rourke McDermott)

Chapter 3. Setting

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

The Valles Caldera National Preserve includes much of the *Valles* caldera, a geologic formation easily identifiable from space. The term *valle is* a Spanish term, which refers to the large grassy valleys; *caldera* is a cauldron-like volcanic feature usually formed by the collapse of land following a volcanic eruption; sometimes confused with volcanic craters. The *Valles* caldera is the "type specimen" of a resurgent caldera, a kind of complex volcano. As well as being a geologic term, *caldera* is also a Spanish term meaning "cooking pot".

3.1 Physical Setting

3.1.1 Location

The Valles Caldera National Preserve (VCNP) is located in north central New Mexico, primarily in Sandoval County but with an inclusion in Rio Arriba County. As shown in Figure 3-1., the VCNP is a unit of National Forest System land surrounded by the Santa Fe National Forest (SFNF) and abuts Bandelier National Monument (BNM) to the southeast and Santa Clara Pueblo tribal lands to the northeast.

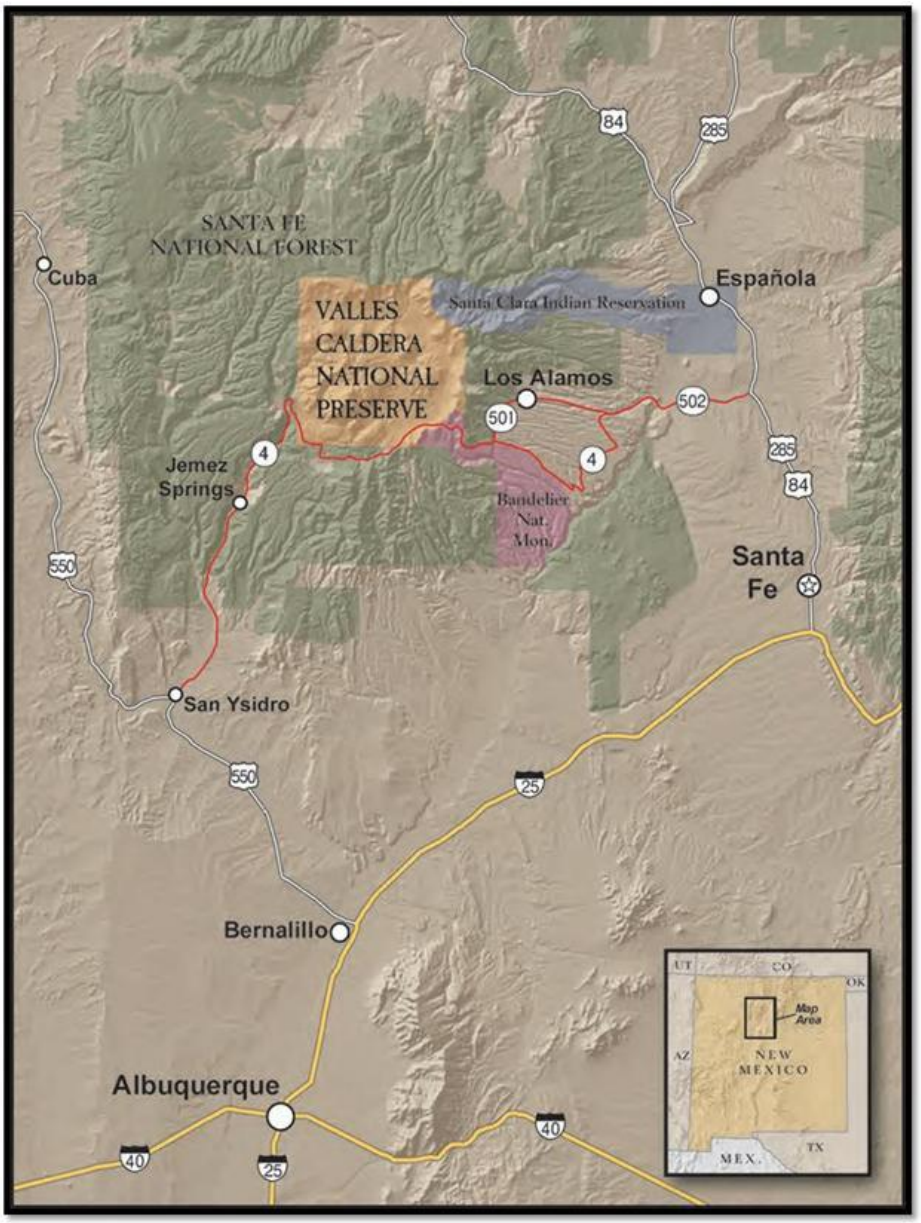


Figure 3-1. Location and jurisdictional setting of the VCNP

At the southern extent of the Rocky Mountain range, the Valles Caldera sits atop the Jemez Mountains, at the southernmost point of the Southern Rocky Mountains Level III Ecoregion[27] of the United States shown in Figure 3-2 (Griffith, et al., n.d.). The Preserve presents a unique landscape form in the Southern Rockies. The Valles Caldera is a largely intact volcanic caldera characterized by expansive grassland valles (valles) with a series of forested domes. Perennial streams that originate in the caldera meander through the grasslands and contribute to the Jemez River. Figure 3-3 highlights the major landscape features of the preserve.

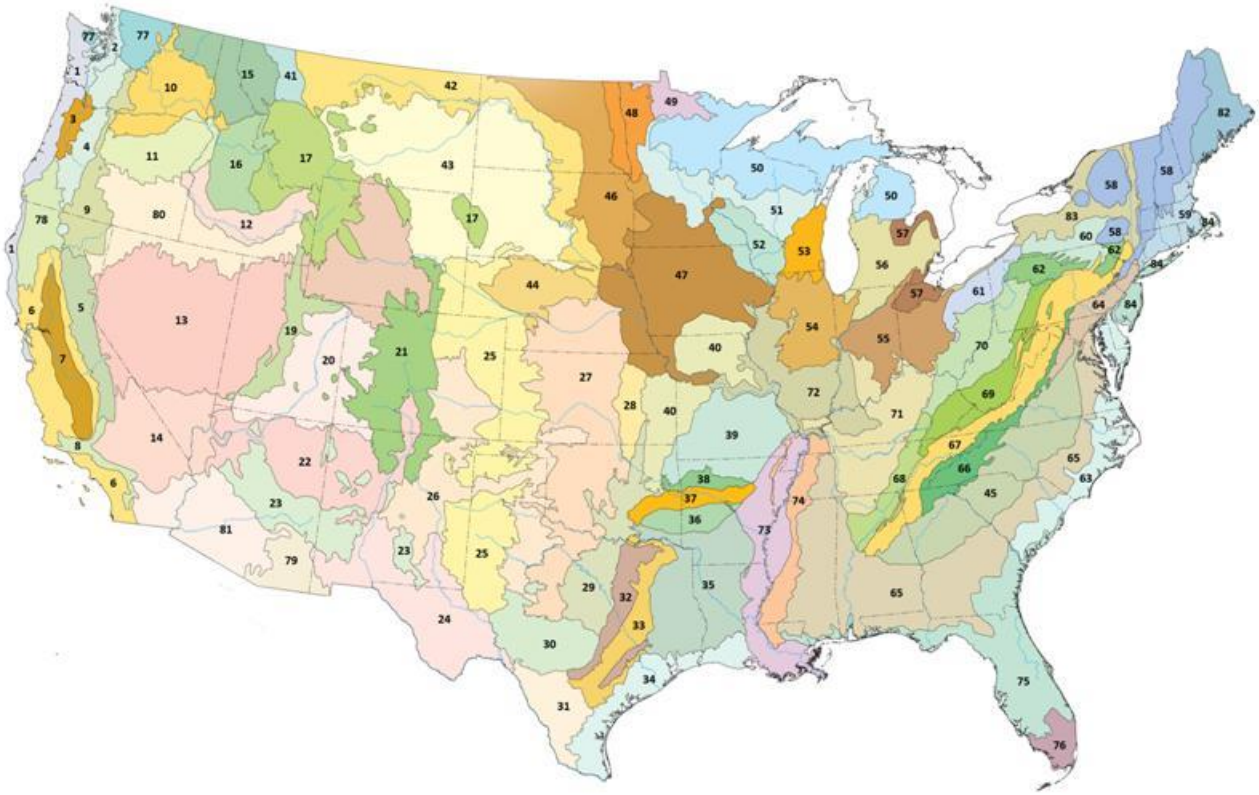


Figure 3-2. Level III ecoregions of the United States

[27] **Southern Rockies Level III Ecoregion** - The Southern Rockies are composed of high elevation, steep, rugged mountains. Although coniferous forests cover much of the region, as in most of the mountainous regions in the western United States, vegetation, as well as soil and land use, follows a pattern of elevation banding. (Griffith, et al., n.d.)

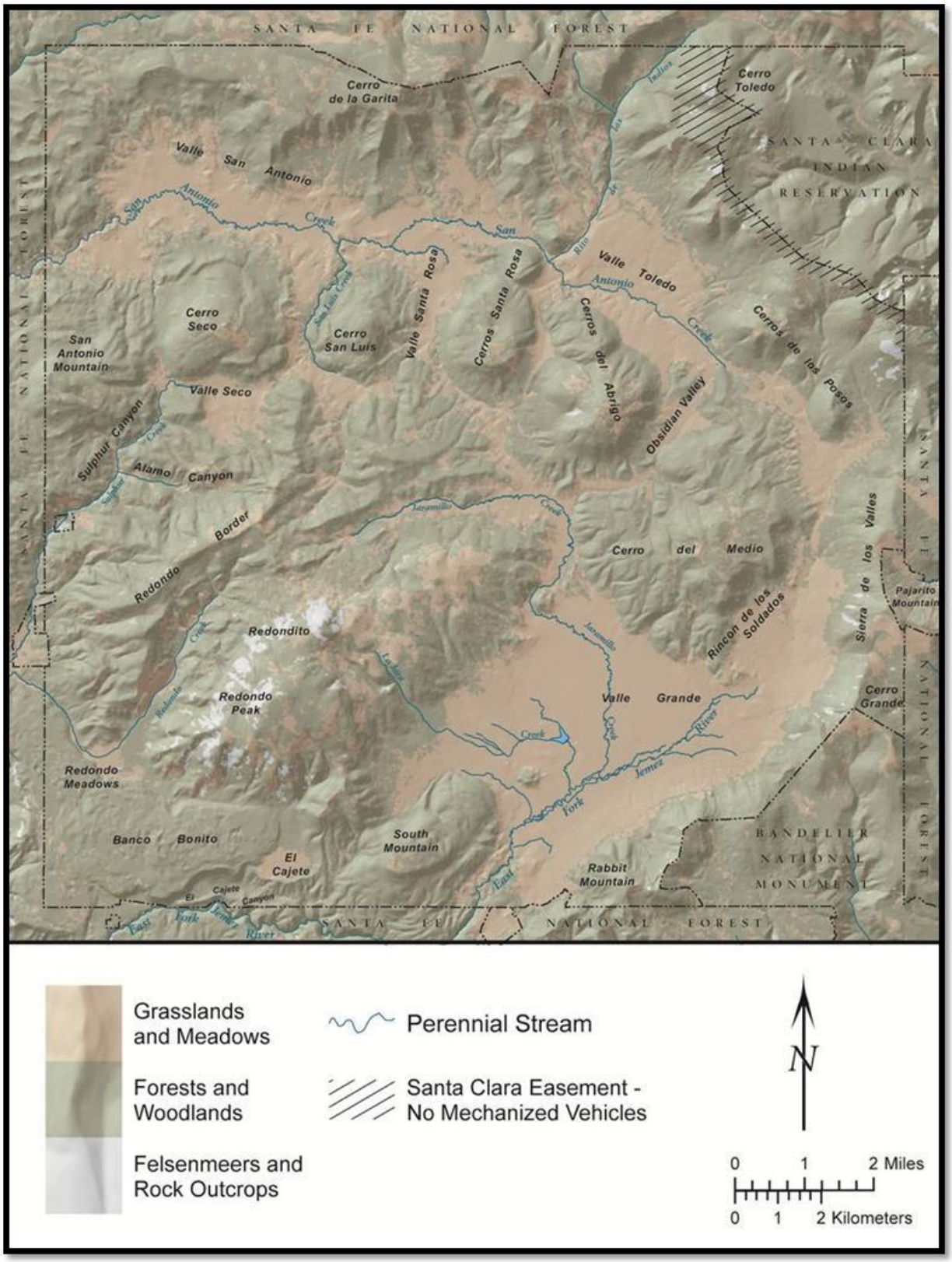


Figure 3-3. Landscape features of the VCNP

3.1.2 Geology

About 1.25 million years ago, a spectacular eruption created the 13-mile wide crater-shaped landscape now commonly known by the place name, Valles Caldera. The eruption tapped a vast magma chamber that exploded catastrophically, depleting the magma chamber and creating a void into which the surface landscape collapsed. The enclosed caldera filled with water forming a large freshwater lake. The subsurface remained in turmoil as new magma refilled the collapsed chamber, and within 50,000 years Redondo Peak rose up through the lake bottom. Following the resurgence of Redondo Peak, the first of many eruptive flows from ring fractures in the caldera formed the dome at Cerro del Medio, followed by Cerro del Abrigo. This continued counter clockwise around the ring fracture creating the domes in the northern half of the caldera; these eruptions periodically blocked flows from the Rio San Antonio, forming a series of northern caldera lakes that would periodically drain as rising lake levels eventually breached the volcanic deposits.

From about 550,000 to 500,000 years ago, the southwestern portion of the caldera experienced additional dome formation eruptions, creating Cerro la Jara and South Mountain. These eruptions plugged the outflow of the ancestral East Fork Jemez River, forming yet another deep, freshwater lake in what is now the Valle Grande. About 250,000 years ago, this lake breached, emptying the caldera of water and sediments and forming San Diego Canyon to the southwest.

Approximately 55,000 years ago, an explosive eruption occurred in the southwest corner creating the crater known as El Cajete. The resulting pyroclastic flow filled in much of the Jemez river valley, and through subsequent erosion by the Jemez River, produced the striking landmark known as Battleship Rock where the waters from the Valle San Antonio meet the East Fork of the Jemez River flowing from the Valle Grande. Then, about 40,000 year ago, the last known eruption produced the broad sloping landform in the southwest corner known as the Banco Bonito. The Valles Caldera, while not the largest, is one of the most intact calderas in the world, making it ideal for studying the complex geology of caldera formation (Goff, et al., 2011; Goff, 2009; Kempter and Huelster, 2009). The 2011 Geology Map (Goff, et al., 2011) is presented in Figure 3-4 below.

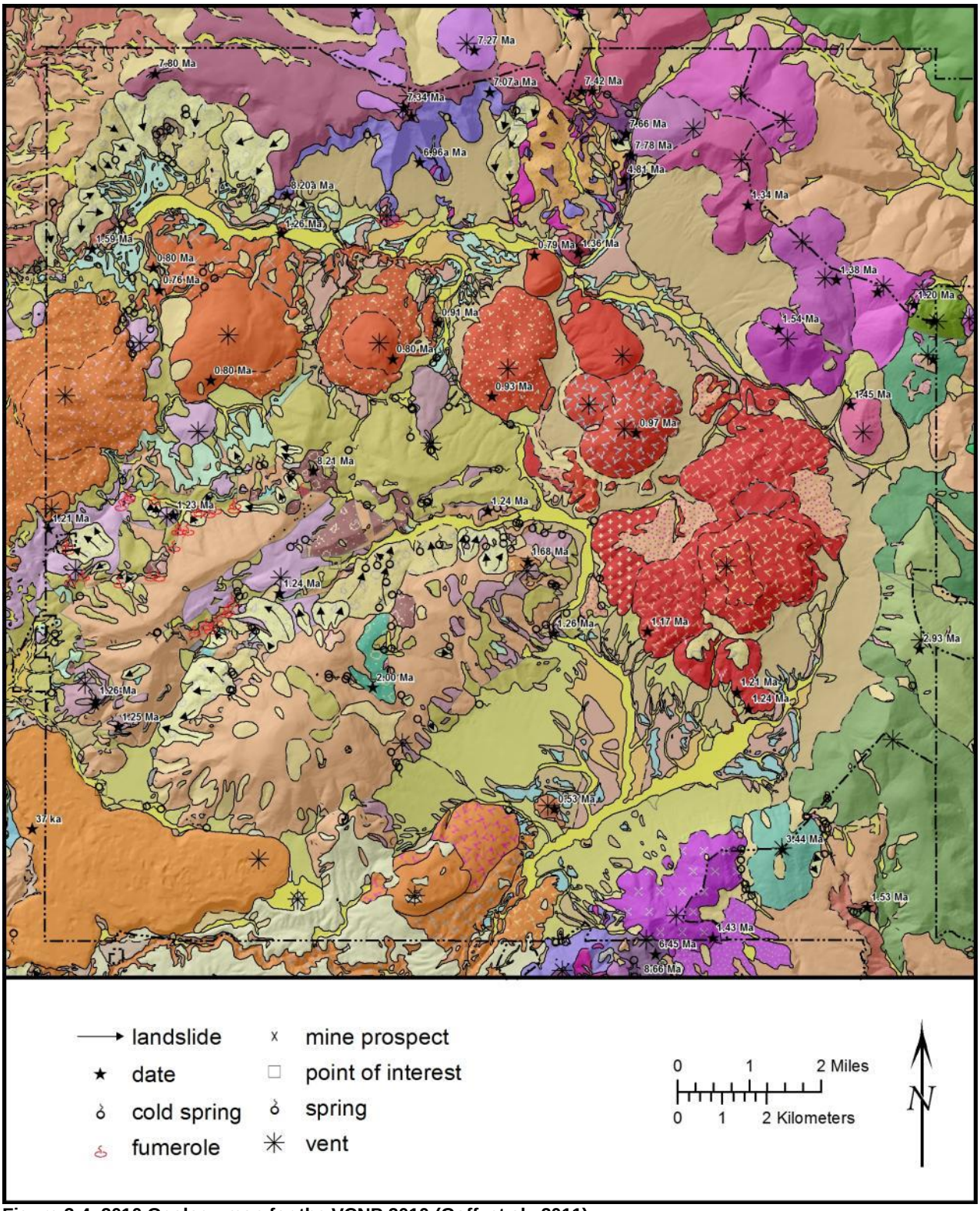


Figure 3-4. 2010 Geology map for the VCNP 2010 (Goff, et al., 2011)

3.1.3 Climate

The regional climate is semi-arid continental[28]. Cyclonic storms associated with the polar jet stream bring snow in the winter and rain in the spring and fall. April through June is usually dry. Half or more of the precipitation comes in the summer months in the form of convectional "monsoon" storms when the Bermuda high-pressure system drives moist oceanic air into the Southwest. Periodic El Niño events bring increased winter and spring precipitation to the Southwest, while interspersed La Niña events cause droughts. El Niño events affect stream flows, wildfire activity, and plant productivity (Allen, 2004).

The climate scenario is modified by the high elevations and topographical variability of the preserve. The average precipitation reported for Los Alamos is 18.93 inches and over 35 inches at the caldera rim (Allen, 1989). The annual average precipitation at the Valle Grande weather station (2003-2012) was 23.9 inches (Figure 3-5). Snow accumulation, while minimal at Los Alamos, can be significant in the Valles Caldera. The temperatures at the highest elevations of the preserve may be 25-35°F colder than Los Alamos; the valles are 10-15°F colder still. The effect of the cold air drainage into the valle bottoms may drive temperatures down even further (Muldavin E., 2006); the low temperature recorded at the Valle Grande (2003-2012) was -24ºF.

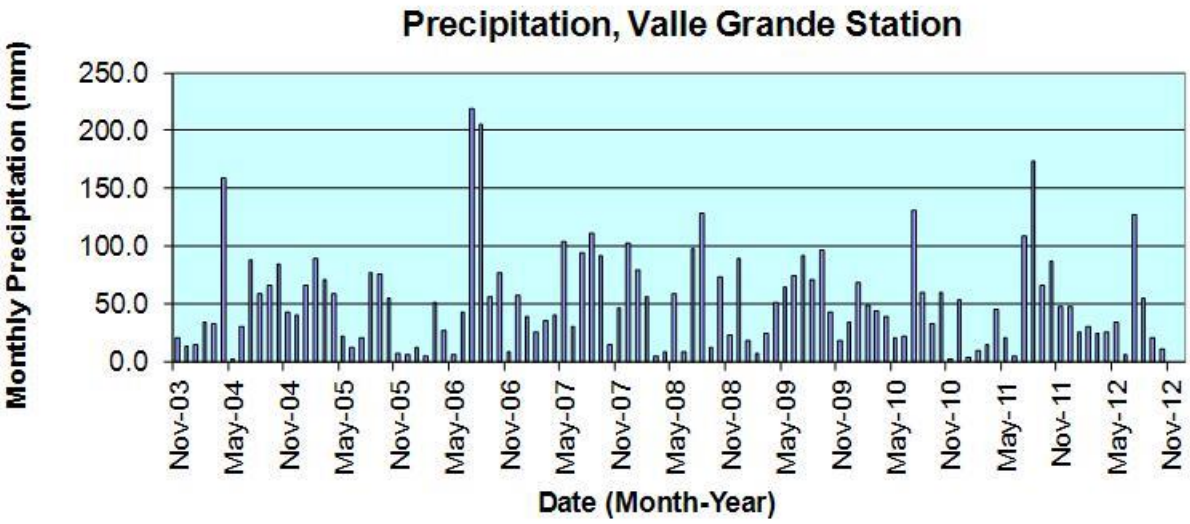


Figure 3-5. Precipitation measured at the Valle Grande climate station 2003 – 2012

28 Semi-arid is a climate between desert and humid climates; continental is climate which is not influenced by a large body of water.

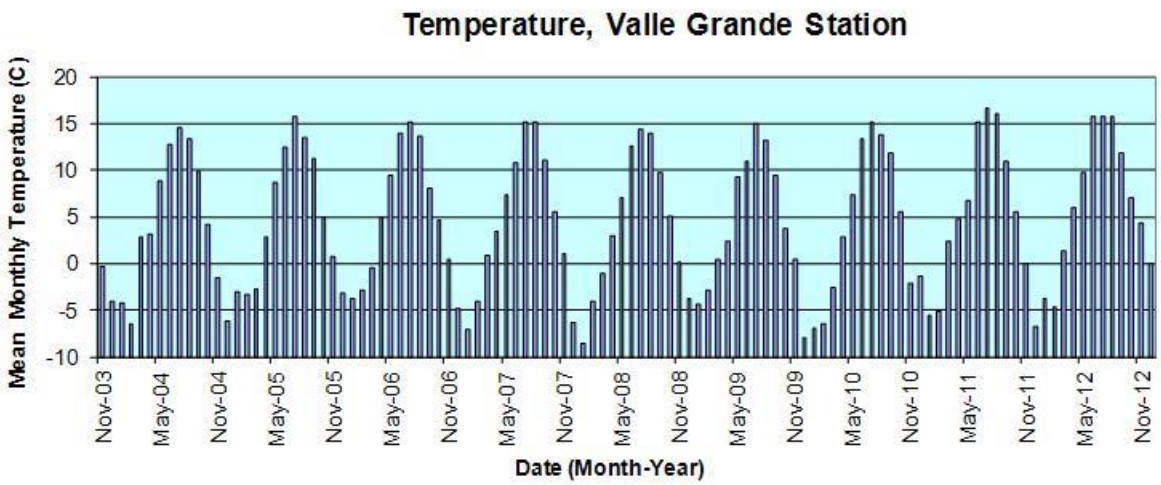


Figure 3-6. Mean monthly temperatures measured at the Valle Grande climate station 2003 - 2012

Conditions on the preserve are confounded by several trends. Weather records dating back to 1914 show a general increase of warmer temperatures and drier conditions over the past century (Figure 3-7-Figure 3-9). Figure 3-7, shows the mean annual temperature while Figure 3-8 and Figure 3-9 , which follow, highlight the mean temperature for the July and January, illustrating that summer-time temperatures have increased to a greater degree.

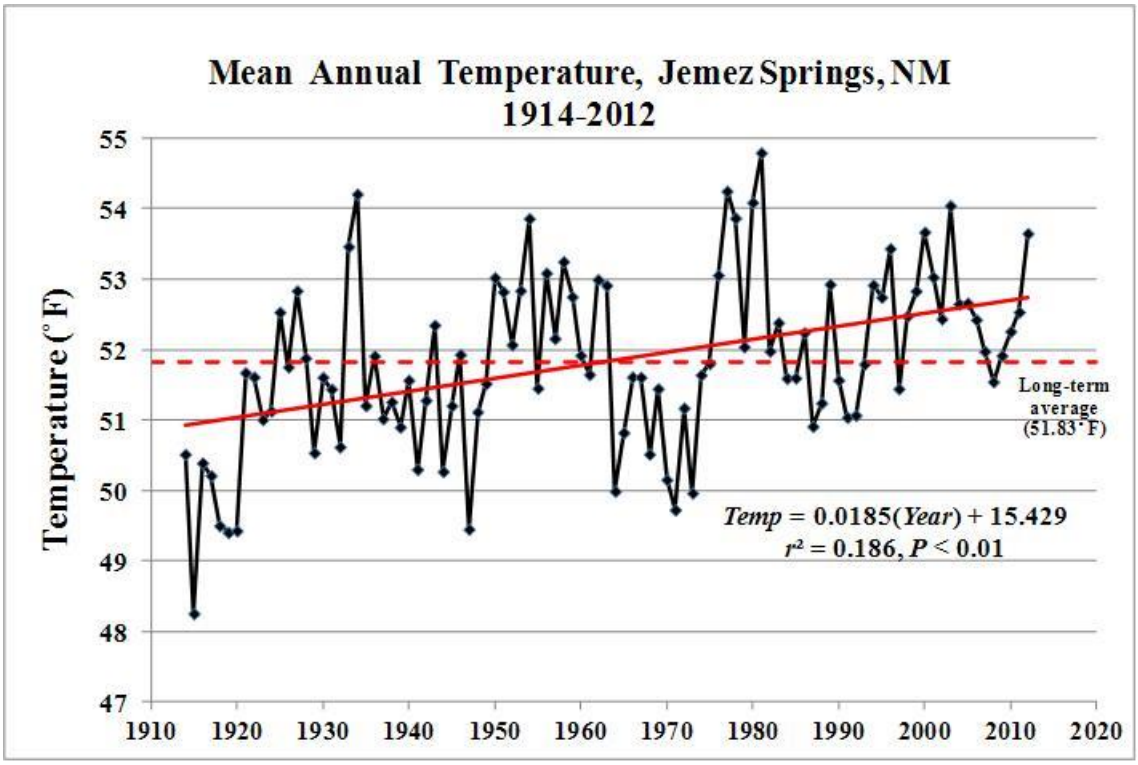


Figure 3-7. Mean annual temperature at Jemez Springs: 1910 – 2012

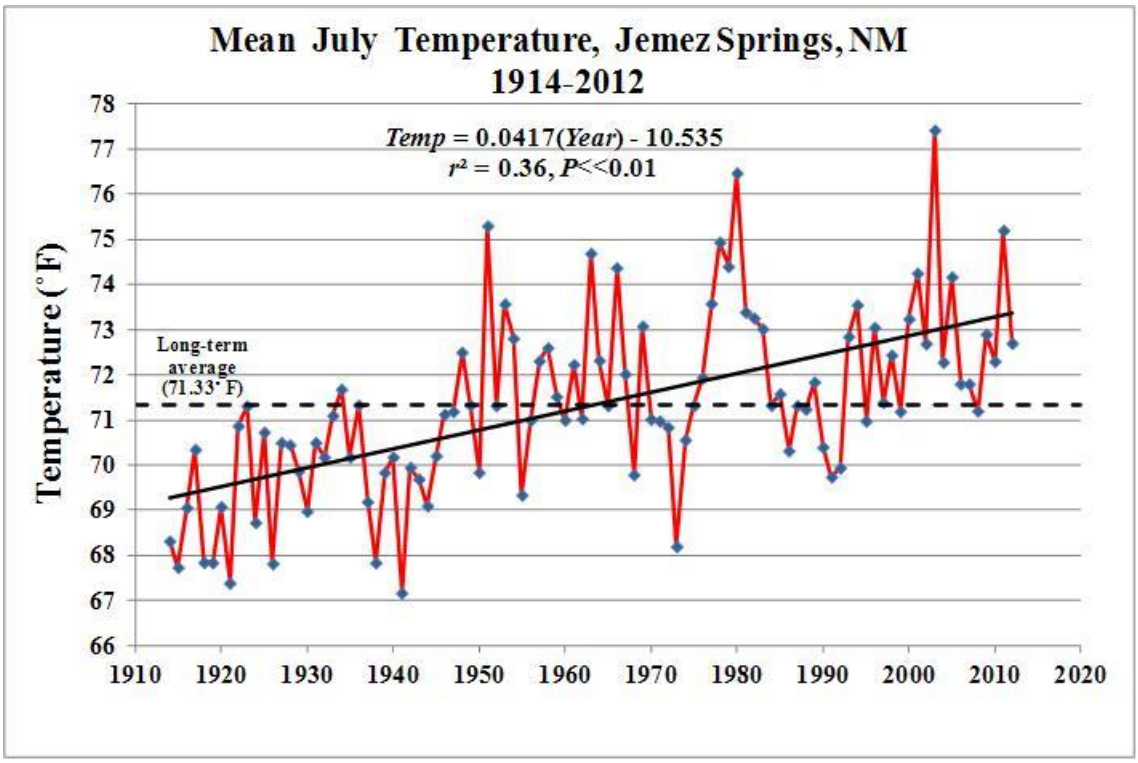


Figure 3-8. Mean July temperature: 1914 – 2012

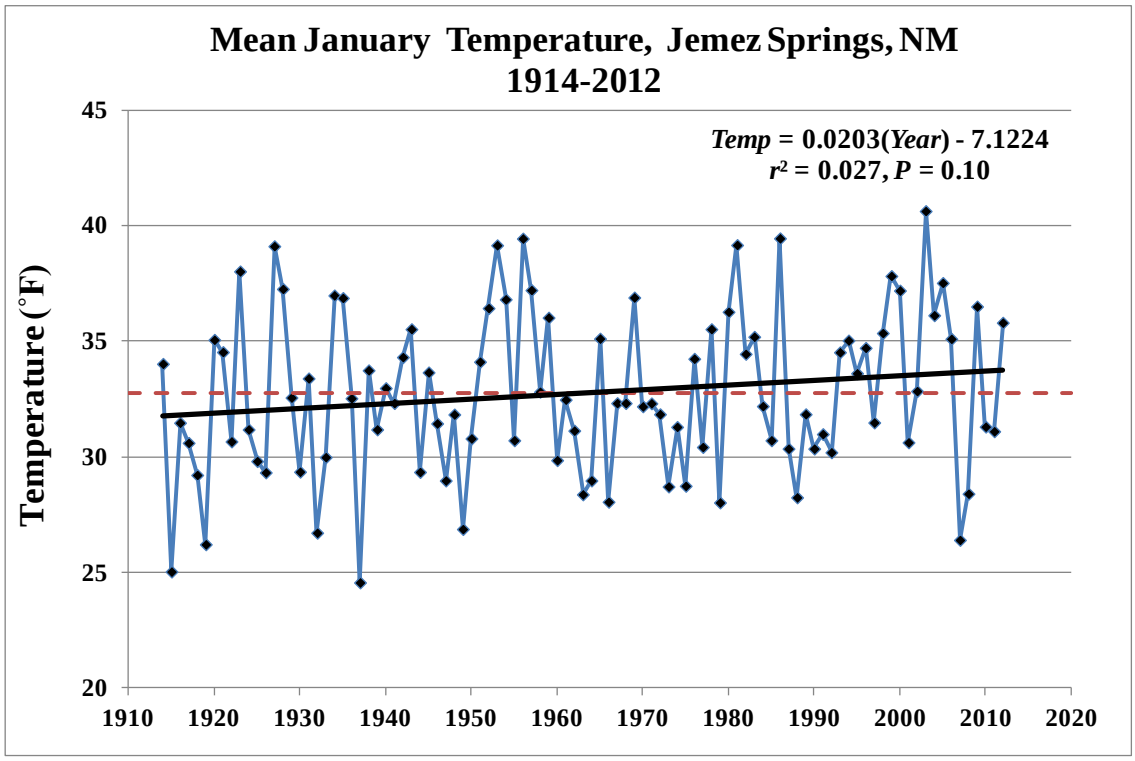


Figure 3-9. Mean January temperature in Jemez Springs: 1914 - 2012

A simple linear regression of weather data indicates a decline in precipitation of .03 inches annually as depicted in Figure 3-10. However, fitting a 4th order polynomial shows the correlation with the Pacific Decadal Oscillation (PDO)[29] with distinct wet and dry periods of about 25 years. This correlation is depicted in Figure 3-11; note the trend of lower values in the troughs and peaks. Also note the extreme variability in year-to-year climate displayed. In the 1950's, one year measured 6 inches of precipitation with the following year measuring over 25 inches; a fourfold difference.

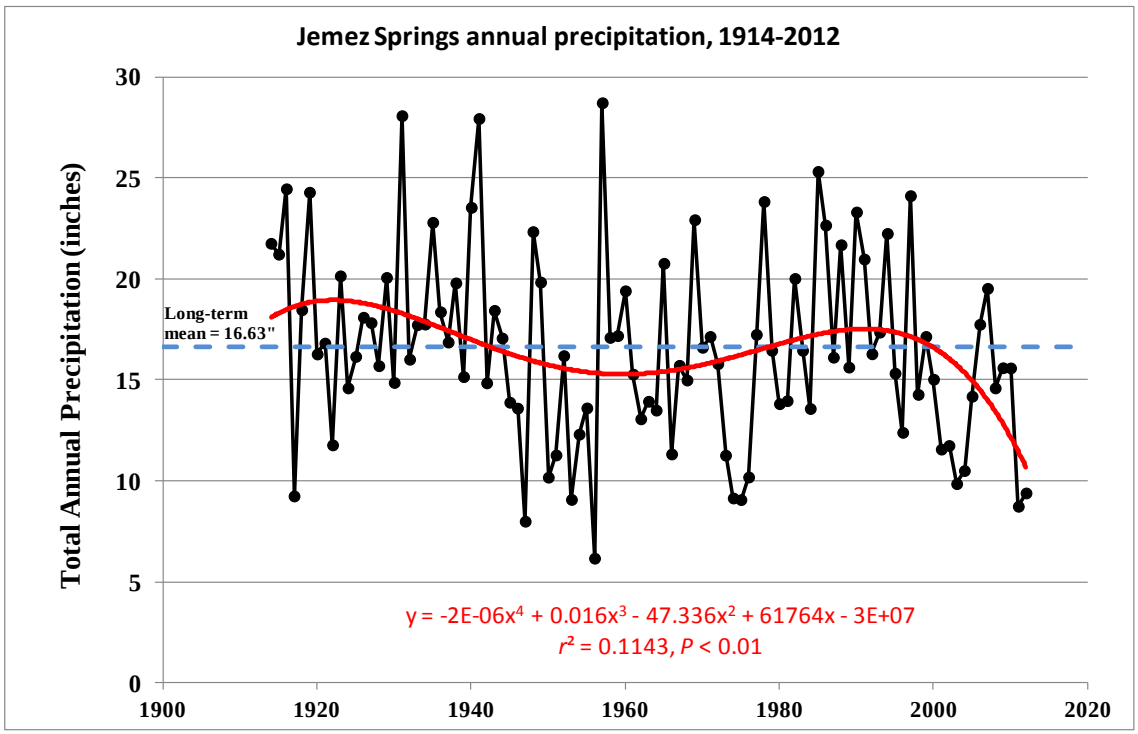


Figure 3-10. Mean monthly precipitation, Jemez Springs, New Mexico: 1914-2012. Note cyclic pattern, and that peaks and troughs appear to be moving lower.

[29] The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of 20° N. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs.

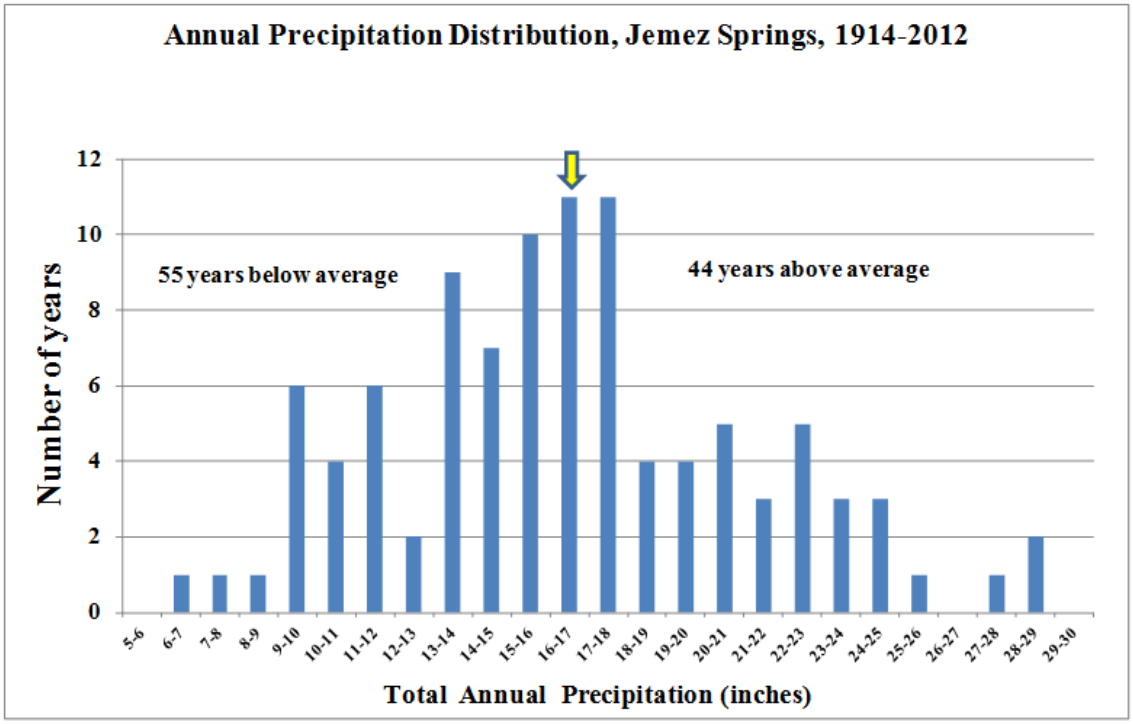


Figure 3-11. Distribution of annual precipitation, Jemez Springs, New Mexico: 1914-2012. Note: more below-average years during 1914-2012 than above-average years.

It is critical to appreciate that the climate of the Jemez Mountains is changing, becoming warmer and more arid. The records depicted in the figures above show clearly that temperatures have risen significantly during that period, and that summer temperatures (July) have been rising faster than winter temperatures (January). In addition, precipitation follows a cycle that mirrors the Pacific Decadal Oscillation, operating on a time scale of 50-60 years per cycle. The Jemez Mountains are currently in a drought phase that will likely last another 10-20 years into the future. The effects of warmer temperatures and less precipitation are manifested in both longer and more severe fire seasons (Westerling, et al., 2006), and changes in grassland forage production (and eventually plant species composition) – factors that will affect forest and fire management, livestock grazing, wildlife, recreation and watershed health. From Figure 3-11, one can also see that there are more below-average precipitation years than above-average years over the last century, potentially leading to below-average precipitation years being more likely to occur in the future if this pattern continues.

3.2 Biodiversity

Compared to other high elevation sites in the southern Rocky Mountains and Colorado Plateau, the vegetative communities of the preserve are quite diverse and harbor many plant communities that are unique to the landscape (Valles Caldera Trust, n.d.). The New Mexico Natural Heritage Program has documented 65 plant associations within the preserve encompassing high elevation sub-alpine forests, mixed conifer and pine woodlands, high montane grasslands, and valley floor wetlands. The extensive montane grassland and wetland communities found on the preserve are relatively scarce anywhere in

the Southern Rocky Mountains Ecoregion (Muldavin and Tonne, 2003). Major cover types and acreages are listed in Table 3-1. The distribution of these cover types on the preserve is displayed in Figure 3-12.

The highly localized occurrence of distinct plant associations, old growth forests, and individual species found on the preserve makes it one the most diverse sites in the Southern Rocky Mountains Ecoregion (Muldavin and Tonne, 2003) representing an uncommon nexus of western North American biomes.

Since we assumed management of the Valles Caldera, many biologists have conducted species inventories, which have informed our knowledge and understanding of the resident flora and fauna. This work, accomplished by professional scientists, students, and expert volunteers, has resulted in comprehensive lists for many groups in the Valles Caldera.

Table 3-1. Cover type and area covered (Muldavin E. 2006) listed in order of dominance

Cover	Acres	% Cover
Mixed conifer forest and woodland	36,566	40.4
Montane grasslands	19,858	22.4
Ponderosa pine forest	9,241	10.4
Spruce/fir forest	7,005	7.9
Wetlands and wet meadows	6,853	7.7
Aspen forest and woodland	5,103	5.8
Roads-disturbed ground	1,536	1.7
Gambel oak-mixed montane shrubland	1,443	1.6
Felsenmeer rock field	915	1.0
Sparsely vegetated rock outcrop	159	0.2
Open water	56	<0.1
Post-fire bare ground	17	<0.1
Montane riparian shrubland	14	<0.1
Total	**88,765**	**100.0**

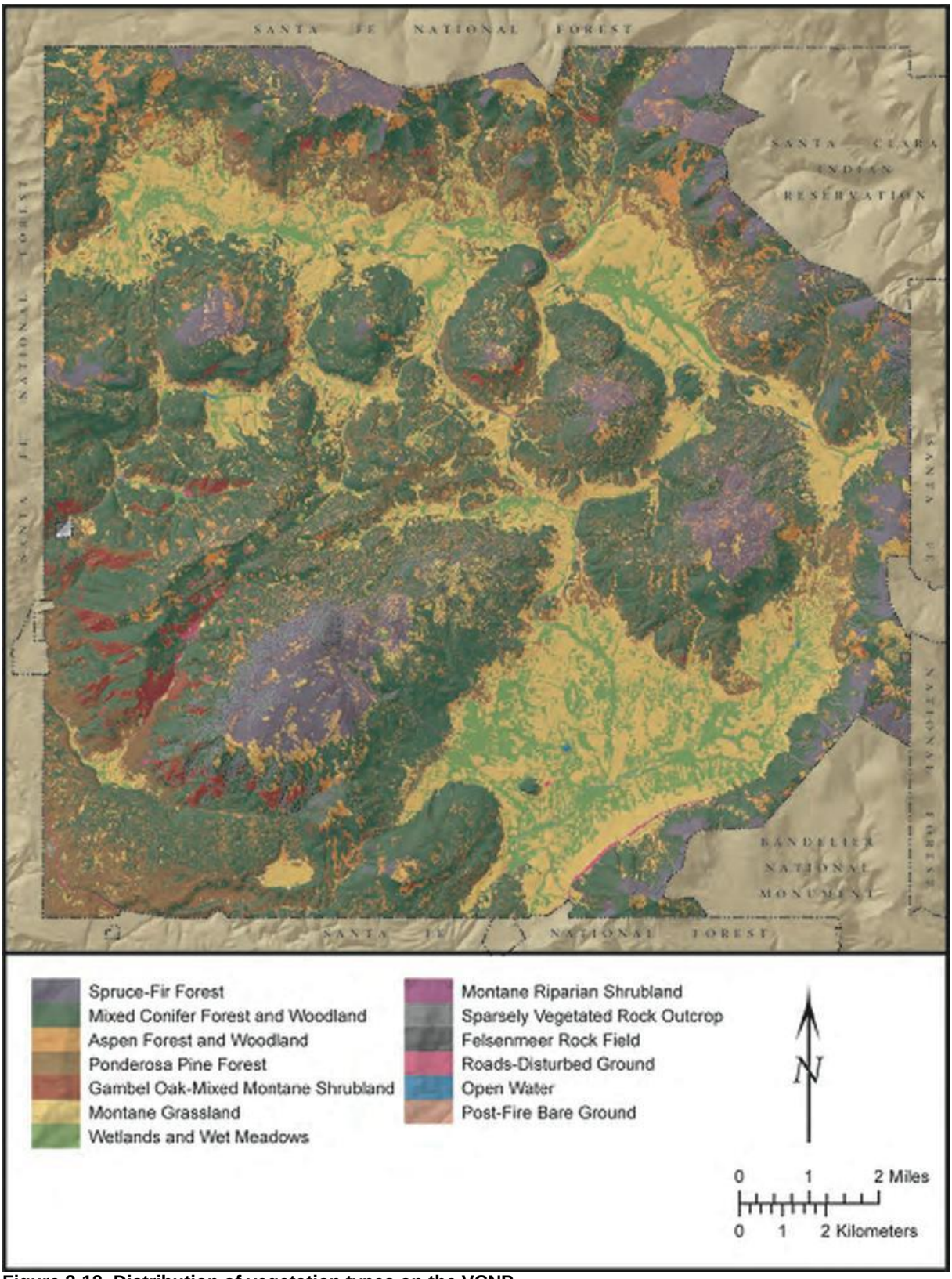


Figure 3-12. Distribution of vegetation types on the VCNP

3.2.1 Plants

Based on plant inventories conducted by University of Wyoming professor Dr. Ron Hartman and his colleagues and graduate students, coupled with surveys by other botanists for specialized groups of plants, the plant list now stands at 536 species listed in Table 3-2. Table 3-3, which follows, lists 23 species that were considered sensitive by the Native Plant Society of New Mexico (Keller, 2010). Among these is *Delphinium sapellonis*, or Sapello Canyon larkspur (a New Mexico endemic found only in the Jemez, Sangre de Cristo and Sandia Mountains). Also among the 536 species are some species that are rare within the region, lying about one hundred miles from the nearest known populations. Bog birch (*Betula glandulosa*), for example, is somewhat common at higher latitudes of the U.S. and Canada, but is found nowhere else in New Mexico except in the Valles Caldera, around the fens in Alamo Canyon. There are five other species listed in Table 3-4, whose only known occurrence in the state is in the VCNP (Hartman and Nelson, 2005; Keller, 2010).

Also of note is the presence of non-native species, many of which are well established. Of the 536 total species, 68 species are non-native (Table 3-5), having either been deliberately introduced to the preserve over the years (e.g., planting of non-native cool-season grasses for livestock forage), accidently introduced via domesticated animals, people and vehicles, or naturally invaded via normal dispersal movements of seeds (e.g., wind). Five of these are classified as noxious weeds in the State of New Mexico. In total, non-native plant species comprise 13 percent of the preserve's flora.

In addition, 16 species of algae and cyanobacteria have been identified on the preserve.

Table 3-2. Plants of the VCNP, organized by life form and families

Plant Taxa	Families	Genus	Species	Non-native
TREES	**6**	**11**	**23**	**1**
Evergreens	2	5	10	
Cupressaceae		1	2	
Pinaceae		4	8	
Deciduous	4	6	13	1
Aceraceae		1	1	
Betulaceae		2	3	
Salicaceae		2	8	
Ulmaceae		1	1	1
SHRUBS	**16**	**31**	**43**	**1**
Agavaceae		1	1	
Anacardiaceae		1	1	
Asteraceae/Compositae		4	10	
Berberidaceae		2	2	
Cactaceae		2	2	
Caprifoliaceae		3	3	
Cupressaceae		1	1	
Elaeagnaceae		1	1	
Fabaceae/Leguminosae		1	1	
Fagaceae		1	1	

Plant Taxa	Families	Genus	Species	Non-native
Grossulariaceae		1	5	
Hydrangeaceae		2	2	
Oleaceae		1	1	
Rhamnaceae		1	1	
Rosaceae		9	11	2
Viscaceae		1	2	
FORBS	**57**	**174**	**325**	**51**
Alismaceae		1	1	
Amaranthaceae		1	2	1
Anacardiaceae		1	1	
Apiaceae		6	7	
Apocynaceae		2	2	
Asclepiadaceae		2	1	
Asteraceae/Compositae		34	63	16
Boraginaceae		6	8	
Brassicaceae/Cruciferae		10	14	9
Callitrichaceae		1	2	
Campanulaceae		1	2	
Cannabaceae		1	1	
Caprifoliaceae		1	1	
Caryophyllaceae		6	13	2
Celastraceae		1	1	
Chenopodiaceae		2	7	3
Clusiaceae {Hypericaceae}		1	1	
Commelinaceae		1	1	
Cornaceae		1	1	
Crassulaceae		1	1	
Ericaceae		7	7	
Euphorbiaceae		1	1	1
Fabaceae/Leguminosae		7	7	6
Fumariaceae		1	1	
Gentianaceae		5	6	
Geraniaceae		1	2	1
Hydrocharitaceae		1	2	
Hydrophyllaceae		2	3	
Iridaceae		2	2	
Lamiaceae/Labiatae		4	4	2
Lemnaceae		1	1	
Liliaceae		7	9	
Linaceae		1	1	
Malvaceae		2	2	1
Nyctaginaceae		1	2	
Onagraceae		4	8	
Orchidaceae		5	11	
Oxalidaceae		1	1	
Parnassiaceae {Saxifragaceae}		1	1	

Plant Taxa	Families	Genus	Species	Non-native
Plantaginaceae		1	2	2
Polemoniaceae		3	3	
Polygonaceae		3	5	5
Portulacaceae		1	1	
Potamogetonaceae		1	6	
Primulaceae		2	2	
Ranunculaceae		8	13	
Rosaceae		4	15	
Rubiaceae		1	3	
Saxifragaceae		2	3	
Scrophulariaceae		8	18	1
Solanaceae		1	1	1
Typhaceae		1	1	
Urticaceae		2	2	
Valerianaceae		1	2	
Verbenaceae		1	2	
Violaceae		1	3	
Zannichelliaceae		1	1	
GRASSES	**4**	**34**	**99**	**15**
Juncaceae		2	11	
Juncaginaceae		1	1	
Poaceae/Gramineae		28	70	15
Sparganiaceae		1	2	
SEDGES	**1**	**4**	**31**	
Cyperaceae		4	31	
FERNS AND FERN ALLIES	**5**	**4**	**15**	
Aspleniaceae		2	1	
Dennstaedtiaceae		2	1	
Dryopteridaceae		1	6	
Pteridaceae		1	3	
Equisetaceae		3	4	
TOTALS		**1**	**536**	**68**

Table 3-3. Sensitive plant species inventoried on the VCNP

Species	Common Name
Cerastium brachypodum	shortstalk chickweed
Corallorrhiza wisteriana	spring coralroot
Cryptogramma acrostichoides	American rockbrake
Cymopterus alpinus	alpine oreoxis
Epilobium saximontanum	Rocky Mountain willowherb
Erigeron lonchophyllus	shortray fleabane
Gentiana aquatica	moss gentian
Geum rivale	purple avens
Luzula comosa	Pacific woodrush
Muhlenbergia sinuosa	marshland muhly

Species	Common Name
Parnassia palustris	mountain grass of Parnassus
Potentilla concinna	Rocky Mountain cinquefoil
Potentilla diversifolia	varileaf cinquefoil
Potamogeton alpinus	alpine pondweed
Potamogeton gramineus	variableleaf pondweed
Potamogeton richardsonii	Richardson's pondweed
Rosa acicularis	prickly rose
Sagittaria cuneata	arumleaf arrowhead
Salix lasiandra	Pacific willow
Scutellaria galericulata	marsh skullcap
Stellaria calycantha	northern starwort
Stellaria umbellata	umbrella starwort
Viola pedatifida	prairie violet

Table 3-4. New state record species found on the VCNP

Family	Genus and Species	Functional Group
Asteraceae/Compositae	*Erigeron acris L. var. asteroides (Andrz. ex Besser) DC. -- 2002*	F
Asteraceae/Compositae	*Microseris nutans (Hook.) Sch. Bip. -- 2002*	F
Betulaceae	*Betula glandulosa Michx. -- 2003*	T
Brassicaceae/Cruciferae	*Lepidium ramosissimum A. Nelson var. bourgeauanum (Thell.) Rollins*	EF
Cyperaceae	*Carex brunnescens (Pers.) Poir. subsp sphaerostachya (Tuck.) Kalela -- 2003*	C
Cyperaceae	*Carex conoidea Willd. -- 2002*	C
Poaceae/Gramineae	*Oryzopsis pungens (Torr. ex Spreng.) Hitchc. Piptatherum pungens (Torr.) Barkworth*	G

Table 3-5. Non-native species inventoried on the VCNP

Family	Genus and Species
Amaranthaceae	[a] *Amaranthus retroflexus L. [5]*
Asteraceae/Compositae	[a] *Bidens cernua L. [1]*
Asteraceae/Compositae	[a] *Carduus nutans L. -- 2003 [2] (noxious weed)*
Asteraceae/Compositae	[a] *Chrysanthemum leucanthemum L. [4[b]2] noxious weed*
Asteraceae/Compositae	[a] *Cirsium arvense (L.) Scop. [3] (noxious weed)*
Asteraceae/Compositae	[a] *Cirsium vulgare (Savi) Ten. [10] (noxious weed)*
Asteraceae/Compositae	[b] *Conyza canadensis (L.) Cronquist var. canadensis [7]*
Asteraceae/Compositae	[a] *Lactuca serriola L. [2]*
Asteraceae/Compositae	[b] *Laennecia schiedeana (Less.) G. L. Nesom [5]*
Asteraceae/Compositae	[b] *Madia glomerata Hook. [7]*
Asteraceae/Compositae	[a] *Matricaria matricarioides (Less.) Porter [HPNM]*
Asteraceae/Compositae	[b] *Pseudognaphalium macounii (Greene) Kartesz [10]*
Asteraceae/Compositae	[a] *Sonchus asper (L.) Hill [1]*
Asteraceae/Compositae	[a] *Taraxacum laevigatum (Willd.) DC. [5]*

Family	Genus and Species
Asteraceae/Compositae	[a] *Taraxacum officinale Weber ex F. H. Wigg. [19]*
Asteraceae/Compositae	[a] *Tragopogon dubius Scop. [24]*
Brassicaceae/Cruciferae	[b] *Arabis glabra (L.) Bernh. var. glabra [8]*
Brassicaceae/Cruciferae	*Arabis hirsuta (L.) Scop. var. pycnocarpa (M. Hopkins) Rollins [3]*
Brassicaceae/Cruciferae	[a] *Berteroa incana (L.) DC. [2]*
Brassicaceae/Cruciferae	[a] *Capsella bursa-pastoris (L.) Medik. [19]*
Brassicaceae/Cruciferae	[a] *Descurainia sophia (L.) Webb ex Prantl [9]*
Brassicaceae/Cruciferae	[b] *Lepidium ramosissimum A. Nelson var. bourgeauanum (Thell.) Rollins [19[b]1] (state record)*
Brassicaceae/Cruciferae	[b] *Lepidium virginicum L. var. pubescens (Greene) Thell. [21]*
Brassicaceae/Cruciferae	[a]*Nasturtium officinale R. Br. [2]*
Brassicaceae/Cruciferae	[a] *Sisymbrium altissimum L. [1]*
Brassicaceae/Cruciferae	[a] *Sisymbrium loeselii L. [1]*
Caryophyllaceae	[a] *Cerastium fontanum Baumg. subsp. vulgare (Hartm.) Greuter and Burdet [16[b]1]*
Caryophyllaceae	[a] *Dianthus armeria L. subsp. armeria [2]*
Chenopodiaceae	[b] *Chenopodium capitatum (L.) Asch. -- 2003 [1]*
Chenopodiaceae	[b] *Chenopodium graveolens Willd. [5]*
Chenopodiaceae	[a] *Kochia scoparia (L.) Schrad. [1]*
Euphorbiaceae	[a] *Chamaesyce serpyllifolia (Pers.) Small [12]*
Fabaceae/Leguminosae	[a] *Medicago lupulina L. [8]*
Fabaceae/Leguminosae	[a] *Medicago sativa L. [2]*
Fabaceae/Leguminosae	[a] *Melilotus albus Medik. [7]*
Fabaceae/Leguminosae	[a] *Melilotus officinalis (L.) Pall. [6]*
Fabaceae/Leguminosae	[a] *Trifolium pratense L. var. pratense [1]*
Fabaceae/Leguminosae	[a] *Trifolium repens L. [35[b]2]*
Geraniaceae	[a] *Erodium cicutarium (L.) L'Hér. ex Aiton [8]*
Lamiaceae/Labiatae	[a] *Marrubium vulgare L. [1]*
Lamiaceae/Labiatae	[b] *Prunella vulgaris L. var. lanceolata (W. P. C. Barton) Fernald [28[b]1]*
Malvaceae	[a] *Malva neglecta Wallr. [1]*
Plantaginaceae	[a] *Plantago lanceolata L. -- 2002 [1]*
Plantaginaceae	[a] *Plantago major L. var. major [17]*
Poaceae/Gramineae	[a] *Agropyron cristatum (L.) Gaertn. var. cristatum [2]*
Poaceae/Gramineae	[a] *Agrostis gigantea Roth [HPNM]*
Poaceae/Gramineae	[a] *Agrostis stolonifera L. [10[b]1]*
Poaceae/Gramineae	[a] *Bromus inermis Leyss. var. inermis [11[b]1]*
Poaceae/Gramineae	[a] *Bromus japonicus Thunb. ex Murray [1]*
Poaceae/Gramineae	[a] *Bromus tectorum L. [7] (noxious weed)*
Poaceae/Gramineae	[a] *Dactylis glomerata L. [14[b]1]*
Poaceae/Gramineae	[a] *Elymus elongatus (Host) Runem. var. elongatus [1]*
Poaceae/Gramineae	[a] *Elymus hispidus (Opiz) Melderis var. hispidus [9]*

Family	Genus and Species
Poaceae/Gramineae	[a] *Elymus hispidus (Opiz) Melderis var. ruthenicus (Griseb.) Dorn [2]*
Poaceae/Gramineae	[a] *Festuca arundinacea Schreb. [3[b]5]*
Poaceae/Gramineae	[a] *Festuca pratensis Huds. [2]*
Poaceae/Gramineae	[a] *Phleum pratense L. var. pratense [15[b]1]*
Poaceae/Gramineae	[a] *Poa annua L. [9]*
Poaceae/Gramineae	[a] *Poa compressa L. [17]*
Poaceae/Gramineae	[a] *Poa pratensis L. var. pratensis [39]*
Polygonaceae	[a] *Polygonum aviculare L. [30]*
Polygonaceae	[a] *Polygonum convolvulus L. var. convolvulus [1]*
Polygonaceae	[b] *Polygonum lapathifolium L. var. lapathifolium [4[b]1]*
Polygonaceae	[a] *Rumex acetosella L. [46]*
Polygonaceae	[a] *Rumex crispus L. [12]*
Rosaceae	[a] *Malus pumila Mill. [1] [planted]*
Rosaceae	[a] *Prunus persica (L.) Batsch [1] [planted]*
Scrophulariaceae	[a] *Verbascum thapsus L. [11]*
Solanaceae	[a] *Solanum ptycanthum Dunal ex DC. [2]*
Ulmaceae	[a] *Ulmus pumila L. [1]*

a - Indicates introductions from outside North America
b - Indicates introductions from within North America

3.2.2 Fungi, Slime Molds, and Lichens

A large group of volunteer scientists, led by Dr. Relf Price of Los Alamos National Laboratory, have spent nearly a decade compiling a species list of fungi in the Valles Caldera (which includes slime molds and lichens). Thus far, these mycologists have identified 28 species of fleshy fungi, 31 species of parasitic fungi (parasitic on plants), 28 species of lichens, and 5 species of slime molds.

3.2.3 Vertebrate Wildlife

Surveys for wildlife in the Valles Caldera have yielded a rich diversity of species. A total of 51 species of mammals frequent the preserve, with another 9 species suspected of being possible inhabitants (but not observed as yet – mostly bats, but some shrews, jumping mice, ringtail and pine martin). Two species that used to roam the Jemez Mountains are known to have been extirpated from the area: grizzly bears and wolves. Of the resident species in the Valles Caldera, we have recorded 5 species of shrews, 13 bat species, 2 rabbit species, 7 chipmunk species, 8 species of mice and rats, 2 species of weasels, pika, ground squirrels, tree squirrels, prairie dog, gopher, skunk, badger, raccoon, gray fox, coyote, bobcat, mountain lion, black bear, mule deer, and elk.

Birds also are both common and diverse on the preserve. Thus far, 117 species of birds have been observed during the summer season; with 98 species being likely breeding bird species within the Preserve (see section on bird populations below). Among the “charismatic” bird species are Merriam’s wild turkey, bald eagles (autumn periods), golden eagles, mountain bluebirds, magpies, and northern

flickers. The preserve's streams, marshes and wetlands support six species of waterfowl, while the forests are home to seven species of woodpeckers and five species of owls. Overall, the preserve provides habitat for 74 species of songbird.

Reptiles and amphibians are common on the preserve, but are represented by only a few species. The reptile fauna are comprised of 3 snake species, 2 species of lizards and a 1 species of skink, and while few in species, the snakes (mostly garter snakes) are commonly observed along the streams and wetlands of the preserve, as well as crossing the roads of the valles. Amphibians are represented by only the tiger salamander, the Jemez Mountains salamander (a federally-protected species – see below) and the boreal chorus frog. The chorus frog is common along the streams, and in the spring, the males broadcast a cacophony of calls from vernal ponds and wetlands across the valles.

The fish community is made up of six species, four of which are native: long-nose dace, Rio Grande sucker, Rio Grande chub, and the fathead minnow. Two non-native trout are common in the preserve's streams: the German brown trout, and the rainbow trout. Brown trout are ubiquitous in the preserve streams, while the rainbow trout is restricted to the East Fork Jemez River watershed. The original native trout, the Rio Grande cutthroat trout, was extirpated from the preserve in the 20th century, due to predation from the brown trout and competition from the rainbow trout. A reintroduction of the Rio Grande cutthroat in the preserve is often suggested, and based on our ability to improve stream condition and water quality may be possible in the future

3.2.4 Invertebrates

Prior to federal acquisition of the Valles Caldera, very little was known about the insects, spiders, mites, centipedes, millipedes, worms and other invertebrates of the Jemez Mountains. Invertebrates, including pest and beneficial insects, are critically important to the functioning of Jemez Mountain's ecosystems, as they serve as herbivores, predators, parasitoids, decomposers, pollinators, granivores, and fungivores, as well as being prey species for a whole host of vertebrate insectivores. For the past four years, we have been working with entomologists from the Smithsonian Institution and USDA's Systematic Entomology Laboratory (Beltsville, MD), as well as many university scientists, to inventory the major groups of invertebrates in the Valles Caldera. Thus far, some of the major groups we have documented include 29 species of grasshoppers and crickets (order Orthoptera), 47 species of aphids (order Homoptera), 62 species of bees and 159 species of wasps (order Hymenoptera), 60 species of butterflies and 209 species of moths (order Lepidoptera), 35 species of fruit flies (family Tephritidae), 22 species of dragonflies and damselflies (order Odonata), 45 species of ground beetles (family Carabidae), 46 species of scarab beetles (family Scarabaeidae), 19 species of long-horned beetles (family Cerambycidae), 6 species of darkling beetle (family Tenebrionidae), and 131 species of aquatic insects. In addition, continuing surveys and identifications are underway for spiders, worms, and mollusks (snails and freshwater clams).

3.3 Human Occupancy and Use

The history of human use of the Valles Caldera began as early as any region in the Southwest. The Jemez Mountains have been occupied more-or-less continuously for at least 10,000 years. The following is a

brief summary of the ancient and contemporary cultural history of the preserve; a more detailed discussion is provided in *Part Three – State of the Preserve*.

Contemporary Native Americans from surrounding Pueblos maintain a deep connection to the caldera and trace their entry to the area back over 800 years. Ancestral Puebloans used the caldera for game hunting, gathering of medicinal and food plants, maize agriculture, and collecting obsidian. Today, tribal members from the Pueblos of Jemez, Cochiti, San Ildefonso, and Santa Clara continue to visit the caldera to collect medicinal and ceremonial plants or to visit shrines and ancestral sites. More distant groups such as the Hopi, Navajo, Ute, and Zuni also maintain a connection with the caldera.

The Spanish arrived over 400 years ago and began using the area for livestock grazing. The Baca Location No. 1[30] was an indirect land grant in 1860 to the heirs of Luis Maria Cabeza de Vaca as settlement of a land dispute. However, the large tract passed quickly out of the grantees hands and was acquired in 1899 by the Valles Land Company. Grazing, logging/milling, and mining activities increased in the region throughout the late 1800s and early 1900s as the railroad and timber industry brought Euro-Americans to expanded settlements in the Jemez Valley.

These grazing, logging/milling and mining activities increased within the Valles Caldera as in the region. As detailed in Part Three – State of the Preserve, the land and the rights to its forage, timber, and mineral resources changed hands frequently during this period. Extractive uses were often intense and left long-lasting and cumulative impacts on the structure, composition and function of the natural and cultural resources.

Many of those who labored in the Valles Caldera were from the local communities and they formed special ties to the land and cherished stories passed down through generations continue the kinship of local communities to the landscape. The communities that surround the preserve today, including numerous Pueblos and Tribes as well as local Hispanic and Anglo communities, continue to hold these deep historic and cultural connections to the caldera, which are expressed through on-going ceremonial activities as well as rich oral histories and sacred traditions.

3.4 Socioeconomic Setting

The preserve is located primarily in Sandoval County with a small inclusion in Rio Arriba County. Los Alamos and Santa Fe counties to the east also contribute to the socioeconomic setting Figure 3-13. These counties all have a single urban center and strong rural roots and continued rural influence in their culture. The urban and government employment and economic factors are so dominant in these counties that the agricultural and forest industries are barely measurable, even in the directly related Sandoval and Rio Arriba Counties (Valles Caldera Trust, 2009). However, forest and agriculture are important economic factors in the numerous small towns and villages that comprise the cultural roots of the impact area. The preserve has been an important feature of the working landscape of the area for many generations (Anschuetz and Merlan, 2007).

30 The Baca Location No. 1 included all of what is now the VCNP as well as portions of the Santa Clara and Frijoles watersheds.

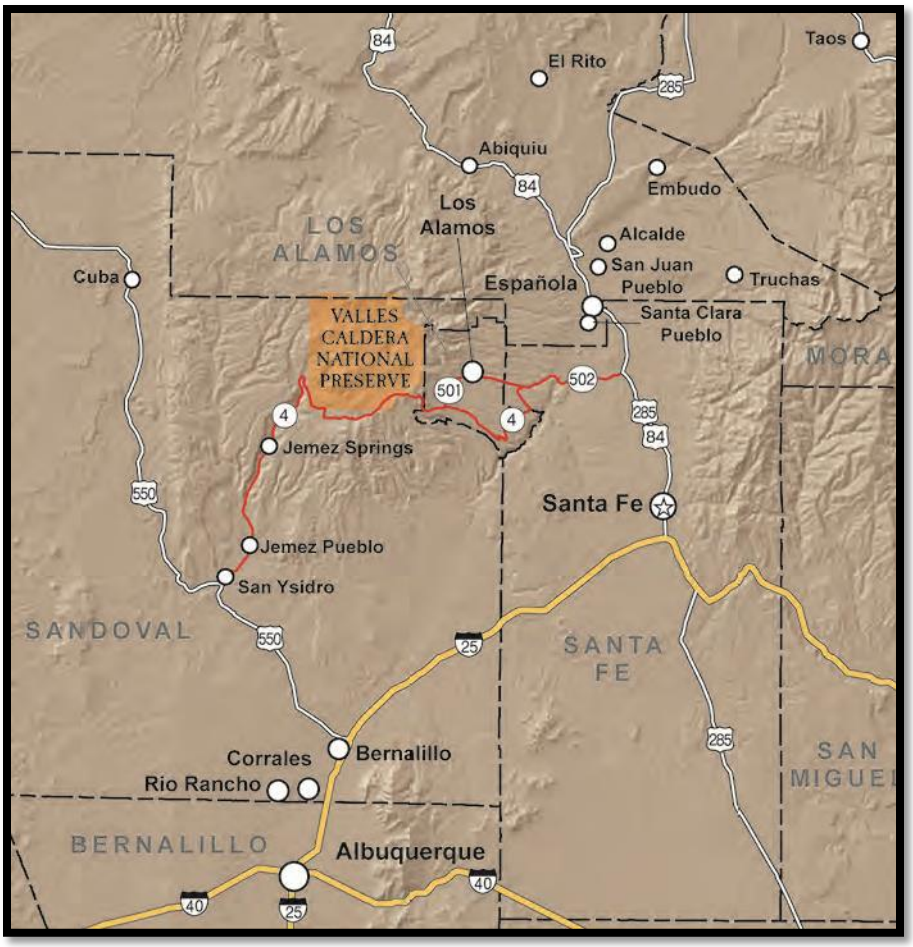


Figure 3-13. Socioeconomic setting of the VCNP

3.5 Administrative Setting

The Valles Caldera National Preserve is a unit of the National Forest System (NFS). It was acquired in 2000 through the Valles Caldera Preservation Act. The act not only provided for the acquisition of the preserve but also created an experimental management regime – the Valles Caldera Trust, The trust is a wholly owned government corporation whose purpose is "*… to establish a demonstration area for an experimental management regime adapted to this unique property which incorporates elements of public and private administration in order to promote long term financial sustainability consistent with the other purposes [protection and preservation of resources and values, providing for public recreation] enumerated in this subsection*;" (U.S.C., 2000).

While most laws that apply to the USDA Forest Service also apply to the Valles Caldera Trust, and preserve management, we are exempt from federal procurement laws and the Forest and Rangeland and Renewable Resources Planning Act as amended. The trust is also a 501c (1) not for profit organization and has the ability to solicit donations and generate revenues. Revenues and donations are

deposited in an interest bearing account, where they can be used without further appropriations for the management of the preserve (U.S.C., 2000).

3.5.1 Mission, Vision, and Management Principles

In November of 2006, the Valles Caldera Trust, Board of Trustees prepared a strategic plan for an undefined period or "near term" management of the preserve. In 2011 we initiated the development of a strategic plan to comply with the Government Performance and Results Act (GPRA) of 1993 and the GPRA Modernization Act of 2010. In 2012 we submitted our *Strategic Management Plan for Fiscal Years 2012 -2018*[31] to Congress and the Office of Budget and Management (OMB).

Strategic planning by nature is a long view approach to management and is inspired by a *Mission,* which is a declaration of the purpose and focus of our existence; and a *Vision,* which is an aspirational description of what we would like to achieve or the state of our being in the future. Management principles are an expression of our core values and principles of conduct. While mission and vision are used to inspire and direct *what* we do, management principles guide *how* we do it.

Mission Statement

Based on formal and informal comments received over time from our stakeholders, including members of the public and Congress, and input from our staff we developed a broad statement of purpose that identifies what we do, why and for whom: *The Valles Caldera Trust, is an experiment in public land management, and is responsible for protecting and preserving the natural and cultural resources of the Valles Caldera National Preserve for present and future generations, while being dedicated to sustainable public access and use.*

Vision Statement

A statement of vision describing our "ideal future" was also derived from both internal and external contributions: The Valles Caldera National Preserve is a place of learning and inspiration, where focused, efficient, competent professionals implement adaptive management as an ecologically and economically viable method of public land management.

Management Principles

The following principles describe how we, the Valles Caldera Trust, will conduct our business and define our code of ethics and organizational values. These principles were adopted by the Board of Trustees December 13, 2001 and were subsequently incorporated into our procedures for implementing the NEPA and thus were published in the Federal Register July 17, 2003.

1. We will administer the Preserve with the long view in mind, directing our efforts toward the benefit of future generations;

31 Available online: http://www.vallescaldera.gov/about/trust/docs/Valles%20Caldera%20Trust%20SMP%202012-2018.pdf

2. Recognizing that the Preserve imparts a rich sense of place and qualities not to be found anywhere else, we commit ourselves to the protection of its ecological, cultural, and aesthetic integrity;

3. We will strive to achieve a high level of integrity in our stewardship of the lands, programs, and other assets in our care. This includes adopting an ethic of financial thrift and discipline and exercising good business sense;

4. We will exercise restraint in the implementation of all programs, basing them on sound science and adjusting them consistent with the principles of adaptive management;

5. Recognizing the unique heritage of northern New Mexico's traditional cultures, we will be a good neighbor to surrounding communities, striving to avoid negative impacts from Preserve activities and to generate positive impacts;

6. Recognizing the religious significance of the Preserve to Native Americans, the Trust bears a special responsibility to accommodate the religious practices of nearby tribes and pueblos, and to protect sites of special significance;

7. Recognizing the importance of clear and open communication, we commit ourselves to maintaining a productive dialogue with those who would advance the purposes of the Preserve and, where appropriate, to developing partnerships with them;

8. Recognizing that the Preserve is part of a larger ecological whole, we will cooperate with adjacent landowners and managers to achieve a healthy regional ecosystem;

9. Recognizing the great potential of the Preserve for learning and inspiration, we will strive to integrate opportunities for research, reflection and education in the programs of the Preserve; and

10. In providing opportunities to the public we will emphasize quality of experience over quantity of experiences. In so doing, while we reserve the right to limit participation or to maximize revenue in certain instances, we commit ourselves to providing fair and affordable access for all permitted activities.

3.5.2 Goals

Goals are the general end toward which we shall direct our efforts. The strategic plan addresses three levels of goals: *Agency Goals, Strategic Goals,* and *Performance Goals.* Goals stretch and challenge us; attaching measurable, time-based statements of intent and a strategy for their attainment assures that our goals remain realistic and achievable.

Agency Goals

Congress assigned the following management goals in 2000 within the Valles Caldera Preservation Act [32]

32 32 U.S.C. (2000, July 25). P.L. 106-248 - July 25. Valles Caldera Preservation Act , Section 108 Resource Management (d) Management Program. Washington D.C.: 106th Congress

1. operation of the Preserve as a working ranch, consistent with paragraphs (2) through (4);
2. the protection and preservation of the scientific, scenic, geologic, watershed, fish, wildlife, historic, cultural and recreational values of the Preserve;
3. multiple use and sustained yield of renewable resources within the Preserve;
4. public use of and access to the Preserve for recreation;
5. renewable resource utilization and management alternatives that, to the extent practicable—
    a. benefit local communities and small businesses;
    b. enhance coordination of management objectives with those on surrounding National Forest System land; and
    c. provide cost savings to the Trust through the exchange of services, including but not limited to labor and maintenance of facilities, for resources or services provided by the Trust; and
6. optimizing the generation of income based on existing market conditions, to the extent that it does not unreasonably diminish the long-term scenic and natural values of the area, or the multiple use and sustained yield capability of the land."

Strategic Goals

Strategic goals are statements of aim or purpose to advance the agency mission and address relevant problems, needs, and challenges. Achieving our strategic goals is key to meeting the purposes and goals established by Congress in the enabling legislation.

Strategic Goal 1 – Public Access and Use

Encourage public understanding and enjoyment of the preserve, including the development of facilities and infrastructure to expand the capacity for visitors consistent with resource protection.

This goal reflects the priorities of both the public and congress for the management of the preserve and was identified as an important benchmark for management in the *2000-2015 Plan for Decreasing Appropriations*.

Strategic Goal 2 - Natural and Cultural Resources

Restore and enhance the preserve's rich natural, cultural and historic resources for sustainable use and enjoyment by present and future generations of Americans.

The second goal, restoration and rehabilitation of the preserve's natural and cultural resources, is critical for meeting the purposes and goals put forth by congress in the 2000 legislation. Understanding the changing patterns across 10,000 years of human use of the caldera provides a context for conceiving of our stewardship of the preserve. The last two centuries of human activity, including grazing, logging, road building and geothermal exploration have significantly degraded the preserve's natural resources.

Strategic Goal 3 – Financial Sustainability

Establish a public-private model of administration to optimize revenues and develop philanthropy to support the preservation, enhancement and operation of the Valles Caldera National Preserve.

The goal of generating revenue, grants, and other sources of non-Federal funding, addresses the financial self-sufficiency goal set out by congress in the purposes and goals of the act. This goal will also assure the continued economic viability of education and other programs that enhance the benefits of public lands. Three performance goals have been selected to optimize income, increase philanthropy, and enhance the economic vibrancy of the surrounding area.

3.5.3 Organization

The Valles Caldera National Preserve is a unit of National Forest System land. While strongly tied to the USDA – Forest Service, The Valles Caldera Trust, is a wholly owned government corporation under the Secretary of Agriculture. Management of the Valles Caldera Trust, and National Preserve are governed by a board of trustees seven of which are presidentially appointed and two of which are ex-officio (Santa Fe National Forest, Forest Supervisor and Bandelier National Monument, Superintendent). Valles Caldera Trust, employees are federal employees in the excepted service.

The Valles Caldera Trust, is organized into over-lapping management divisions, which support programs for research, inventory and monitoring, planning and adaptive management, natural resource management, public access and use, care and maintenance of our facilities and infrastructure, and our enterprise activities (marketing and Information Technology). Management divisions are overseen by the Executive Director (who reports to the Board of Trustees) and are supported by an administrative service division.

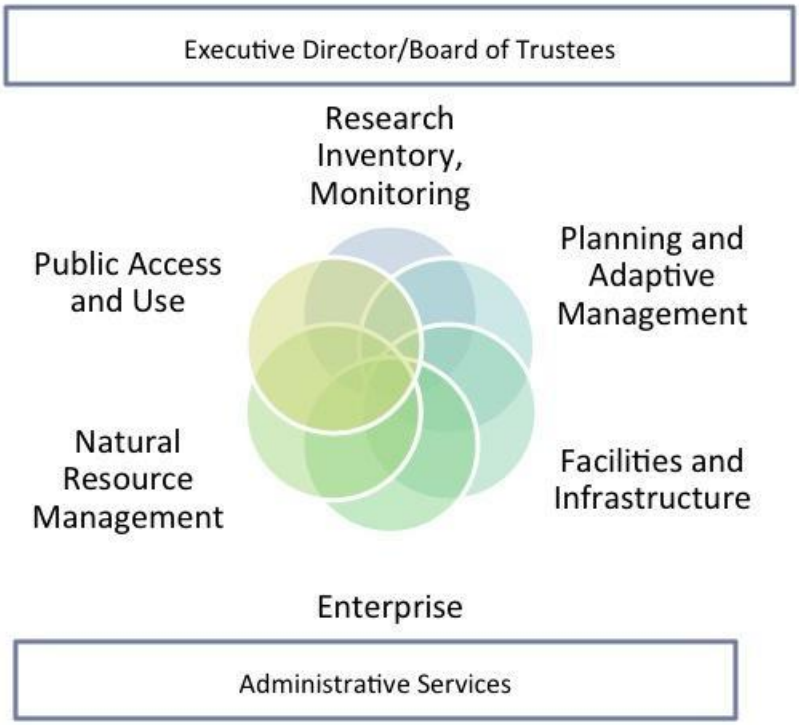


Figure 3-14. Overlapping management divisions of the VCT

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Chapter 4. Affected Environment

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

The whole is greater than the sum of its parts”

- Aristotle

4.1 Introduction

This chapter provides a landscape scale assessment of the current composition, structure and function of the preserve's forest, grassland and woodland vegetation, as well as detailed discussions of the existing condition of the watershed, fisheries and wildlife, cultural resources, visitation, sensory values, and socio economic environment[33]. This section provides the technical basis for developing the purpose and need, proposed action, issues, and alternatives, in chapters one and two, and for predicting the environmental consequences in chapter 5.

4.2 Vegetation and Ecological Condition

Considerable amounts of vegetation data have been collected on the preserve. Plant alliances have been mapped at a six-meter resolution preserve-wide (Muldavin E., 2006) and the vegetation of the preserve has been delineated into stands similar in structure and composition. The forested stands were then stratified by composition and structure into 35 strata for inventory. A preserve-wide inventory of forest structure was conducted using the standard protocols employed by the USDA Forest Service (Common Stand Exam). Inventory data were entered into the Forest Service national vegetation data base, FSVEG, and exported into an FVS database in order to model growth and succession.

Rangeland vegetation monitoring has provided valuable information regarding rangeland health and biotic integrity, the identification of sites that may be at risk ecologically, and the assessment and reporting of any trends or changes in rangeland health between years.

Using these data we have assessed ecological condition at a landscape scale using the Vegetation Condition Class methods described by LANDFIRE in the Fire Regime Condition Class Guidebook FRCC[34] (LANDFIRE, 2010) to apply a quantified measure of ecological condition.

4.2.1 Methods

A brief overview of the key concepts and terms used for measuring ecological condition is helpful to ensure a mutual understanding and interpretation of the assessment. The existing condition of the vegetation types is framed as a measure of *ecological departure* or a measure of the current condition relative to the *reference condition.* The simple definition of reference condition is what we think of as a healthy and functional ecosystem. The complete, standard definition is: *the composition of landscape vegetation and disturbance attributes that, to the best of our collective expert knowledge, can sustain current native ecological systems and reduce future hazards to native diversity* (USDA - Forest Service -

33 The order is designed for efficiency and does not reflect an order of importance. For example, the condition of wildlife and their habitats is related to ecological and watershed condition.

34 The term Fire Regime Condition Class (FRCC) was replaced with Vegetation Condition Class (VCC) since the publication of the 2010 FRCC Guidebook.

Interagency Fuels Group, 2005). Ecological departure was determined using the Vegetation Condition Class (VCC) methods using local data and locally adjusted landscape delineations.

Vegetation Condition Class

The VCC attribute indicates the degree of departure from reference condition, possibly resulting in changes to key ecosystem components, such as vegetation characteristics; fuel composition; fire frequency, severity, and pattern; and other associated disturbances. VCC is commonly reported in three classes as displayed in Table 4-1: VCC 1 (no or low departure), VCC 2 (moderate departure), or VCC 3 (high departure).

Table 4-1. Vegetation condition class attributes criteria

VCC	Departure	Departure Description
VCC 1	< 33%	Low departure based on a central tendency representing a composite estimate of the reference condition including structure, composition, and process.
VCC 2	33– 66%	Moderately departed from the reference condition
VCC 3	> 66%	High degree of departure from the reference condition

The VCC class is based on the distribution of forest in various *seral* stages (stages of growth and development) within a landscape relative to the reference condition as well as a comparison of the frequency and severity of recent disturbance relative to the natural fire regime. The natural fire regime considers the frequency and severity of fire during the reference period.

VCC determination requires an understanding of several key terms and concepts including *Reference Condition, Biophysical Setting (*BpS*), Fire Regime,* and *Forest Succession (*s-class*).*

Reference Condition

The FRCC Guidebook includes that reference conditions should be defined in terms of a range of conditions over space and time, rather than in terms of a fixed set of conditions. We see two main approaches for defining the range of variation: the *historical range of variation* (HRV) and the *present natural range of variation* (PNRV).

In North America, HRV is usually defined by the period prior to Euro-American settlement[35]. In the southwestern United States, it is generally considered to be prior to the widespread exclusion of fire from the landscape in the late 1800s as determined by tree ring analysis (Allen, 1989).

The PNRV is defined by a time period starting at the present and reaching into the future, with the future endpoint typically defined at 100 years and sometimes even up to 500 years (or further). Such modeling is based on a hypothetical future climate, and therefore PNRV could be more useful than HRV (Running, 2006; Westerling, et al., 2006). But this concept also has drawbacks, notably in the inherent speculation about forest succession, fire frequency, and fire severity. Moreover, we are uncertain of what will be sustainable in the future.

[35] Settlement by Europeans initiated the cumulative impacts of fire suppression, grazing, road building; introduced new species and extirpated others initiating profound changes in southwestern ecosystems (C. D. Allen 1989)

We have used HRV as the reference condition noting that estimating VCC is a systematic tool for assessing landscapes and to support the development of strategies for management. Other models, data, and information including estimations of future climate scenarios are also among the tools available to managers. In addition, the reference condition is not to be confused with desired future condition or management objectives, which incorporate consideration of future climate as well as social and economic contexts.

Biophysical Setting Models

Biophysical setting (BpS) models of vegetative structure and composition provide landscape scale reference conditions. These models were peer developed and reviewed for use in the United States by the LANDFIRE project. For VCC purposes, biophysical settings use dominant vegetation types and their associated fire regimes as a proxy for the integration of a landscape's structure, composition and function considering both the biotic and abiotic components of the setting. BpS Models can often be described according to their respective fire regimes and associated vegetation composition (native overstory species) and structures (major successional stages). BpS models are the primary environmental descriptors used for determining a landscape's natural fire regimes, vegetation characteristics, and resultant VCC category. BpS models incorporate both map unit concepts and classification (taxonomic) as the structure and composition of a particular forest type varies by its geographic setting. Each model is identified by a 2-digit map unit and 4-digit vegetation classification. The BpS models used to establish the reference condition and measure ecological departure on the preserve are presented below in Table 4-2.

Table 4-2. Biophysical setting models used to establish reference condition and estimate ecological departure on for each major cover type on VCNP

VCNP Cover Type	Biophysical Setting Model
Ponderosa Pine Savanna	Southern Rocky Mountain Ponderosa Pine Savanna (BpS Model 281117)
Ponderosa Pine Forest	Southern Rocky Mountain Ponderosa Pine Forest and Woodland (BpS Model 281054[a])
Xeric Mixed Conifer Forest	Southern Rocky Mountain Dry-Mesic Mixed Conifer (BpS Model 28051)
Mesic Mixed Conifer Forest	Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland (BpS Model 28052)
Aspen Forest	Intermountain Basin Aspen - Mixed Conifer Forest and Woodland (BpS Model 281061[b])
Xeric Spruce-fir Forest	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (BpS Model 281055)
Mesic Spruce-fir Forest	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland (BpS Model 281056)

a – BpS Model descriptions and reference conditions were reasonable although local information indicates that Fire Regime I more accurately describes the fire history rather than Fire Regime III identified in the model description.
b - The interdisciplinary team referred to the BpS Model descriptions for mapping unit 28, which includes the preserve and mapping unit 25 adjacent to the preserve as well as VDDT model outputs to estimate the reference condition.

Fire Regime

A natural *fire regime* is a general classification of the role fire would play across a landscape in the absence of modern human mechanical intervention but including the possible influence of aboriginal fire

use (Agee, 1993; Brown, 1995). Course-scale definitions for five fire regimes are classified based on the average number of years between fires or *mean fire interval* (MFI) combined with characteristic fire severity reflecting percent replacement of dominant overstory vegetation. The forests of the preserve have evolved under three fire regimes as presented in Table 4-3 below.

Table 4-3. Natural fire regimes (USDA - Forest Service - Interagency Fuels Group, 2005)

Group	Frequency (MFI)	Severity	Severity Description
I	0 – 35	Low	Generally low severity fires replacing less than 25% of the dominant overstory vegetation.
III	35 – 200	Mixed/low	Replacing up to 75% of the overstory, mixed with low severity.
IV	35 - 200	Replacement	High severity, replacing more than 75% of the overstory.

Forest Succession (S-Class)

Forest succession is defined in the FRCC Guidebook as, "*The progression of change in the composition, structure, and processes of a plant community through time*." A succession stage or *s-class* is defined by specific compositional and structural traits associated with a phase of forest growth and development or *succession*. Forest succession in the Southwest is not a linear path but a cycle that is adapted to fire and other disturbance. Forests mature and develop in response to area climate and disturbance as well as site-specific productivity. Over long periods of time and across large landscapes the distribution of forests in various stages of development is somewhat stable with a range of variability. VCC methods compare the present distribution of vegetation types in stages of succession (s-class distribution) to the modeled distribution within the given BpS to provide a quantified standardized estimate of ecological departure.

Table 4-4 describes the s-classes for growth and maturation in a forest ecosystem; Figure 4-1 Illustrates the successional pathways of a fire adapted, ponderosa pine forest. Not all ecosystems conform to the standard 5-box model depicted. Some grassland types might have only two or three succession classes, and some classes might have age and canopy characteristics different from those in the forest ecosystem model (USDA - Forest Service - Interagency Fuels Group, 2008).

Table 4-4. Classes represented in a standard "5-box" model for succession in a forest ecosystem

S-class	A - Early Development	B - Mid-Development, Closed Canopy	C - Mid-Development, Open Canopy	D - Late Development, Open Canopy	E - Late Development, Closed Canopy
Description	Seedlings/saplings < 5-in. (diameter)	Trees, immature, ≈5 – 16 in. Canopy closure > 50%.	Trees, immature, ≈ 5 – 16 in. Canopy closure <50%.	Trees mature, >16-in. Canopy closure <50%.	Trees mature, > 16-in. Canopy closure >50%.

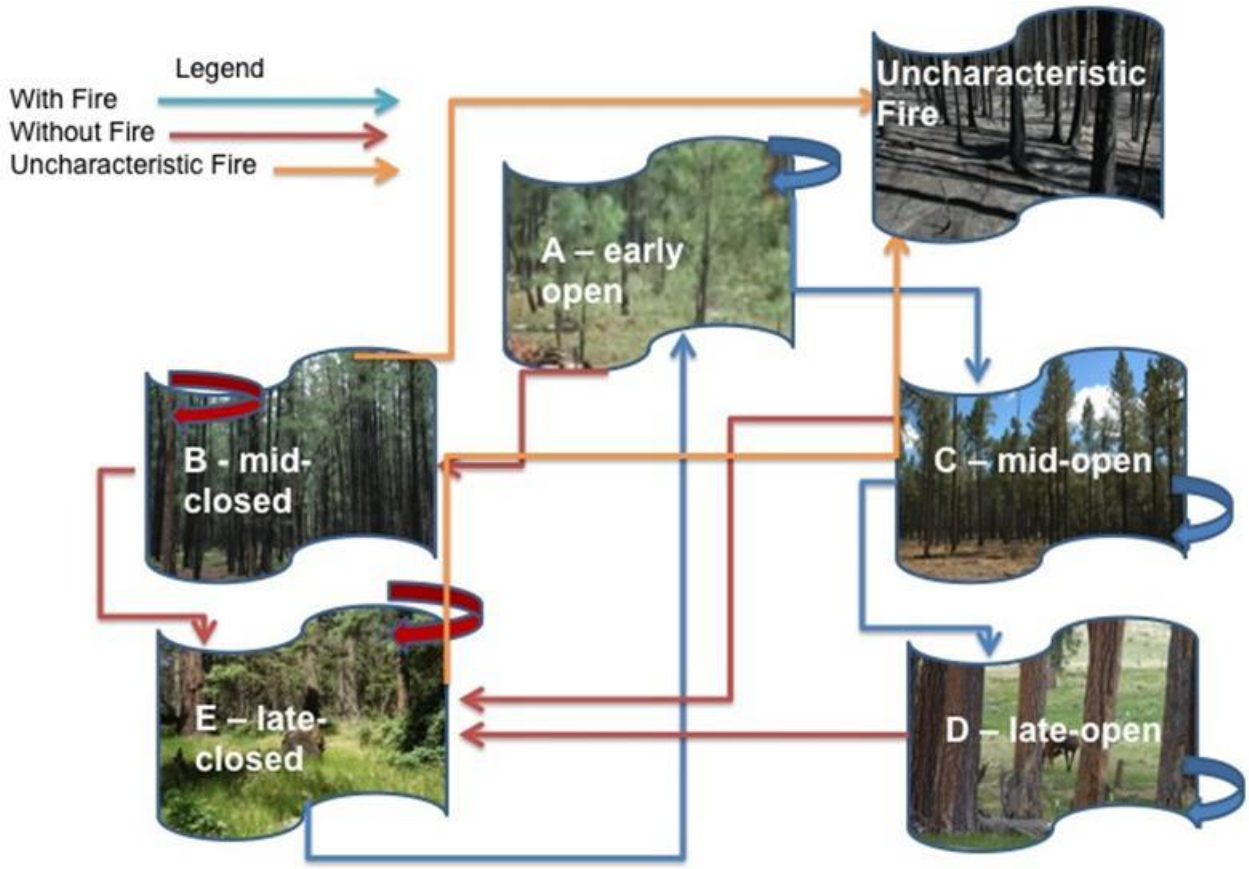


Figure 4-1. Simplified 5-box succession model illustrating forest succession in a ponderosa pine forest with and without fire and with uncharacteristic fire

4.2.2 Forests

This section describes the VCC of the preserve's forests and represents the state of our knowledge to date.

The information is presented in order fire regime beginning with the ponderosa pine and dry- mixed conifer forest types associated with frequent, low severity fire (Fire Regime I); followed by wet-mixed conifer and aspen-mixed conifer forest types adapted to less frequent, mixed severity fire regimes (Fire Regime III), and then the spruce-fir forest types, which are adapted to infrequent fire return intervals (Fire Regime IV). Each section includes a general description of the fire regime and associated forest types, a map showing the distribution of the forest types within that fire regime, tabular data of composition structure and ecological departure (pre-Las Conchas), followed by a detailed narrative of the existing condition of each forest type on the preserve. This narrative describes our current state of knowledge regarding the effects of the Las Conchas fire.

In summary most of the forest types on the preserve are dominated almost exclusively by mid-aged closed forests (or were, prior to the Las Conchas fire). This is due to logging that removed the large trees and the exclusion of fire, which permitted seedlings to survive in unprecedented numbers. Interestingly,

while the xeric mixed conifer and mesic mixed conifer forests have a similar distribution of seral stages the distribution represents a far greater degree of ecological departure in the xeric forest than the mesic. This is due to the difference in the reference conditions between these two forest types.

In 2011, the 156,000-acre Las Conchas wildfire burned over 30,000 acres of the preserve's forests and grasslands under extreme conditions of heat, wind and drought (Figure 4-2).

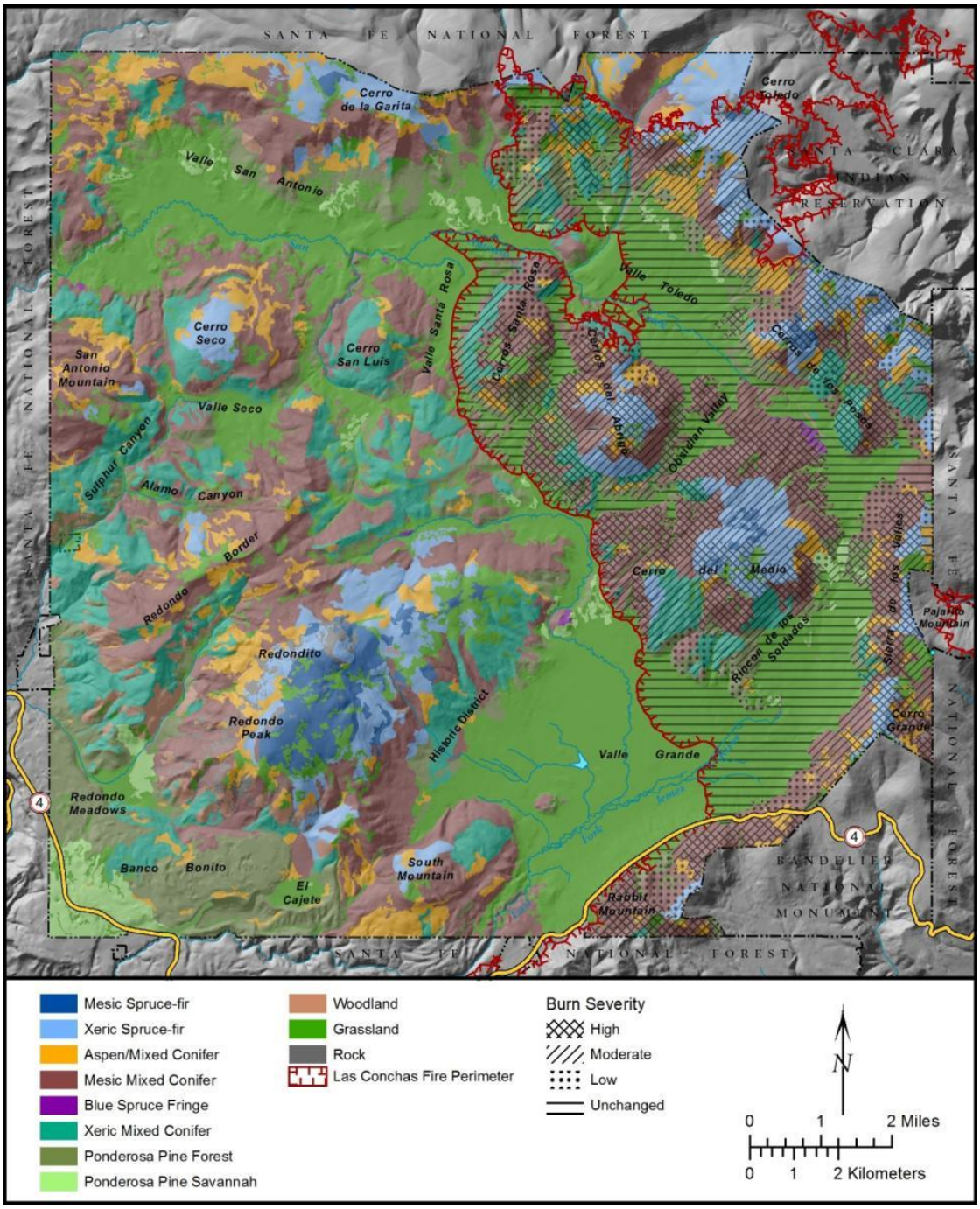


Figure 4-2. Distribution of forest types across the VCNP overlaid with the Las Conchas fire perimeter and severity

As shown in Table 4-5, most of the forested area within the burn perimeter burned with moderate to high severity while most of the grassland showed no change (this is not because the grassland was not burned, but because the rapid recovery occurred before the satellite imagery was taken. Within the other cover types, no change likely indicates unburned areas). Table 4-6 breaks down burned area and severity within the forest cover to the specific forest type. A lower proportion of the blue spruce fringe and ponderosa pine burned with high severity. This is likely due to their position lower on the slopes where fire entered into these forest types as a surface fire and transitioned to a crown fire as it burned up the slope. All other forest types had similar proportions of burn severity.

The assessment of VCC does not incorporate the Las Conchas burn area. Assumptions regarding the VCC in the burned area would be based solely on initial severity assessments and would likely have a high degree of error and/or uncertainty. Narrative descriptions do include a discussion of burn severity and expected impacts.

Table 4-5. Las Conchas fire burned area (acres/%) by severity and cover type

Cover Type	High Severity		Mod Severity		Low Severity		No change		Total	% of Total
Forest	7664.0	39	6556.1	34	3441.9	18	1857.3	10	19519.3	65
Grass	339.7	5	827.6	11	538.4	7	5665.3	77	7371.0	25
Post Fire	2.5	15	9.3	55	0.4	2	4.4	26	16.6	0
Riparian	13.4	1	25.7	1	47.1	2	1980.7	96	2066.9	7
Rock	216.0	24	318.4	35	148.0	16	225.2	25	907.6	3
Shrub	41.0	32	47.4	37	26.2	20	12.9	10	127.5	0
Water	0.0	0	0.3	3	0.5	5	9.2	92	10.0	0
Total	**8277**	**28**	**7785**	**26**	**4202**	**14**	**9755**	**32**	**30019**	**100**

Table 4-6. Las Conchas fire burned area (acres/%) by severity; forest cover only by forest type

Forest Type	High Severity		Mod. Severity		Low Severity		Unchanged		Total	%
Ponderosa Pine	659	23	930	32	594	21	709	25	2893	15
Xeric Mixed Conifer	2957	42	2529	36	1100	16	401	6	6987	36
Mesic Mixed Conifer	1893	42	1383	31	866	19	322	7	4464	23
Xeric Aspen	496	41	462	38	189	16	66	5	1213	6
Mesic Aspen	264	40	233	35	120	18	40	6	657	3
Blue Spruce Fringe	37	13	62	22	49	17	135	48	284	1
Xeric Spruce/Fir	691	43	530	33	277	17	120	7	1618	8
Mesic Spruce/Fir	667	47	427	30	246	18	64	5	1404	7
Total	**7664**	**39**	**6556**	**34**	**3442**	**18**	**1857**	**10**	**19519**	

Fire Regime I

Ponderosa pine woodlands and savannas and dry-mixed conifer forests, which occupy the lower and warmer forest zones of the preserve (Figure 4-3), are adapted to frequent, low severity fire with return intervals of 5-15 years. For 10,000 years fire shaped the structure, composition and function of ponderosa pine forests in the Jemez Mountains (Allen, 1989). The frequent low intensity fires burned through the ponderosa pine forests removing competing understory vegetation, killing conifer seedlings and consuming woody debris. Prehistorically, these fires maintained an open structure of *uneven age*

groups of *even age* trees growing over a grassy understory dominated by late-open seral structure (s-class D). Drought and other weather events, parasites and disease may have played a minor disturbance role but had very long rotations. Insects may have been a significant, but infrequent disturbance. These effects may contribute to rare stand replacement events although there is no evidence of stand replacement events in this forest type in the Jemez Mountains during the reference period (Allen, 1989).

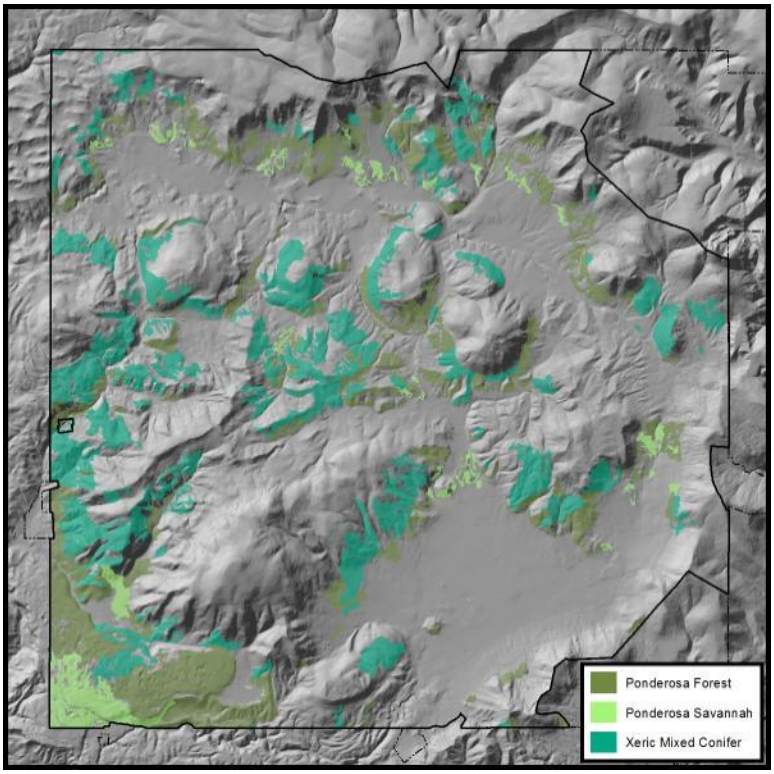


Figure 4-3. Distribution of ponderosa pine savanna, ponderosa pine forests, and xeric mixed conifer on the VCNP

Influenced by climate, topography, soils and fire two distinct types of ponderosa pine forests have evolved: *Southern Rocky Mountain Ponderosa Pine Savanna* and *Southern Rocky Mountain Ponderosa Pine Forest and Woodland.* The ponderosa pine savanna has widely spaced mature groups of ponderosa pine, other conifer species are generally not present. The grassy understory includes Arizona fescue and mountain muhly; minor amounts of Gambel oak may be present. In the ponderosa pine forest and woodland, ponderosa pine is the dominant conifer, but Douglas-fir, Gambel oak or other species may also be present. A transition from the ponderosa pine forests to the xeric mixed conifer forest follows a moisture gradient influenced by elevation and aspect. The xeric mixed-conifer (*Southern Rocky Mountain Dry-mesic Mixed Conifer Forest and Woodland)* includes Douglas-fir as co-dominate along with ponderosa pine with inclusions of white fir, aspen, and blue spruce.

As presented in Table 4-7 below there is a significant degree departure in the VCC rating for these forests. The current condition is due to the combination of fire exclusion and past intensive logging. While nearly 90 percent of the ponderosa pine and xeric mixed conifer forest on the preserve is currently within s-class B. The ponderosa pine savanna also is heavily dominated by mid-closed forest however; mid-open forests are also well represented where this forest type has expanded into the grasslands.

Table 4-7. VCC determination, forest types in fire regime I

Southern Rocky Mountain Ponderosa Pine Savanna								
Class	**A**	**B**	**C**	**D**	**E**	**UE**	**UN**	**Total**
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	73	27	0	0	0	0	100
VCC Rating								**2 (65)**
Southern Rocky Mountain Ponderosa Pine Forest and Woodland								
Class	**A**	**B**	**C**	**D**	**E**	**UE**	**UN**	**Total**
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	89	10	1	0	0	0	100
VCC Rating								**3 (79)**
Southern Rocky Mountain Dry-Mesic Mixed Conifer Forest and Woodland								
Class	**A**	**B**	**C**	**D**	**E**	**UE**	**UN**	**Total**
Reference Condition	15	15	10	50	10	0	0	100
Existing Condition	0	97	3	0	0	0	0	100
VCC Rating								**3 (82)**

Forest inventory data shown in Table 4-8 shows the distribution of trees by measured diameter class confirming the surplus of trees in the mid-size diameters. Table 4-9 presents species composition as percent cover. Not surprising the ponderosa pine savanna shows 100 percent cover by ponderosa pine with species mixtures increasing in the ponderosa pine forest and xeric mixed conifer forest types.

Table 4-8. Existing forest cover by size class (percent cover, percent of cover); fire regime I

Size Class	1-4.9 in dbh	5-8.9 in dbh	9-15.9 in dbh	16+ in dbh
Southern Rocky Mountain Ponderosa Pine Savanna				
% Cover	6 (10)	15 (24)	35 (56)	7 (11)
Southern Rocky Mountain Ponderosa Pine Forest and Woodland				
% Cover	7 (15)	21 (46)	12 (26)	6 (13)
Southern Rocky Mountain Dry-Mesic Mixed Conifer Forest and Woodland				
% Cover	5 (10)	12 (24)	23 (46)	10 (20)

Table 4-9. Forest species composition; fire regime I

Species	Blue Spruce	Corkbark/ Subalpine Fir	Douglas -fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total
Southern Rocky Mountain Ponderosa Pine Savanna									
% Cover	0	0	0	0	0	52	0	T	52
Southern Rocky Mountain Ponderosa Pine Forest and Woodland									
% Cover	2	0	5	0	T	34	8	5	48
Southern Rocky Mountain Dry-Mesic Mixed Conifer Forest and Woodland									
% Cover	6	1	12	1	3	11	10	9	44

Fire exclusion appears to be responsible in part for expansion of ponderosa pine into the valle grasslands. Monitoring has shown that moderate cattle grazing combined with fire exclusion favors ponderosa pine seedling establishment on ponderosa pine/grassland ecotonal communities (Coop and Givinish, 2007). Before fire exclusion, frequent fire likely excluded the majority of ponderosa pine

seedlings at the ecotonal boundary. Now on the preserve, there can be a difference of 150 years between the present and historic tree line indicating relatively recent colonization of sites previously dominated by herbaceous vegetation (Muldavin and Tonne, 2003). A comparison of the 1935 treeline with the present reveals an 18 percent loss of grassland to forest (Coop and Givinish, 2007).

However, the lack of fire may not be the sole causal factor behind encroachment of ponderosa pine into grassland communities. Studies also suggest that climate change may be exerting its influence on the expansion of this forest community. The spatial position of the forest/grassland ecotone in the large valles was at least in part determined by frost. Cold air accumulation subjects valley bottoms to frequent summer frosts and drops minimum temperatures below those of adjacent slopes, which have been shown to exert strong effects on seedling growth. Historically, slowly growing, frost-damaged seedlings would have been extremely vulnerable to the low-severity fires that burned valley margins until the late 19th century. Over the last one hundred years mean annual and winter temperatures have increased indicating that recent forest encroachment may be driven by both rising minimum temperatures and cessation of frequent fire (Coop and Givinish, 2007).

Figure 4-4. Late-open (s-class D) forest structure

Figure 4-5. Mid-age closed (s-class B) ponderosa pine forest (left), mid-age open (s-class C) ponderosa pine expanding across Mollic, grassland soils right

Fire Regime I - Las Conchas Fire Effects

As shown previously in Table 4-6, nearly 2,900 acres of ponderosa pine burned in the Las Conchas fire and more than half of that (55 percent) burned with moderate to high severity. Nearly 7,000 acres of the xeric mixed conifer forest burned, with 78 percent burning with moderate to high severity. Forests adapted to frequent fire regimes conversely are not adapted to severe burning. These severely burned areas may simply be reset to an early successional stage (s-class A). However, it is more likely that extensive areas of severely burned ponderosa pine or dry mixed conifer forests may transition to an alternative, uncharacteristic state. Ponderosa pine and dry mixed conifer forests that burned severely in the La Mesa fire transitioned to brush cover for extensive periods (Allen, 1996).

The 45 percent of the ponderosa pine that burned with low severity or remained unburned are largely the mid-open stands (s-class C) that fringe the *valles.* In these stands the fire was likely beneficial; killing the smallest trees, consuming litter, and recycling nutrients for uptake by the trees.

Fire Regime I - Insects and Disease

Based on site visits and a review of the field sampled data, resource specialists found that diseases and insects typical for ponderosa pine forests are present and active in the preserve although no epidemic levels were observed. These include ponderosa pine dwarf mistletoe (*Arceuthobium vaginatum spp. cryptopodum*) (shown right), a parasitic flowering plant that occurs in roughly one third of the pine type on the preserve. Infection by dwarf mistletoe was found to be chronic, and tended to be patchy within stands and across the landscape. Some extensive infestation was observed in the southwest corner of the preserve. Armilllaria root disease is common in the pumice soils of the Jemez Mountains, affecting ponderosa pine and other conifers. Other diseases of ponderosa pine observed (at low frequency) during site visits include Elytroderma needle blight and Western gall rust (*Endocronartium*

Figure 4-6. Ponderosa pine dwarf mistletoe (Ciesla, 2008)

harknessii). While causing deformities on affected trees, these fungal diseases are generally of minor importance in the Southwest. Limb rust (*Peridermium filamentosum*) is fairly common in the Jemez Mountains, causing progressive branch mortality, usually within the center of the crown, and mostly affecting older trees.

Fire Regime I - Understory Composition

The Ponderosa Pine/Common Juniper plant association represents a transition from ponderosa pine to the mixed conifer zones and is known from the lower toe slopes of Redondo Peak. While the canopy is dominated by ponderosa pine, there is little ponderosa reproduction. Instead, white fir, Douglas-fir, and blue spruce are prevalent; suggesting that fire suppression is leading to the slow transformation from ponderosa pine woodland to a mixed conifer forest. Common juniper is well represented and characteristic in the shrub layer (in some cases it may be more abundant due to fire suppression). There are still several grassland forbs in the understory such as bluebell bellflower, Rocky Mountain iris, and yarrow (Figure 4-7), but grassland dominants such as Parry's oatgrass and Arizona fescue are absent. This association is not widely reported in New Mexico and is more common in the northern Rockies (Muldavin and Tonne, 2003).

In contrast to the other associations, the Ponderosa Pine/Gambel Oak/Arizona Fescue plant association is not linked directly to valle grasslands. Rather, it occurs along slopes of the southern flank of Redondo Peak and Redondo Border and in the rolling terrain of Banco Bonito (and occasionally along the caldera rim). It has been noted that the Gambel oak shrub component seemed under-represented relative to other sites in the Southwest. Arizona fescue is also poorly represented, but both the low cover of Gambel oak and fescue may be due to increased tree canopy due to fire suppression or simply the dryness of the sites.

Figure 4-7. Left to right: Rocky Mountain iris, bluebell bellflower, and yarrow

Fire Regime III

The middle elevations of the Valles Caldera are dominated by mesic mixed conifer forests (*Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland*) composed of various mixtures of conifers (Douglas-fir, white fir, blue spruce, southwestern white pine, limber pine, and ponderosa pine) along with scattered aspens. Approximately 24,295 acres of this forest type was mapped on the preserve

through the forest stand delineation. Fringes of pure blue spruce have recently gained importance (Muldavin E., 2006) and likely reflect an encroachment of the conifers into the grasslands.

Also characterized within Fire Regime III are just over 6,700 acres of the *Intermountain Basin Aspen-Mixed Conifer Forest and Woodland*. It should be noted that aspen is often present within most forest types in response to disturbance by historic logging. As a major succession species aspens can vigorously re-sprout post-disturbance and can come to dominate a site for decades or even centuries. Aspen regeneration is particularly strong on severely burned sites, but may be controlled to some degree by preferential elk and deer browsing in those areas. Although some aspen forests are known to be self-perpetuating, conifers will typically regain a site in the absence of fire and with adequate conifer seed sources. The distribution of mesic mixed conifer and aspen forests is presented below in Figure 4-8.

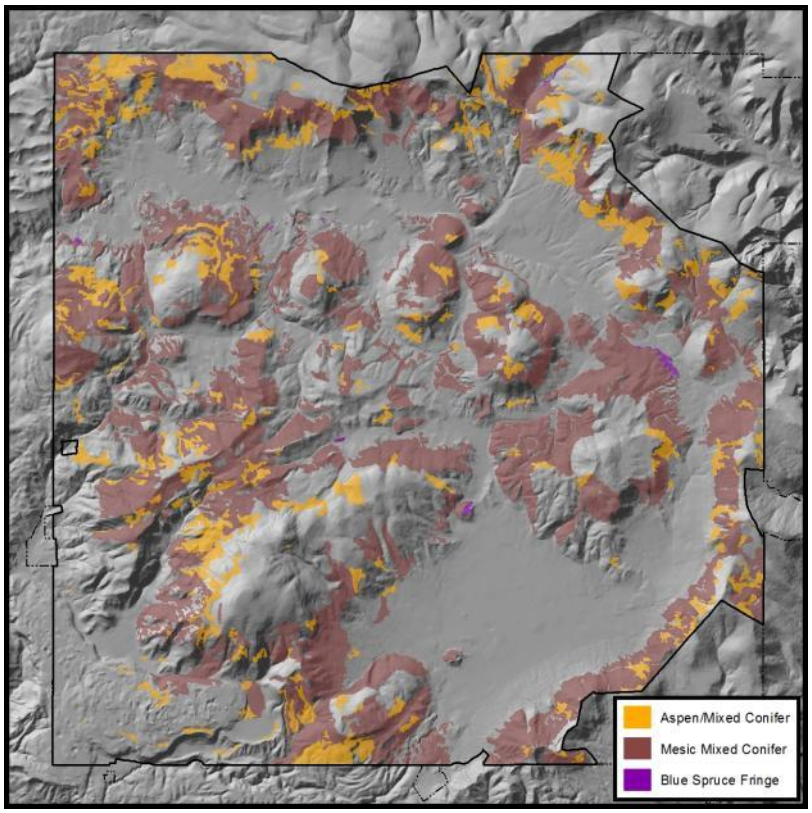


Figure 4-8. Distribution of mesic mixed conifer, aspen-mixed conifer and blue spruce fringe on the VCNP

The mixed conifer is a transitional forest and therefore best thought of as a continuum that follows a moisture gradient driven by elevation and aspect, bound by ponderosa pine forests at the low end and the spruce-fir forest on the upper end. The major tree species found in the mesic montane mixed conifer forests are Douglas-fir, ponderosa pine, blue spruce, Engelmann spruce, white fir, and aspen. Species composition varies based on the tolerance for disturbance or shade as depicted in Figure 4-9.

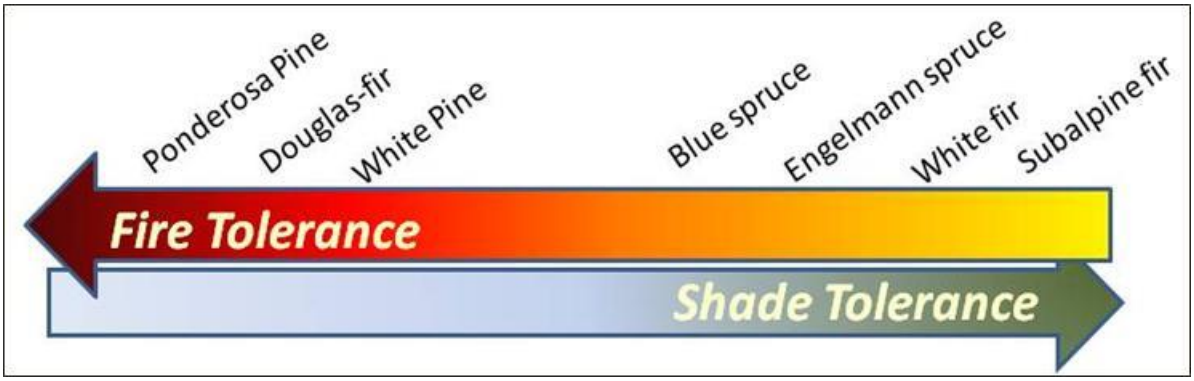


Figure 4-9. Species on a gradient related to tolerance to fire and shade

Fire Regime III - Structure and Composition

In this fire regime, mixed severity fires occur every 6-60 years. Lethal fires are usually at longer intervals, exceeding 100 years. Therefore, fire is been the primary disturbance in mesic mixed conifer and aspen-mixed conifer forests although insects have also played a major role. The present structure and composition of these forests on the preserve are comprised almost exclusively of mid-closed forests due to the intensive clearcutting that occurred throughout this zone in the 1960's. Surprisingly the adjective rating for ecological departure is only 2 – *moderately departed.* This is because periodic stand replacement fire creating an even age distribution over varying sized landscapes is not completely uncharacteristic.

Table 4-10. VCC determination, forest types in fire regime III

Southern Rocky Mountain Wet Mesic Mixed Conifer								
Class	**A**	**B**	**C**	**D**	**E**	**UE**	**UN**	**Total**
Reference Condition	10	40	25	10	15	0	0	100
Existing Condition	0	96	0	4	0	0	0	100
VCC Rating								**2 (56)**
Intermountain Basin Aspen/Mixed Conifer								
Class	**A**	**B**	**C**	**D**	**E**	**UE**	**UN**	**Total**
Reference Condition	25	40	5	30	0	0	0	100
Existing Condition	0	98	2	0	0	0	0	100
VCC Rating								**2 (58)**

While there are still relatively large patches of aspen on the preserve, there are indications that fire suppression in twentieth century has led to significant declines regionally, and there is the possibility that stands are also declining on the preserve. The interdisciplinary team surmised that aspen on the preserve has probably benefited by the disturbance of the intensive 20th century logging. Even given forest gaps for regeneration, browsing by wildlife (primarily elk) may also be affecting aspen regeneration success (Muldavin and Tonne, 2003).

Within Fire Regime III, this is a strongly fire adapted community. Without regular fire, mixed conifers replace the aspen community. As a species, aspen is adapted to a much broader range of environments than most plants found associated with it.

Inventory data as shown in Table 4-11 confirms the distribution of the forest in the mid-size diameter classes. Aspen exist in single-storied and multi-storied stands depending on disturbance history and local stand dynamics. Conifer species are common stand components, often comprised of subalpine fir and Engelmann spruce with minor amounts of Douglas-fir and pine species (Table 4-12).

Table 4-11. Forest cover (%) by size class; fire regime III (percent cover, percent of cover)

Size Class	1-4.9 in dbh	5-8.9 in dbh	9-15.9 in dbh	16+ in dbh
Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland				
% Cover	8 (12)	17 (25)	30 (43)	14 (20)
Intermountain Basin Aspen Mixed - Conifer Forest and Woodland				
% Cover	8 (8)	29 (35)	37 (45)	10 (12)

Table 4-12. Forest cover (%) by species; fire regime III

Species	Blue Spruce	Subalpine Fir	Douglas-fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total
Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland									
% Cover	9	1	20	8	3	7	14	9	56
Intermountain Basin Aspen - Mixed Conifer Forest and Woodland									
% Cover	2	2	9	8	T	12	42	5	64

Fire Regime III - Las Conchas Fire Effects

Mesic Mixed Conifer

As shown previously in Table 4-5, nearly 4500 acres of mesic mixed conifer burned in the Las Conchas fire; most (73 percent) burned with moderate to high severity. The mesic mixed conifer forests in the Jemez Mountains are adapted to a mixed severity fire regime. However, because the existing condition was so homogenous (nearly 90 percent was closed, mid-age forest) the extent and severity of the Las Conchas fire likely exceeds the extent and severity of any past event and certainly does not resemble the types of fires described by those who have documented fire history in the area or within the forest types (LANDFIRE, 2006; Dewar, 2011; Allen, 2004).

Where aspen clones are present then these forests will likely move into an early-open aspen forest (s-class A) where aspen is not present they may or may not reset to an early conifer class. Depending on the severity of impacts to soils they may become dominated by grass or shrubs into the near or foreseeable future.

Aspen – Mixed Conifer

While only about 9 percent of the forested area burned on the preserve was designated as aspen forest nearly all of that area burned with moderate to high severity. Aspen forests are resilient following moderate to high severity fire and sprouting aspen were observed shortly following the fire. Inventories (not yet reviewed for quality control or published) found thousands of aspen shoots per acre in some areas. Aspen is included in the composition of nearly all forest types on the preserve except for the

ponderosa pine savanna and the mesic spruce fir. Therefore aspen is likely to expand following the Las Conchas fire.

Fire Regime III - Insects and Disease

Mesic Mixed Conifer

Western spruce budworm (*Choristoneura occidentalis*) has historically been the most widespread and noticeable insect affecting conifers on the preserve and throughout much of northern New Mexico. In recent decades, budworm activity has been of chronic occurrence, with the more severe infestations often shifting location from year to year. In favorable years (such as 2009), at least some defoliation can be observed throughout most of the mixed conifer type. Bark beetle activity, especially fir engraver beetle (*Scolytus ventralis*) and Douglas-fir beetle (*Dendroctonus pseudotstugae*), has been high the past several years. Douglas-fir dwarf mistletoe (*Arceuthobium douglasii*) is common and widespread on the preserve, with over 50 percent of the host type (acres) affected.

Aspen – Mixed Conifer

Aspen is host to many damaging insects and diseases, a factor in its relatively short life-span. Elevated levels of aspen mortality have been observed throughout much of the interior West, including northern New Mexico in the past few years. Some recent dieback and mortality was seen on the preserve during site visits and was mapped during the regional 2009 aerial detection. Although most of the stands are dominated by mid-succession, closed forests, (Table 4-10), field sampled data show a greater diversity in size class distribution within the stands. Species composition indicates only minor competition from conifers.

The greatest threat to the health and vigor and future development of these stands is likely to be from climate or insects and disease triggered by climate. Aspen regeneration is particularly vulnerable to elk and browsing by elk is also affected by climate. Deep, wet snow moves elk to lower elevations and otherwise protects young trees with cover. Aspen regeneration is especially hard hit during years with late snowfall, light snowfall, and/or early spring melt.

Fire Regime III - Understory Composition

Mesic Mixed Conifer

On moist mesic mixed conifer sites the understory is dominated by herbs and can be diverse and luxuriant in cover. With the exception of Gambel oak and Rocky Mountain maple, shrubs and sub-shrubs are typically poorly represented. Grassy understories can occasionally occur adjacent to lower montane grasslands as well. Three forest alliances of mixed conifer communities (White Fir, Douglas-fir, Blue Spruce) and one woodland alliance (Limber Pine) have been classified based on canopy dominance and tree reproduction status in the understory. In addition, a White Fir – Quaking Aspen alliance was identified where conifers and the broadleaf deciduous trees co-dominate (Muldavin E., 2006).

Eight plant associations have been identified for the White Fir Alliance with a variety of understories and canopy structures. The White Fir/Forest Fleabane (*Abies concolor*/*Erigeron eximius*) plant association has a rich and often luxurious undergrowth dominated by mesic forbs and grasses that include, beside forest

fleabane, woodland strawberry, Canadian white violet, fringed brome, and Ross sedge (*Carex rossii*). Sites are typically cool, northerly mid to lower slopes down to elevations of 8,800 feet. In drier upper slope positions this association grades into those dominated by shrubs and sub-shrubs. Specifically, the White Fir/Whortleberry plant association dominated by sub-shrubs such as whortleberry and myrtle boxleaf (*Paxistima myrsinites*), and the White Fir-Douglas-fir/Common Juniper plant association dominated by taller shrubs such as common juniper (*Juniperus communis*), and mountain ninebark (*Physocarpus monogynus*).

Alternatively, these upslope sites can be dominated by the White Fir-Douglas-fir/Creeping Barberry plant association where both shrub and herbaceous cover are minimal. This association is typified by scattered individuals of creeping barberry (*Mahonia repens*) and myrtle boxleaf with a low overall species richness. The sparse understory may result from a combination of dense overstory canopies and dry shallow soils. In contrast, the White Fir-Douglas-fir/Thurber Fescue plant association has a distinctive grassy understory similar to the montane grasslands on which it is known to border (Muldavin and Tonne, 2003).

Figure 4-10. Gooseberry current (Powell, 2010)

Cool sites, such as north-facing draws and slopes, commonly support the White Fir-Quaking Aspen/Rocky Mountain Maple plant associations. Five-petal cliffbush (*Jamesia americana*), and Rocky Mountain maple (*Acer glabrum*) typically dominate a conspicuous tall shrub layer that can have additional shrubs such as rock spirea (*Holodiscus dumosus*), trumpet gooseberry (*Ribes leptanthum*), gooseberry currant (*Ribes montigenum*) (Figure 4-10, above), whortleleaf snowberry (*Symphoricarpos oreophilus*), and Fendler's brickellbush (*Brickellia fendleri*). Quaking aspen (*Populus tremuloides*) and white fir may also co-dominate in the canopy within similar habitats. Here the aspens are typically large, mature individuals of 100 years or more, and are likely remnants from a period when aspens dominated the site following a fire (or logging). A White Fir-Douglas-fir/Gambel Oak plant association of north-facing lower slopes of Valle Seco that had a significant quaking aspen component was also identified (Muldavin and Tonne, 2003).

Among the five plant associations identified for the Douglas-fir Alliance, four have close analogs in the White Fir Alliance: the Douglas-fir/Rocky Mountain Maple, Douglas-fir/Five-petal Cliffbush, Douglas-fir/Creeping Barberry, and Douglas-fir/ Whortleberry plant associations. The main difference is the lack of white fir in the canopy and perhaps a tendency for somewhat warmer site conditions. In addition, a Douglas-fir-Limber Pine/Rocky Mountain Trisetum plant association was identified on high exposed ridgelines, above 9,500 feet. Under these dry conditions, the canopies are moderately open, and the understory is typically grassy and dominated by Rocky Mountain Trisetum (*Trisetum montanum*), Ross' sedge, and fringed brome along with a scattering of forbs. One association from the Limber Pine Alliance—the Limber Pine/Common Juniper plant association--- has been identified. This association has

a similar herbaceous layer to the Douglas-fir-Limber Pine/Rocky Mountain Trisetum plant association but with a shrub layer dominated by common juniper (Muldavin and Tonne, 2003).

Although relatively common on the preserve, the Blue Spruce Alliance is usually restricted to northern exposures of lower slopes and along the edges of the grasslands. The understory is dominated by herbs and can be diverse and luxuriant in cover. With the exception of common juniper, shrubs and sub-shrubs are poorly represented. Grassy understories with similar compositions to adjacent valle grasslands can also occur (Muldavin, 2006).

A forb-rich Blue Spruce/Forest Fleabane plant association, a graminoid-dominated Blue Spruce/Dryspike Sedge plant association, and a Blue Spruce-Douglas-fir/Sparse plant association have been identified. These associations can form mature stands on mesic lower mountain slope sites and occur most commonly as dense-canopied “blue spruce fringes” along the borders of the valle grasslands. These fringes are narrow, and because of moisture conditions and the relatively heavier grassland soils, do not seem to be actively encroaching further into the valle grasslands in a significant manner (Muldavin and Tonne, 2003). Early photographs taken from around the turn of the century show this fringe to be largely absent on the preserve as shown in Figure 4-11. Although they are natural they likely represent an uncharacteristic condition.

Figure 4-11. A comparison between 1906 (left) and 1996 (right) of the same slope in the Valle San Antonio showing the development of a fringe blue spruce forest expanding into the grasslands (Muldavin and Tonne, 2003).

Fire suppression has likely been a key to the development of the blue spruce fringes. Prior to settlement, fires likely moved up from the grasslands and burned into the forests a short way until they met natural fuel breaks caused by moisture and topography. Without fire, blue spruces have moved back down slope until they hit grassland soil conditions that are relatively poor for tree growth (Muldavin and Tonne, 2003). Fine soil texture, low soil moisture, herb competition, and low minimum temperatures have all been shown to contribute to stress of other species of experimentally transplanted conifer seedlings (Coop and Givinish, 2007).

Aspen – Mixed Conifer

On drier sites shrubs and sub-shrubs typically dominate the understory of these aspen forests, but on the colder wetter sites soil mosses replace most vascular vegetation. Grassy understories occasionally occur adjacent to upper montane grasslands. On moist mesic sites the understory is dominated by herbs that can be diverse and luxuriant in cover. With the exception Rocky Mountain maple, shrubs and sub-shrubs are typically poorly represented. Grassy understories occasionally occur adjacent to montane grasslands (Muldavin E., 2006).

Figure 4-12. Junegrass

Two associations of the *Quaking Aspen Alliance* have been described in the upper elevations of the preserve above 8,900 feet. The Aspen/Meadow Rue plant association is the most common and is characterized by closed canopies of aspen with few, if any, conifers co-dominating. The understory is typically a luxuriant herbaceous cover represented by a wide variety of mesic forbs and grasses such as meadow rue (*Thalictrum fendleri*), stickywilly bedstraw (*Galium aparine*), strawberry, violet, geranium (*Geranium richardsonii*, *G. caespitosum*), Ross' sedge, and fringed brome. Kentucky bluegrass (*Poa pratensis*), an exotic and invasive rhizomatous grass species, can also dominate the understory. A Kentucky Bluegrass Phase of the association has also been described where the Kentucky bluegrass exceeds 25 percent cover (it can exceed 60 percent). This association has been reported widely in the Rocky Mountains from Canada to the Southwest. Some authors suggest that bluegrass-dominated types are some of the poorest among aspen communities in terms of wildlife habitat because of low plant species diversity. In contrast, the Quaking Aspen/Thurber Fescue plant association is dominated by native grasses and sedges including Thurber fescue, fringed brome, junegrass (*Koeleria micrantha*) (Figure 4-12), and dryspike sedge. Forb richness is lower than in the previous association and more representative of meadows with species such as vetch (*Vicia americana*), pea (*Lathyrus* spp.), and bluebell bellflower (*Campanula rotundifolia*). The understory composition suggests that this aspen association may represent an invasion of montane meadow grassland by trees. Although relatively uncommon, this association has been reported in Colorado as well (Muldavin and Tonne, 2003).

Fire Regime IV

These forests represent the highest elevation forests on the preserve (Figure 4-13). Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snow is often deep and late lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. The tops of the *cerros* are represented in this fire regime. The late-lying snows and generally cool moist conditions prevented the frequent spring fires from spreading into these forests. Without frequent burning, forest fuels could accumulate. When drought conditions or late season fires led to increased burning, the accumulated fuels could burn quite hot, igniting the canopy and resulting in occasional severe burning. These stand replacing fires burned in variable intervals; every 35 – 200 years (LANDFIRE, 2006).

Spruce-fir forests are a minor component in the Jemez Mountains region but are a major element in the preserve's forest ecosystem, covering approximately 8,200 acres. They occupy much of the upper slopes and ridgelines along the caldera rim and on Redondo Peak. There are two distinct forest types represented in the spruce-fir forests: the more xeric *Rocky Mountain Subalpine Dry-mesic Spruce Fir Forest and Woodland* and the cooler, wetter *Rocky Mountain Subalpine Mesic Spruce Fir Forest and Woodland.*

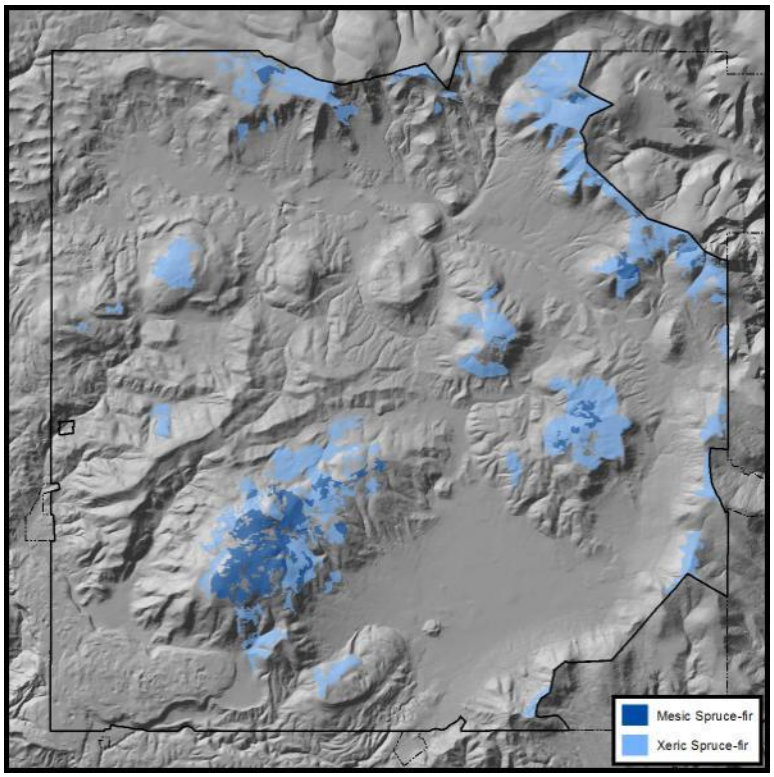


Figure 4-13. Distribution xeric and mesic spruce fir forests on the VCNP

Historic logging has led to forests dominated by mid-succession, closed canopy forest (Table 4-13). This structure is setting the stage for an increase risk of stand replacement fire due to potential interactions with climate and insects. The long fire interval within these forests is due to the very short season in which forest fuels are dry enough to carry fire. Climate trends initiating an earlier, longer fire season (Running, 2006; Westerling, et al., 2006), could increase the risk of a stand replacement event in these young forests.

Table 4-13. VCC determination, forest types in Fire Regime IV

Rocky Mountain Subalpine Dry-Mesic Spruce-fir								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	15	20	15	20	30	0	0	100
Existing Condition	0	94	6	0	0	0	0	100
VCC Rating	0	20	6	0	0	0	0	3 (74)
Rocky Mountain Subalpine Wet-Mesic Spruce-fir								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	15	20	15	20	30	0	0	100
Existing Condition	0	76	24	0	0	0	0	100
VCC Rating								2 (65)

Historic disturbance included occasional blow-down, insect outbreaks and stand-replacing fire. Disturbance by fire is primarily long-interval stand replacement fires, with minor amount of terrain influenced by moderately long-interval mixed severity fires. Intensive clear-cutting on the preserve altered the structure significantly making it difficult to estimate site-specific fire history. Because of the frequency of fire on the preserve in general it is reasonable to presume mixed severity fire as well as occasional replacement fires influenced historic structure and composition. Forest inventories confirm the overabundance of trees in the mid-size diameter classes Table 4-14.

As shown in Table 4-15 the xeric spruce-fir forest includes aspen as an important compositional component along with a minor presence of other conifer species. The mesic spruce-fir forest type only contains Engelmann spruce and sub-alpine fir. The species composition on the preserve is typical for this forest type (LANDFIRE, 2006).

Table 4-14. Cover (%) by size class; Fire Regime IV (percent cover, percent of cover)

Size Class	1-4.9 in dbh	5-8.9 in dbh	9-15.9 in dbh	16+ in dbh
Rocky Mountain Subalpine Dry-mesic Spruce-fir Forest and Woodland				
% Cover	9 (13)	19 (28)	31 (46)	9 (13)
Rocky Mountain Subalpine Wet-mesic Spruce-Fir Forest and Woodland				
% Cover	10 (17)	19 (32)	30 (51)	10 (17)

Table 4-15. Forest cover (%) by species; Fire Regime IV

Species	Blue Spruce	Subalpine Fir	Douglas-fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total
Rocky Mountain Subalpine Dry-mesic Spruce-fir Forest and Woodland									
% Cover	2	3	12	26	1	3	16	4	54
Rocky Mountain Subalpine Wet-mesic Spruce-fir Forest and Woodland									
% Cover	6	23	0	44	0	0	T	0	53

Fire Regime IV – Las Conchas Fire Effects

As shown previously in Table 4-5, just over 3,000 acres of spruce fir forest burned in the Las Conchas fire on the preserve and 76 percent of the xeric spruce fir and 77 percent of the mesic burned with moderate to high severity. These forest types are well adapted to severe fire events but their response is somewhat unpredictable. In the xeric spruce-fir, where aspen was included in the species composition, aspen will likely sprout following the fire. In some areas present cover by spruce-fir may have been maintained by fire as a meadow prior to European settlement (based on 1935 aerial photography) and may transition back towards a grassland after burning. Climate will also influence the succession of these forests, which are adapted to the coldest and wettest sites.

Fire Regime IV - Insects and Disease

Western spruce budworm and bark beetles are the most damaging insects in these high-elevation forests. The past few years have seen major mortality events among corkbark/subalpine fir throughout the Southwest, including the preserve. Figure 4-14 shows spruce budworm activity on the preserve 2003 – 2012.

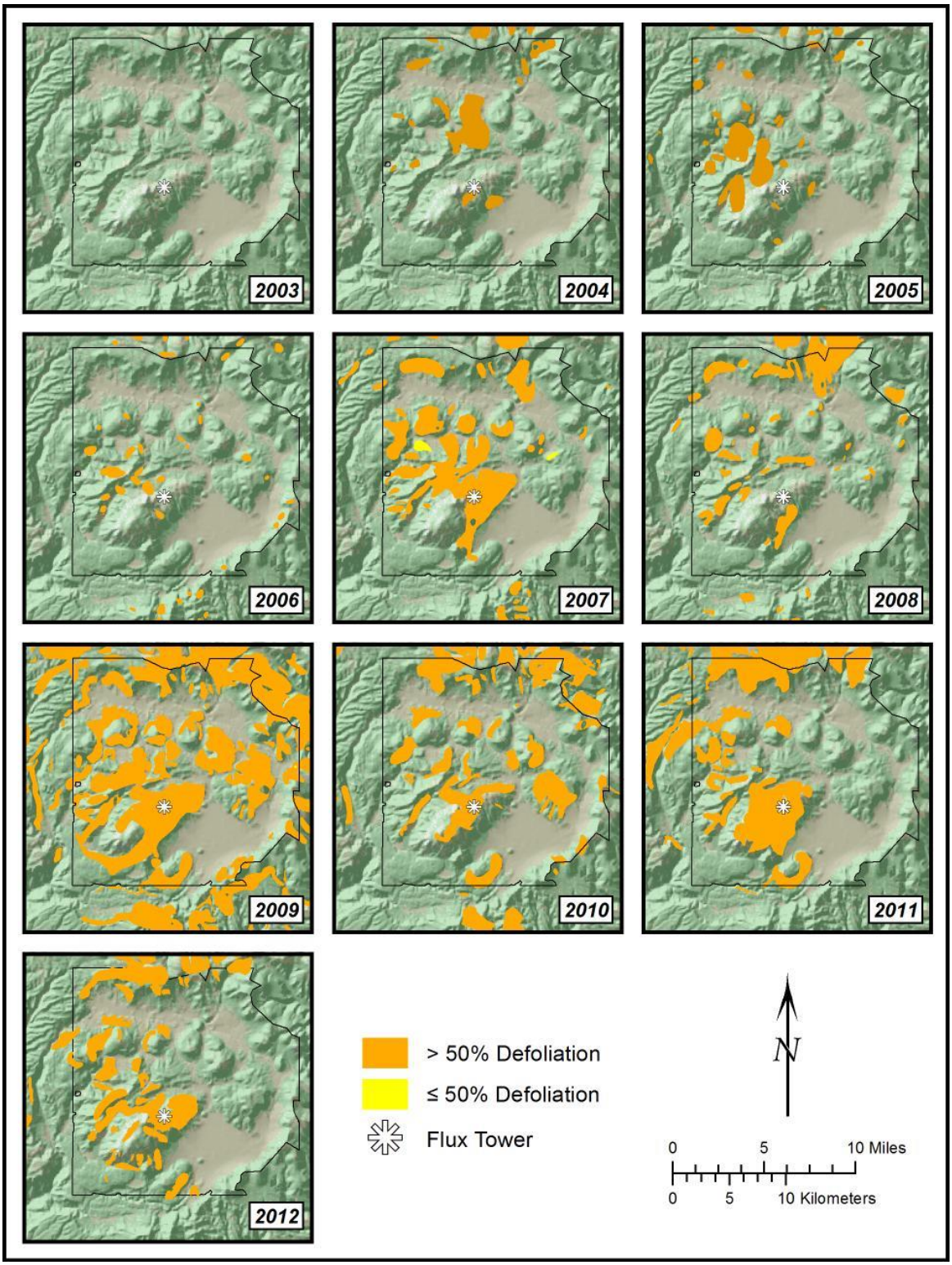


Figure 4-14. Spruce budworm progression on the VCNP

Fire Regime IV - Understory Composition

In dry mesic stands shrubs and sub-shrubs typically dominate the understory, but on the coldest sites most vascular vegetation is replaced by soil mosses. On the mesic sites, the Engelmann spruce and/or corkbark or subalpine fir that dominates the overstory typically form dense closed canopies with shady understories. Grassy understories occasionally occur adjacent to upper montane grasslands. Where there are openings in the mesic sites, the understory is dominated by herbs that can be diverse and luxuriant in cover. With the exception of Rocky Mountain maple, shrubs and sub-shrubs are typically poorly represented (Muldavin E., 2006).

Figure 4-15. Canadian white violet

The most common plant associations within the spruce fir types on the preserve are the Engelmann Spruce/Forest Fleabane, Engelmann Spruce/Whortleberry and Corkbark Fir/Whortleberry plant associations. The latter two occur primarily on upper slopes and drier sites with the understory distinctly dominated by the low-lying sub-shrub whortleberry (*Vaccinium myrtillus*), with only a few scattered forbs or grasses. The Engelmann Spruce/Forest Fleabane plant association is usually found on lower slopes under more mesic conditions that lead to the development of a richer herbaceous layer that often exceeds 30 percent cover, with a minimal amount of shrubs. Forest fleabane (*Erigeron eximius*) is usually the dominant forb, but an overall rich complement of mesic forbs is characteristic including strawberry (*Fragaria vesca*), Canadian white violet (*Viola canadensis*) (shown left), fringed brome (*Bromus ciliatus*), and northern bedstraw (*Galium boreale*). All three of these associations are widely distributed in the Southwest and into the southern Rocky Mountains (Muldavin and Tonne, 2003) The Engelmann Spruce/Parry's Oatgrass plant association was found in the most exposed conditions on northerly slopes and ridges on the borders with montane meadows at elevations above 10,000 feet. This association is characterized by an open canopy of Engelmann spruce and scattered limber pine, and a grassy understory dominated by Parry's oatgrass (*Danthonia parryi*) with occasional bunches of Thurber fescue (*Festuca thurberi*) and Arizona fescue (*Festuca arizonica*). An assortment of forbs commonly associated with montane meadows may also be present. This association may signify encroachment onto montane grasslands by spruce as a result of fire exclusion. Using historical photography, some authors reported a similar invasion of spruce-fir in high elevation grasslands on Sierra Blanca in south-central New Mexico. This association has not been reported elsewhere in the Southwest, and it may be transitory pending re-establishment of natural fire regimes on the preserve (Muldavin and Tonne, 2003).

Also occurring on the ridges and upper slopes was the Engelmann Spruce/Dryspike Sedge plant association, which is characterized by a moderately closed canopy of mixed-aged spruces absent of corkbark fir. A similar closed canopy forest from the upper elevations of Redondo Peak was also mapped as an Engelmann Spruce/Moss plant association with an understory that was very sparse with only a scattering of grasses and forbs. The understory of the former plant association is also relatively low in cover, typically mesic, and dominated by dryspike sedge (*Carex foenea*) as well as an assortment of forbs, many of which are more prevalent in adjoining forest associations. Although this association may be

found near montane meadows, the understory composition, presence of Engelmann spruce in a diversity of size classes, and a closed canopy suggests that this does not represent an invasion of montane meadows. Its presence on forest soil types also supports this assumption (Muldavin and Tonne, 2003).

4.2.3 Montane Grasslands and Forest Meadows

Approximately 27,000 acres in the preserve are non-forested or have a dominant life form cover of either shrubs or grasslands. The non-forested ecotypes on the preserve fall into several categories: montane grasslands, forest meadows, wetlands/wet meadows, montane shrublands, and riparian shrublands.

Montane Grasslands

Montane Grasslands make up the majority of the grasslands on the preserve, covering over 17,000 acres and dominating the expansive lower elevation valles. They are also found at higher elevations along the caldera rim and in small interior mountain valleys.

Despite their seemingly high abundance on the preserve, montane grasslands are relatively uncommon in New Mexico. Other than in the Jemez Mountains, they are found only at the highest elevations of the Sangre de Cristo Mountains along with scattered occurrences in the Sacramento Mountains and in the Gila. Muldavin and Tonne (2003) identified five montane grassland alliances based on relative dominance, i.e., the Parry's oatgrass, Thurber fescue, Arizona fescue, pine dropseed *(Blepharoneuron tricholepis),* and Kentucky bluegrass alliances. Besides the dominant grasses, these alliances are typified by the presence of meadow species such as Fendler's sandwort, bluebell bellflower, Parry's bellflower *(Campanula parryi)* (shown right), yarrow, beautiful fleabane *(Erigeron formosissimus),* heartleaf buttercup *(Ranunculus cardiophyllus),* yellow owlclover *(Orthocarpus luteus),* woolly cinquefoil *(Potentilla hippiana),* and Rocky Mountain iris. Overall, Muldavin and Tonne described highly diverse communities, with over 125 species of grasses and forbs recorded so far.

Figure 4-16. Parry's bellflower (Powell, 2010)

The grasslands of the preserve evolved under a frequent fire regime with fire return intervals estimated at less than 10 years (Dewar, 2011). Intensive grazing as well as the exclusion of fire has impacted the existing condition and spatial extent of the grasslands. Non-native European pasture grasses are naturalized components of the grassland composition (TEAMS Enterprise Unit, 2007). Present day grazing includes a small number of cattle (less than 750 animal units) grazing from June through September and 2000 – 3000 elk grazing from early spring to late fall depending on snow.

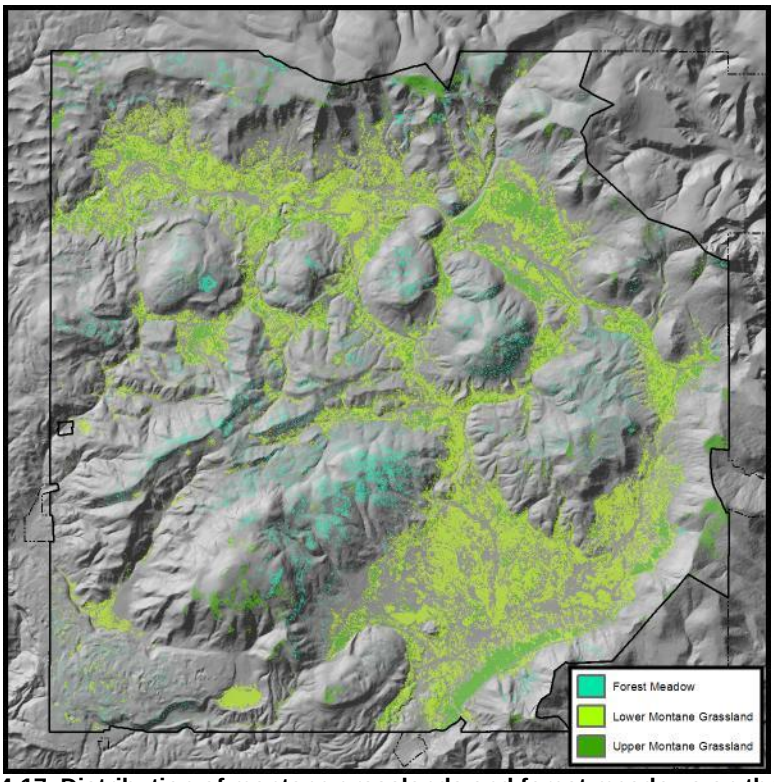


Figure 4-17. Distribution of montane grasslands and forest meadows on the VCNP

A recent assessment of the past five years of annual range monitoring data collected on the preserve was presented to the Board of Trustees at a public meeting in March 2012. These data show a statistically significant improvement to species diversity measures (richness and diversity) in the 10-years since the trust's assumption of management in 2002 as shown in Figure 4-18 and Figure 4-19 below.

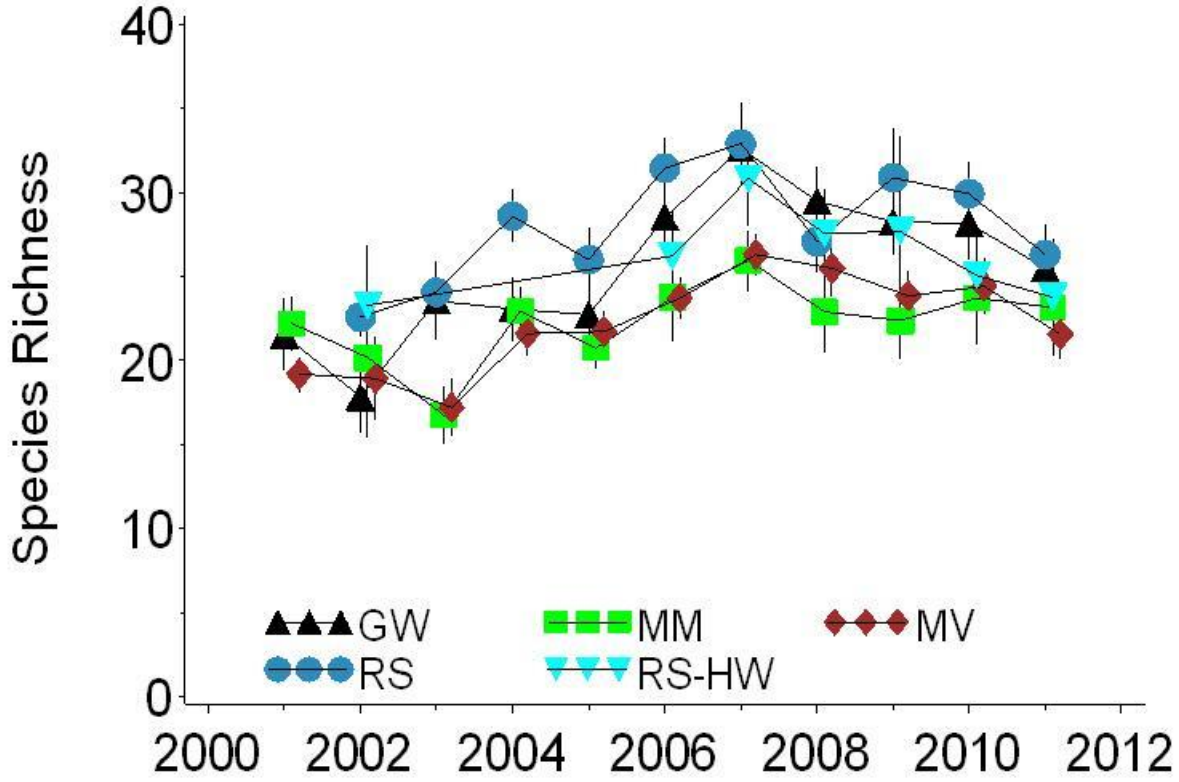


Figure 4-18. Species richness of grassland communities on the VCNP: 2000 – 2012 (GW= grazeable woodlands, MM = mountain meadow, MV = mountain valley, RS = riparian site, RS-HW = riparian headwaters)

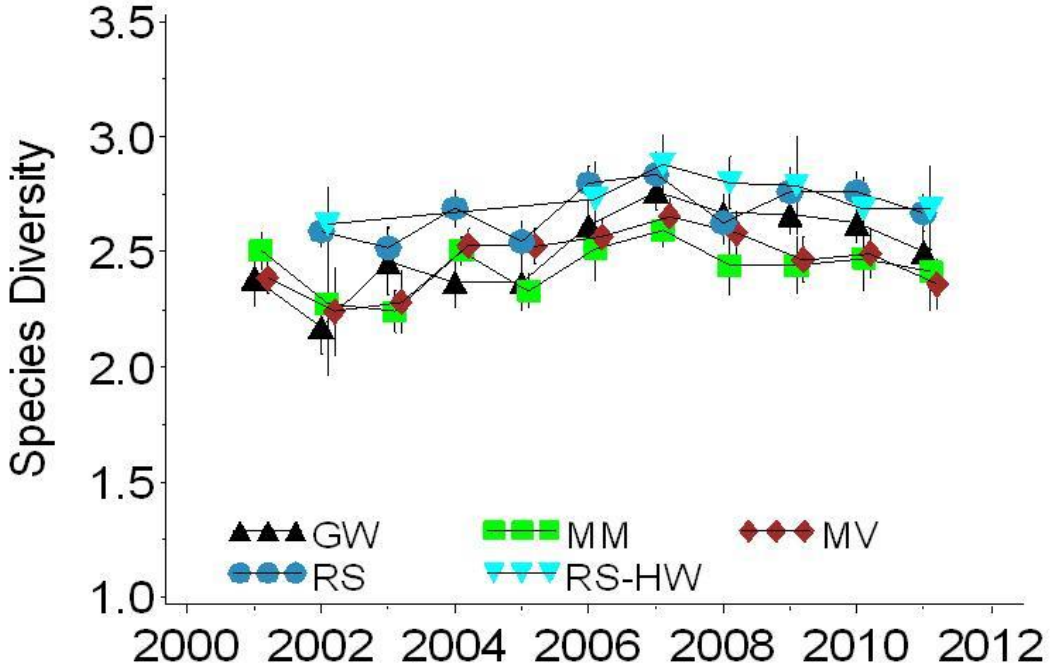


Figure 4-19. Species diversity of grassland communities on the VCNP: 2000 – 2012 (GW= grazeable woodlands, MM = mountain meadow, MV = mountain valley, RS = riparian site, RS-HW = riparian headwaters)

Montane Grasslands - Los Conchas Fire Effects

Montane grasslands that burned in the Las Conchas fire recovered quickly and responded favorably with improvements in protein and nutrient contents (Valles Caldera Trust, Unpublished data) as shown below in Figure 4-20. Figure 4-21 shows the quick regrowth of the grasslands. The fuels and litter that accumulate in the open grasslands are far lighter than those that accumulate under a forest canopy, reducing the downward flux of heat and minimizing the impacts to meristem tissue at the base of the plant (Brown and Smith, 2000), thereby minimizing negative impacts. Also, the removal of leaf litter by the fire exposes the soil to sunshine leading to an increase in soil temperatures, which stimulates plant growth and soil microbe activities. Further, burning releases minerals and salts (nutrients) that stimulate rapid plant growth and uptake. Nutrient content in the new growth grasses is higher in the burned versus unburned grass, creating high-quality forage for wildlife (e.g., elk) and livestock.

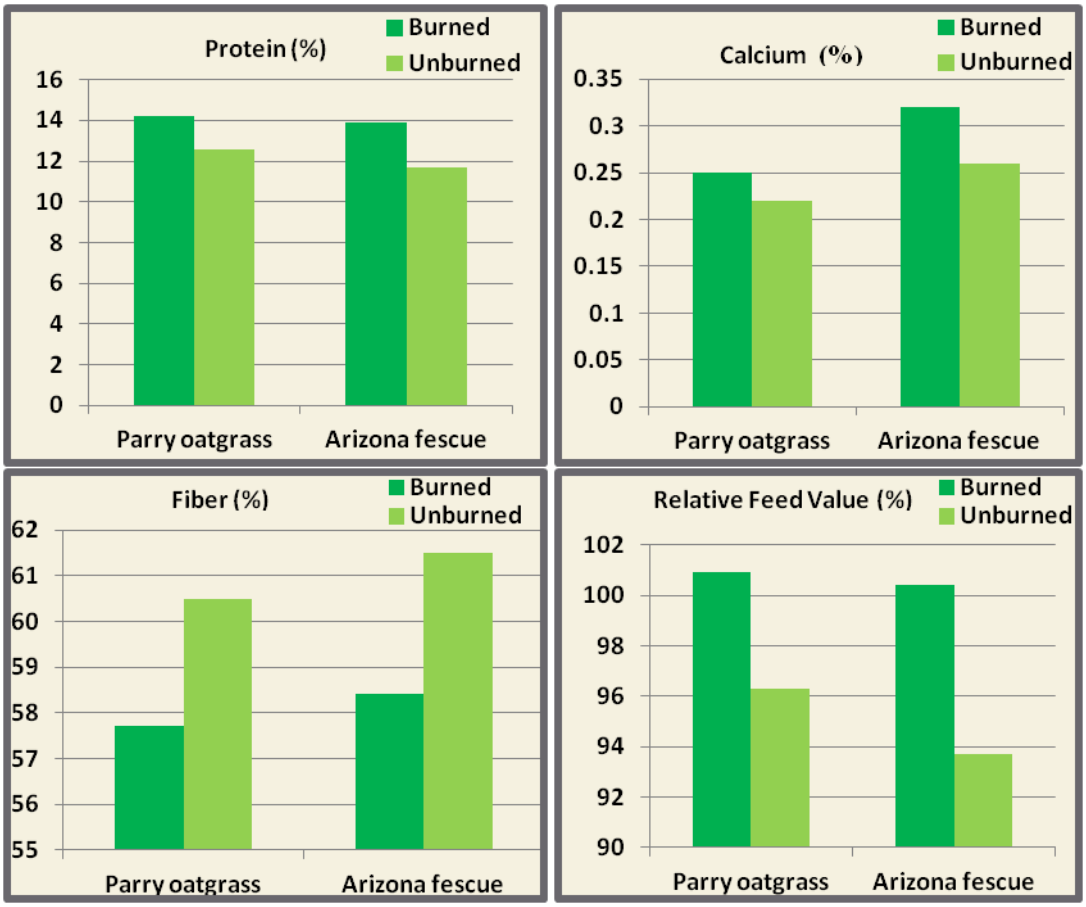


Figure 4-20. Comparative analysis of nutrient and relative feed value in burned and unburned grasslands on the VCNP, post Las Conchas fire

Figure 4-21. Grassland recovery following Las Conchas fire: July 2, 2011 (left) and August 3, 2011 (right)

Forest Meadows

Figure 4-22. Forest Meadow on the VCNP associated with mid-century logging

Of the major vegetation alliances of the preserve mapped by Muldavin et al. in 2006 - 4,700 acres of forest meadow were defined as, "*Grasslands associated with post-burn and post-logging high-elevation forests*" (Muldavin E., 2006). It was noted that scattered remnant trees are common and that these meadows are most common on mountaintops and ridgelines as shown in Figure 4-22. Muldavin's very fine resolution mapping process distinguished these openings within the surrounding forest. Stand delineation often incorporated them into forest stands. The primary plant associations are Thurber Fescue-Kentucky Bluegrass Kentucky Bluegrass/Common Dandelion, as well as secondary associations, Parry Danthonia-Kentucky Bluegrass Arizona Fescue-Kentucky Bluegrass, are either dominated by, or include, naturalized exotics (Kentucky bluegrass and common dandelion). The Las Conchas fire would likely continue to maintain these openings and disrupt any transition back towards a conifer forest.

4.2.4 Riparian Vegetation

Riparian vegetative communities are contained within the wetlands, wet meadows and along the stream corridors of the preserve. Their distribution is shown in Figure 4-23.

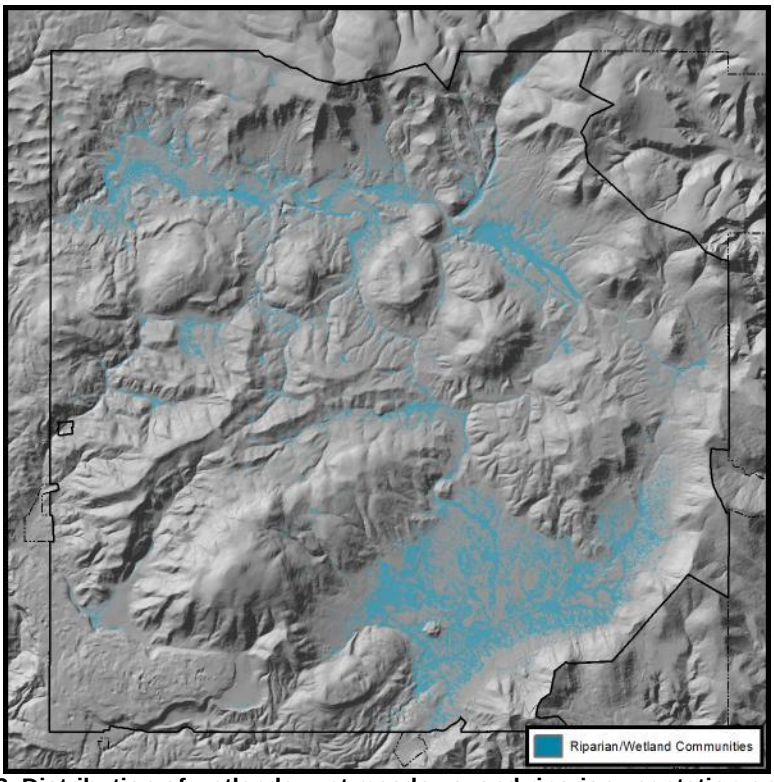


Figure 4-23. Distribution of wetlands, wet meadows, and riparian vegetation on the VCNP

Wetlands and Wet Meadows

Montane Wet Meadows and Wetlands occur throughout the lowland valleys, commonly adjacent to perennial streams of the valley bottoms, but also along seeps, springs and creeks in the uplands. These diverse communities—142 species have been recorded so far—are dominated by facultative and obligate wetland graminoid species, mostly sedges *(Carex sp.)* and rushes (*Juncus sp.).*

In their 2003 report Muldavin and Tonne identified 15 obligate and 13 facultative wetland species as defined by the national wetlands species list. In addition, most of these communities are on sites subject to periodic flooding, or where the soils can become saturated at some point during the year in most years (most of the wet meadows and wetlands are associated with hydric Vastine soils.) Accordingly, these communities would likely be considered jurisdictional wetlands under federal rules.

Field visits and specialist reports completed for this analysis found that wetlands were likely far more extensive in the pre-settlement era. As detailed under the hydrology section of this chapter, prior to intensive sheep grazing the valley bottoms were likely comprised of a multi channeled stream buffered by extensive wetlands rather than the single channel and narrow band of riparian vegetation found today. Annual measures as shown in the previous section (Figure 4-18, Figure 4-19) show maintained improvements in species richness and diversity since 2002. Only a minor component of this vegetation type burned in the Las Conchas fire with most of it showing no visible change.

Riparian Shrublands

Riparian shrublands dominated by thinleaf alder (*Alnus tenuifolia*) that occur along perennial mountain streams. Blue spruce may also be a significant component forming open riparian woodland. Other conifers are typically absent or minor.

Figure 4-24. Riparian shrubland in Redondo Canyon

These riparian shrublands (14 acres) are special habitats of high diversity and importance for water quality. On a regional basis they occupy less than 1 percent of the Southern Rocky Mountain landscape, and they are considered rare and globally threatened. The primary ecological management issues revolve around protection of water quality and quantity, and the enhancement of these sites for their intrinsic biodiversity values and importance to wildlife. Most of the streamside riparian zones (other than upper La Jara) are in need of restoration to increase function and reestablish riparian vegetation (for instance, Bebb willow populations are being browsed into extirpation everywhere except perhaps along Redondo Creek (Figure 4-24), where the largest population is currently found) (Muldavin and Tonne, 2003).

These woody riparian habitats are mostly restricted to mountain stream drainages associated with Redondo Peak and the canyons to the west of Redondo Border in the southwestern portion of the preserve. Understories are forb-rich and luxuriant, and typically have numerous obligate wetland species (Muldavin E., 2006). In the upper reach of La Jara Creek that drains the east flank of Redondo Peak, researchers identified a riparian Blue Spruce/Thinleaf Alder/Fendler's Waterleaf plant association. Here blue spruce forms a moderate overstory with a sub-canopy of thinleaf alder (*Alnus incana* ssp. *tenuifolia*), and a very diverse herbaceous layer of over 40 grasses and forbs. Many these are obligate or facultative wetland species such as Canada reed grass (*Calamagrostis canadensis*), Fendler's waterleaf (*Hydrophyllum fendleri*), seep monkey flower (*Mimulus guttatus*), Columbian monkshood (*Aconitum columbianum*), and Fendler's cowbane (*Oxypolis fendleri*). A similar Blue Spruce/Thinleaf Alder/Kentucky Bluegrass Association was described from streamside terraces along Redondo Creek where blue spruce along with other conifers occupy the lower slopes and terraces adjacent to the streams, and where the undergrowth is distinctively grassy. There are also sites where the conifers have either been removed or have died out leaving scattered thinleaf alder thickets along the streams adjacent to drier terraces that support grassy meadows dominated by Kentucky bluegrass (Muldavin and Tonne, 2003).

One species of interest within this community is the Bebb willow (*Salix bebbiana*). Bebb willow is a shrub or low tree, ranging in height from 10 to 25 feet. In northern New Mexico, this willow occurs in riparian and wetland areas, sometimes in association with other riparian species, such as thinleaf alder (*Alnus tenuifolia*). Members of the USGS from the Jemez Mountains Field Station and resource specialists from Bandelier National Monument surveyed several areas where the shrub was thought to be present in 2003 and 2005. In their 2005 report, “A Survey of the Status of *Salix bebbiana* in the Valles Caldera National Preserve” (Allen, et al., 2005), they noted that many drainages harbor decadent populations of Bebb willow, with no young individuals, indicating a change in the viability of this species in the VCNP.

Both Bebb willow and alder species are susceptible to browsing by the VCNP's large elk population. As such, this willow could be considered an indicator species that reveal elk and other browsing ungulates' impacts on vegetation in sensitive riparian areas. Redondo canyon contains Bebb willow as well as other willow species, but the area was excluded from the original survey due to its length and the multiple species present (Allen, et al., 2005). It may require different survey methods (sampling) rather than the 100 percent survey/cataloging applied to the sparsely populated areas.

Figure 4-25. Bebb willow in the Valle Seco, note browse line and presence of dead plants (Allen, et al., 2005)

Also of note, a special Bog Birch/Water Sedge/Stiff Club moss plant association has been identified as part of the fen complex in Alamo Canyon. Although bog birch (*Betula glandulosa*) (shown right) is prevalent in the Rocky Mountains and northward, this is the only known location for it in New Mexico. Along with bog birch and water sedge (*Carex aquatilis*), this association is typified by a high cover of club moss (*Lycopodium annotinum*), which forms mats in the water channel. Other obligate wetland species that are present include tufted hairgrass (*Deschampsia cespitosa*), rough bent grass (*Agrostis scabra*), and Canada reed grass. The association lies at about 8,680 feet along a low gradient portion of Alamo Creek adjacent to a large fen dominated by tufted hairgrass. Blue spruces are also present along the margins of the occurrence (although their vigor is much reduced) (Muldavin and Tonne, 2003).

Figure 4-26. Bog birch (Harte, 2010)

4.2.5 Montane Woodlands and Shrubs

The preserve contains just under 1500 acres of montane shrublands dominated by Gambel oak (*Quercus gambelii)* and New Mexico locust (*Robinia neomexicana*) that are less than 15 feet tall. Conifer trees are usually scattered and occupy less than 10 percent cover. The distribution of montane shrublands on the preserve is displayed in Figure 4-27. Stands are typically considered successional to lower-elevation ponderosa and mixed conifer fir forests following fire, but clonal Gambel oak shrublands can be long-lived and occupy a site for long periods, particularly with repeated burning. These shrublands provide important diversity for wildlife.

While montane shrublands accounted for less than 1 percent of the area burned on the preserve, the 128 acres that burned represented nearly 10 percent of its cover on the preserve. The Gambel oak and New Mexico locust that dominate this cover type are well adapted to fire and tend to respond vigorously following even high severity events (Brown and Smith, 2000). It is even likely that this cover type will expand in burn area.

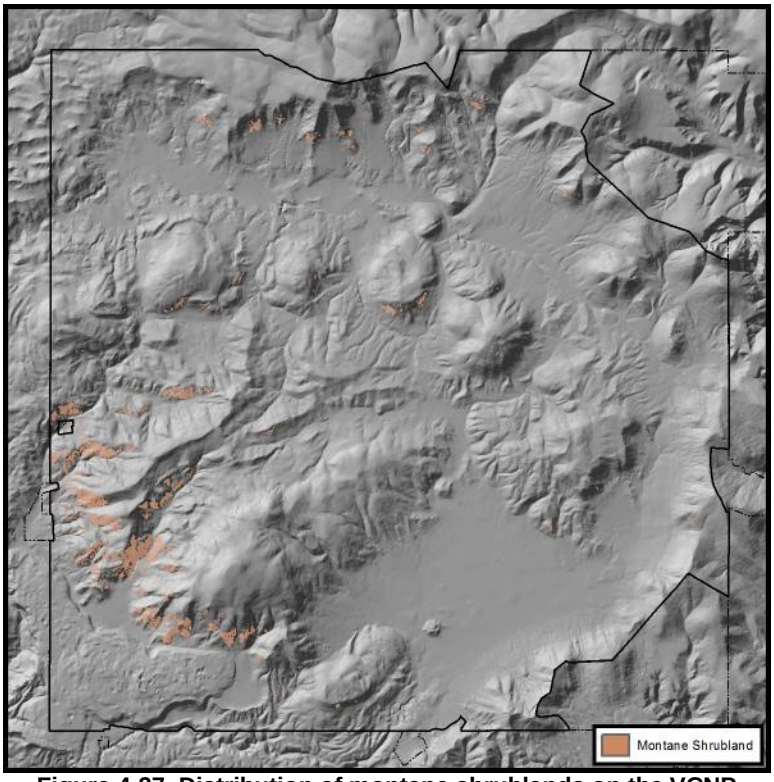


Figure 4-27. Distribution of montane shrublands on the VCNP

4.2.6 Felsenmeer Slopes and Rock Outcrops

Rocky cover on the VCNP is sparsely vegetated although a minor component acreage wise - under 1,100 acres (Figure 4-28) it represents a particular habitat. The felsenmeer rock screes on Redondo and Redondito Peaks account for nearly 900 acres with sparsely vegetative rocky outcrops scattered over less than 200 acres.

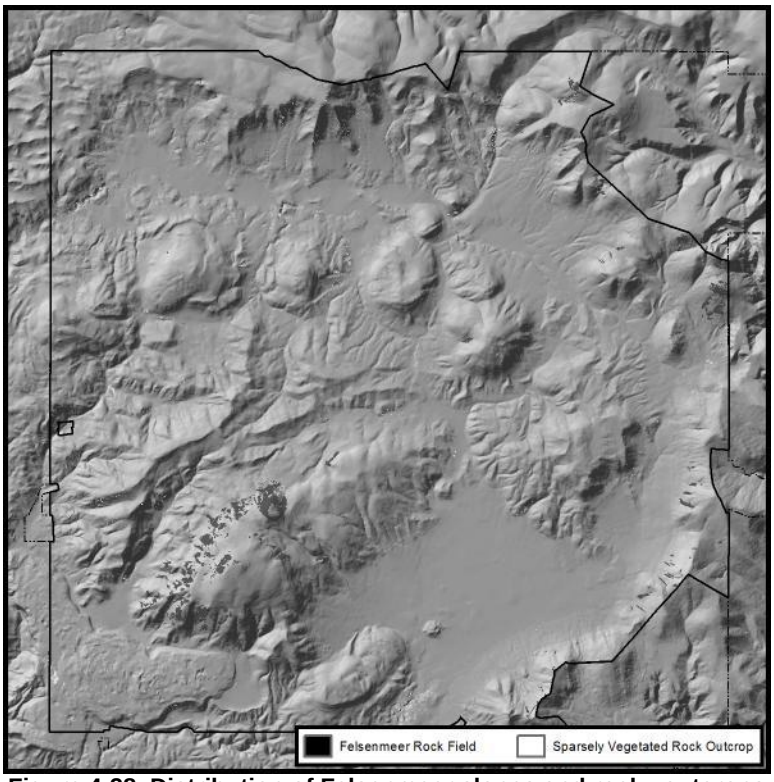


Figure 4-28. Distribution of Felsenmeer slopes and rocky outcrops

4.3 Wildland Fire Environment

4.3.1 Methods

Fuels Data

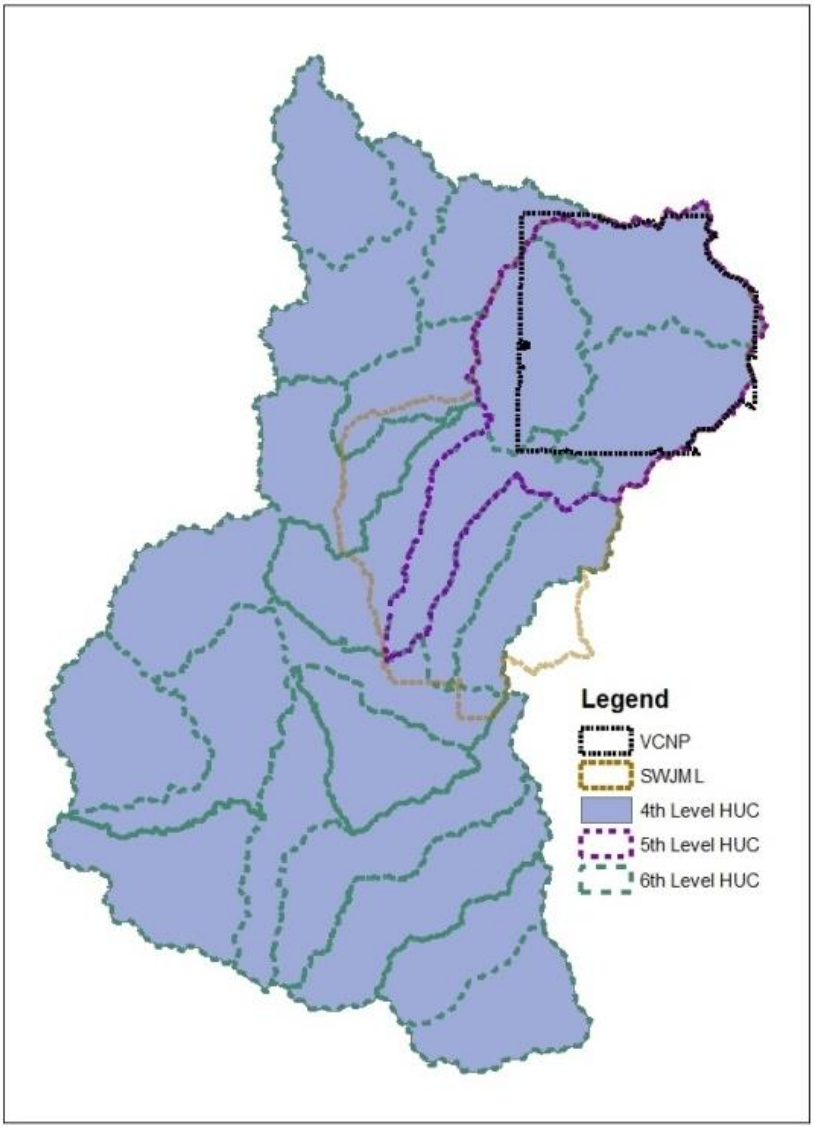


Figure 4-29. The VCNP in context with 4tn, 5tn, and 6tn level HUCs and the SWJML

LANDFIRE (www.landfire.gov) data were used for assessing fuels and fire behavior potential. Modifications were made to the data based on field sampled data, field visits, local knowledge, comparison to local fuel data sources, and knowledge and expertise of LANDFIRE fuel mapping methodology. The assessment considered three scales: preserve-wide, at an extent expanding beyond the preserve boundary which also incorporates the Southwest Jemez Mountains Landscape (SWJML) assessment project area of which the preserve is a part of and at the 5th code HUC. Figure 4-29 shows the preserve in context with the SWJML as well as the 4th, 5th, and 6th level HUCs. This multi-scale approach ensured that no isolated or localized conditions skewed the analysis.

LANDFIRE is national vegetation and fuels mapping project that provides nationally consistent and seamless geospatial data products for use in strategic wildland fire analysis and modeling. LANDFIRE geospatial data layers of elevation, aspect, slope, fire behavior fuel model, canopy cover, canopy height, canopy base height, and canopy bulk density are used together to make up the “landscape” file required by the FlamMap fire behavior modeling system (Finney, 2006) used in In some vegetation types fire

behavior fuel model modifications were made to better reflect the primary fire-carrying fuel type and fuel loading.

Weather Data

Remote Automated Weather Stations (RAWS) collect fire weather that is archived and available through KCFAST (http://fam.nwcg.gov/fam-web/kcfast/mnmenu.htm) and the Western Region Climate Center (http://www.raws.dri.edu/index.html). Weather for this analysis was initially obtained from two RAWS stations. A summary of the length of data and some station information is included in Table 4-16. The Jemez station data were determined to best represent the planning area based on input from the Santa Fe National Forest, the preserve, and a review of the data.

Table 4-16. RAWS station information in the vicinity of the VCNP

Station Name	Station Number	Record Period	Elevation (ft)
Jemez	290702	1966 - 2009	8000
Tower	290801	1964 - 2009	6500

Fuel moisture and wind drive fire behavior in each of the fuel models. Historic fire weather was analyzed to determine winds and fuel moisture conditions during the fire season using FireFamilyPlus (Systems for Environmental Management and USDA - Forest Service, 2002). FlamMap adjusts dead fuel moisture values for each pixel of the landscape to account for the effect of aspect, elevation, slope, and canopy cover. The adjustment is based on weather conditions proceeding the analysis period, referred to as the conditioning period. Two conditioning periods were developed from the Jemez RAWS station data to represent dry and the driest (maximum) fuel moisture conditions recorded at the station. Wind speed and direction are direct inputs into fire behavior calculations. Hourly winds were assessed to determine direction and speed of predominant winds and the strongest winds recorded. Wind Wizard (Butler, et al., 2006) was used to model variability of wind speed and direction due to topography across the landscape Figure 4-30.

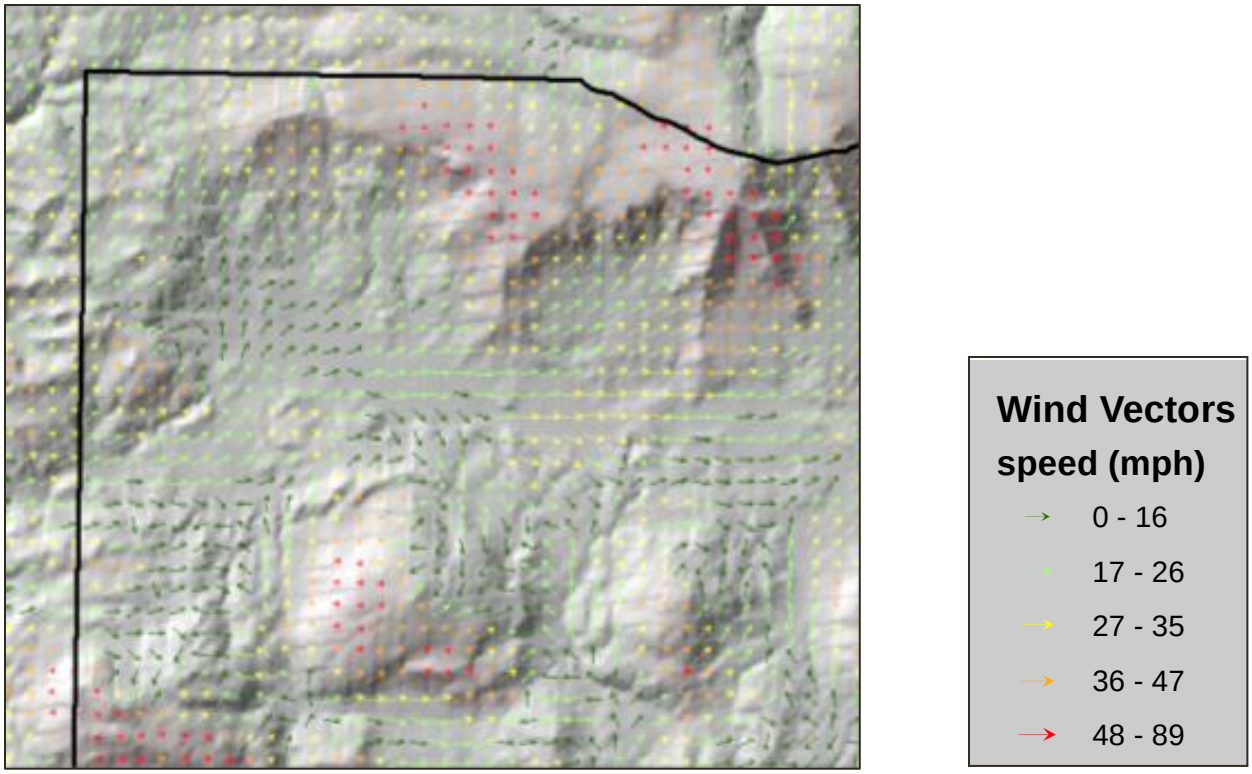


Figure 4-30. Wind vectors depicting the influence of topography on wind speed and direction in the Valle San Antonio (northwest corner of the VCNP). Arrows represent speed and direction the wind is blowing.

4.3.2 Fire Behavior Potential

Fire behavior is driven by the combination of fuels, topography, and weather across the landscape. *Surface fire* (Figure 4-31, left) is fire that burns in the surface fuels (grass, shrubs, litter, dead and down branch wood, and short trees in contact with the ground surface). Crown fire refers to fire burning in the tree canopy. Two types of crown fire can be modeled in fire behavior modeling systems. *Passive crown fire* (Figure 4-31, center), also referred to as torching, kills individual or small groups of trees. *Active crown fire* (Figure 4-31, right), also referred to as continuous or running crown fire, involves the entire surface and canopy fuel complex spreading from tree to tree through the canopy stratum. Crown fires are more difficult to control and have more severe and lasting effects than surface fire due to the increased rate of spread, increased intensity, and likelihood to start spot fires long distances ahead of the fire front from lofted embers.

Figure 4-31. Surface fire (left), passive crown fire (center), active crown fire (right)

The behavior of fire means the intensity at which a fire burns and rate at which it moves across the landscape. Fire behavior potential is a mathematical calculation based on numerical values and relationships of fuels, weather and topography over time and space. Different methods and models are used to assess fire behavior potential depending on the purpose. The FlamMap fire modeling system (Finney, 2006) was used to assess the distribution of potential fire behavior characteristics in the analysis area. Specific characteristics assessed were fireline intensity expressed as flame length, rate of spread, and type of crown fire activity. Additionally, FlamMap was used to estimate burn probability. Burn probability, as used in FlamMap, is defined as the number of times a pixel burned as a proportion of the total number of fires simulated. Five thousand random ignitions were used in the simulations. Burn probabilities are related to the sizes of fires that occur on a given landscape. Large fires burn a larger portion of the landscape than small fires and therefore a given pixel is likely to be burned by multiple fires resulting in a higher burn probability.

Fuels

Fuels in the context of wildland fire behavior refer to the live and dead vegetation that "fuel" the fire's spread across the landscape. Fire managers use "fire behavior fuel models" to classify the volume and structure of wildland fuels. A fire behavior fuel model is a set of numerical inputs calculated to predict surface fire behavior and transition to crown fire. The distribution of fuel models in the preserve is shown in Table 4-17. Figure 4-32 shows the spatial distribution of the fire behavior fuel models across the preserve landscape, followed by Figure 4-33, which presents a graph of the fuel model distribution by acreage. Fifty-two percent of the assessment area is mapped as a timber-understory (TU) fuel model depicting a combination of forest litter and herbaceous or shrub fuels as the primary carrier of fire. Twenty percent of the area is mapped with a timber litter (TL) fuel model where the primary carrier of fire is down and dead woody fuel. Twenty-eight percent of the area is mapped as a grass (GS), grass-shrub (GS), or shrub (SH) fuel model.

Table 4-17. Current distribution of fire behavior fuel models in the VCNP

Fuel Model	Fuel Model Description	Acres	% of Total
TU5	Very high load, dry climate timber-shrub	33,924	39
TL3	Moderate load conifer litter	12,050	14
TU1	Low load dry climate timber-grass-shrub	10,902	13
GR2	Low load, dry climate grass	10,279	12
Custom	Moderate load, dry climate wetland	6,602	8
TL8	Long needle litter	5,246	6
GR4	Moderate load, dry climate grass	3,321	4
GS2	Moderate load, dry climate grass-shrub	1,884	2
GS1	Low load, dry climate grass-shrub	851	1
GR1	Short, sparse dry climate grass	261	<1
TL1	Low load, compact conifer litter	251	<1
SH7	Very high load, dry climate shrub	167	<1
SH1	Low load, dry climate shrub	9	<1

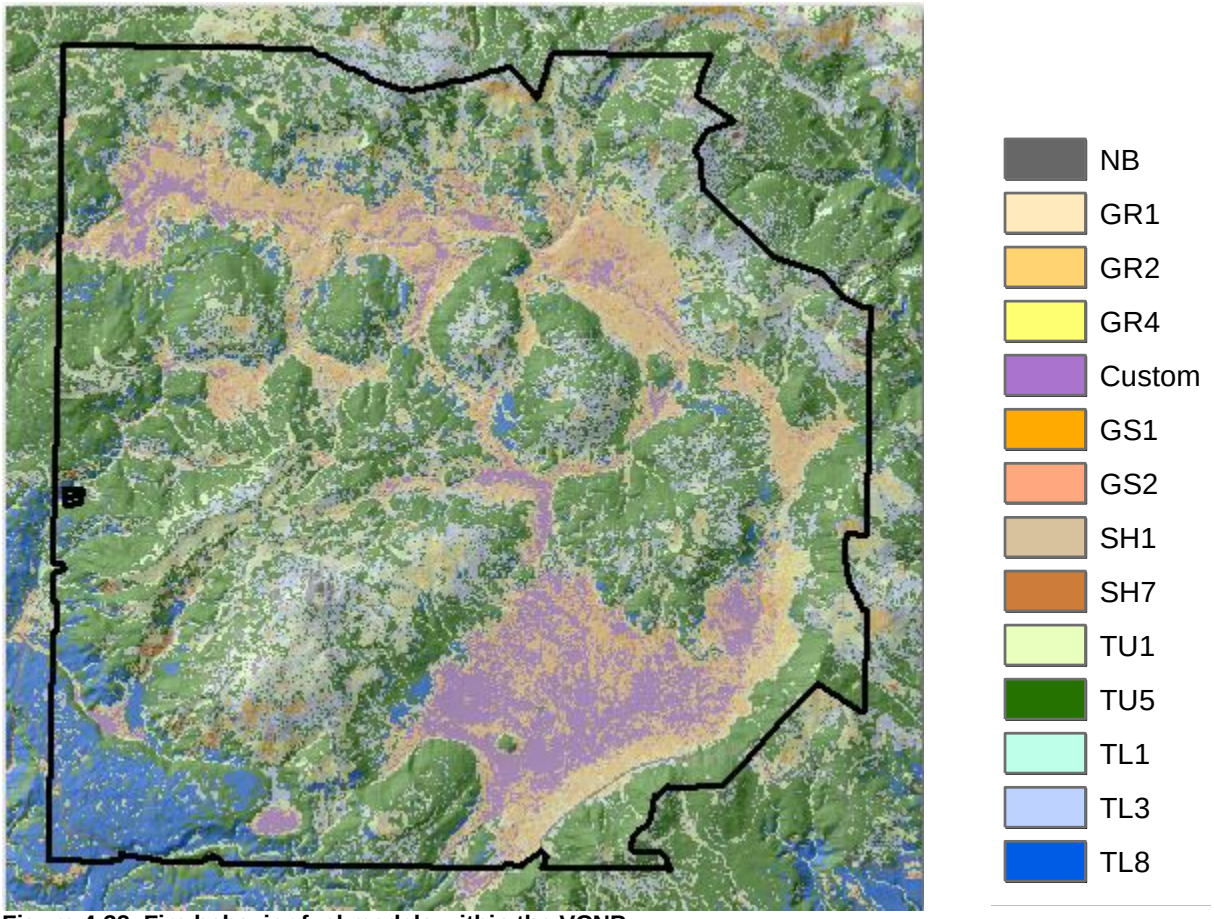


Figure 4-32. Fire behavior fuel models within the VCNP

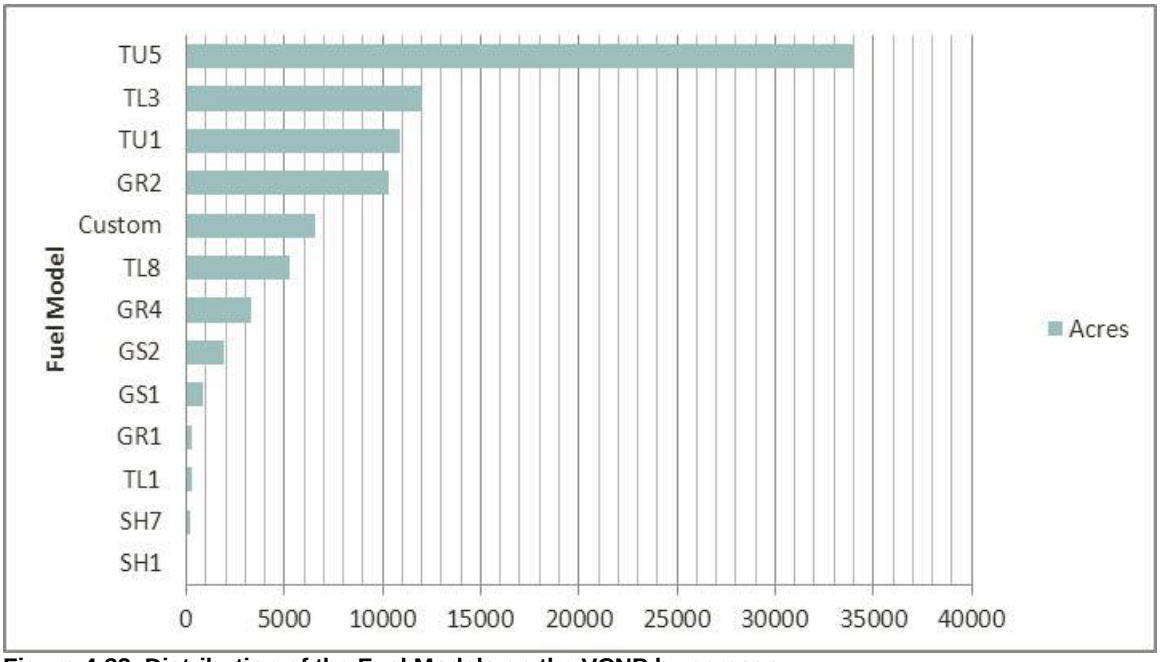


Figure 4-33. Distribution of the Fuel Models on the VCNP by acreage

Fire Season

Energy Release Component (ERC) is a commonly used indicator of drought and fire potential that is calculated from fuel moistures and is used to assess the fire season. A review of the ERC throughout the year and historic fires on the Jemez Ranger District indicates that fires occur throughout the year; however, the primary fire season occurs between April and October with best conditions for active fire May through June, peaking in late June (Figure 4-34 and Figure 4-35). The Jemez Mountains typically experience a monsoon season beginning in mid-July or August. While this can moderate fire behavior, fires do ignite and can spread during this time. Most years also have a post-monsoon increase in fire behavior and potential, which can last through November (i.e. a bimodal fire season).

Approximately 90 percent of human and lightning ignited fires from 1970 to 2008 occurred when the ERC was above 32, which is at the 28th percentile (1988 - 2008). Eighty-five percent of fires greater than 10 acres initiated when the ERC was above 40 (43rd percentile).

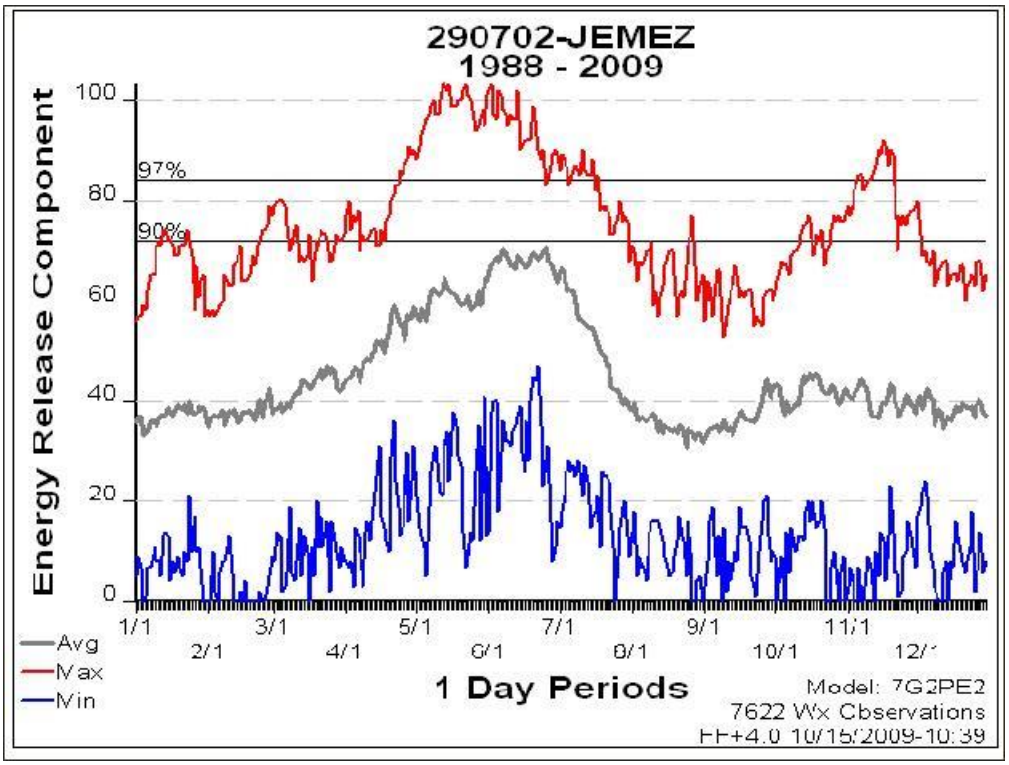


Figure 4-34. Energy release component from the Jemez RAWS station based on year round data: 1989 - 2009

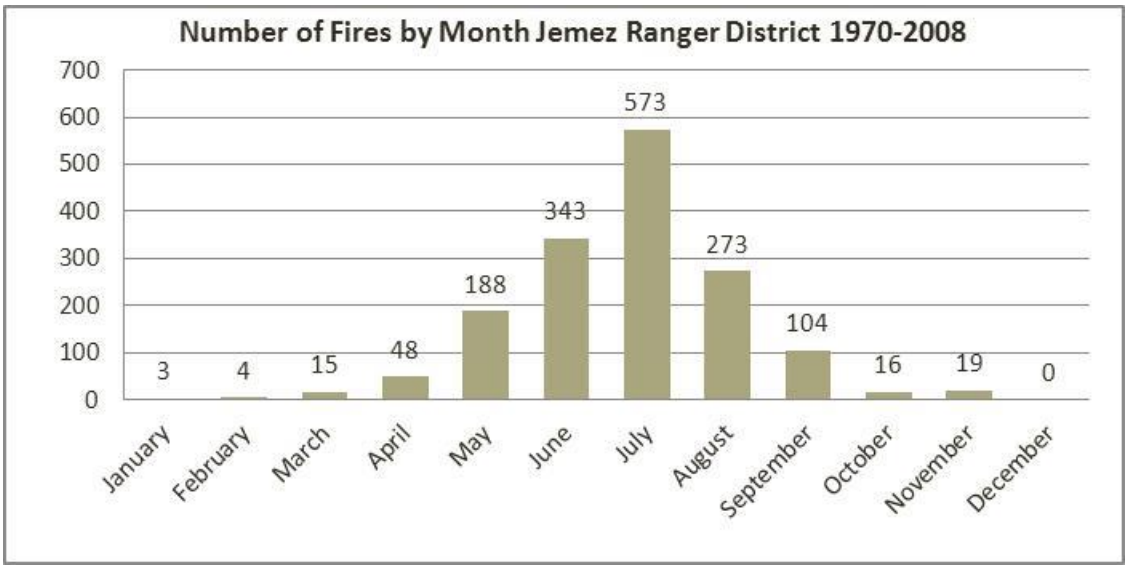


Figure 4-35. Fire occurrence on the Jemez Ranger District, Santa Fe National Forest: 1970 – 2008. Number at top of bar is the number of fires each month for the twenty-nine year period.

To model fire behavior in FlamMap, fuel moistures and conditioning periods were selected to represent conditions when two large fires burned: the Dome Fire (1996) and Cerro Grande Fire (2000). Both fires burned in late spring with dry fuel moistures and strong winds. Conditions during the Dome Fire were the maximum recorded from 1966 to 2009 while the conditions during Cerro Grande Fire approximate the 90th percentile conditions for 1988 – 2009. These conditions are referred to as maximum and dry in this report. Fuel moistures were conditioned using weather data from the time periods these fires exhibited very active fire, including crown fire. FlamMap runs were completed with conditioned fuel moistures at 4:00 pm. One hour fuel moistures for the maximum conditions ranged from 1 to 6 percent across the landscape with a modal value of 2 percent. For dry conditions, one-hour fuel moistures ranged from 2 to 9 percent with a modal value of 4 percent.

Live herbaceous and woody fuel moistures vary greatly depending on time of season. Based on live fuel moisture guidelines (Scott and Burgan, 2005) live herbaceous and live woody fuels are assumed 2/3 cured (60 percent herbaceous, 90 percent woody) for the maximum conditions and 1/3 cured (90 percent herbaceous, 120 percent woody) for dry conditions in the standard fuel models. For the wet meadows of the preserve, live fuel moistures are assumed at full vigor (120 percent herbaceous, 150 percent woody). Generally fire in fuels with shrubs (grass shrub, shrub, and timber understory models) will have more active fire behavior when live woody fuel moisture is below 100 – 120 percent, depending on species and location. By using the selected live fuel moistures, the modeled fire behavior in this analysis will reflect more active fire behavior in fuel models that incorporate live fuels during maximum conditions.

Winds during the daylight hours (1000 to 2000 hours) are somewhat variable, but are predominantly out of the southwest to west (Figure 4-36). Wind gusts of 30 to 40 miles per hour are fairly common. Winds of 30 mph from the southwest were used for analysis.

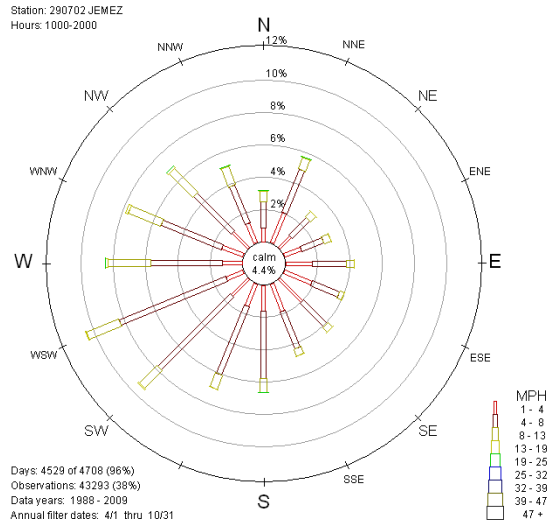


Figure 4-36. Wind rose based on the Jemez RAWS: 1988 - 2009, April 1 through October 31, 1000 - 2000 hours

Fire Behavior Potential

Fire behavior characteristics are directly related to fire behavior fuel models and canopy fuel characteristics but vary with fuel moisture, wind, and topography across a landscape. Modeled minimum, maximum and mean flame lengths (FL) and rates of spread (ROS), and distribution of fire type preserve-wide under dry and maximum conditions are included in Table 4-18.

Table 4-18. Current fire behavior characteristics under dry conditions. (Note that flame length includes flame length when crown fire is predicted).

Flame Length (ft)	Acres/	%	ROS (ch/hr)	Acres	%	Crown Fire	Acres	%	Las Conchas (%)[a]
Total Fire Behavior Characteristics – Dry Conditions									
>0 - 4	38,979	45	>0 - 1	8,540	10	Surface	50,785	59	46
>4 - 8	12,227	14	>1 - 5	26,332	31	Torching	15,920	19	28
>8 - 11	1,962	2	>5 - 10	5,516	6	Active	19,042	22	26
> 11	32,578	38	>10 - 20	5,390	6				
			>20 - 40	9,813	11				
			>40	30,155	35				
Total Fire Behavior Characteristics – Maximum Conditions									
>0 - 4	32,964	38	>0 - 1	3,082	4	Surface	46,792	55	46
>4 - 8	7,282	8	>1 - 5	26,640	31	Torching	14,374	17	28
>8 - 11	6,348	7	>5 - 10	5,528	6	Active	24,581	29	26
> 11	39,153	46	>10 - 20	3,153	4				
			>20 - 40	5,483	6				
			>40	41,860	49				

a - Estimated from post fire burn severity mapping

As shown in Figure 4-37, the proportion of the landscape expected to experience crown fire, active or passive, is related the presence of dense timber with heavy understory fuels. Wet meadows in the valles of the preserve should be resistant to fire spread unless there is drought which greatly reduces soil

moisture and live herbaceous fuel moisture. If this should occur, the meadows could burn as a surface fire.

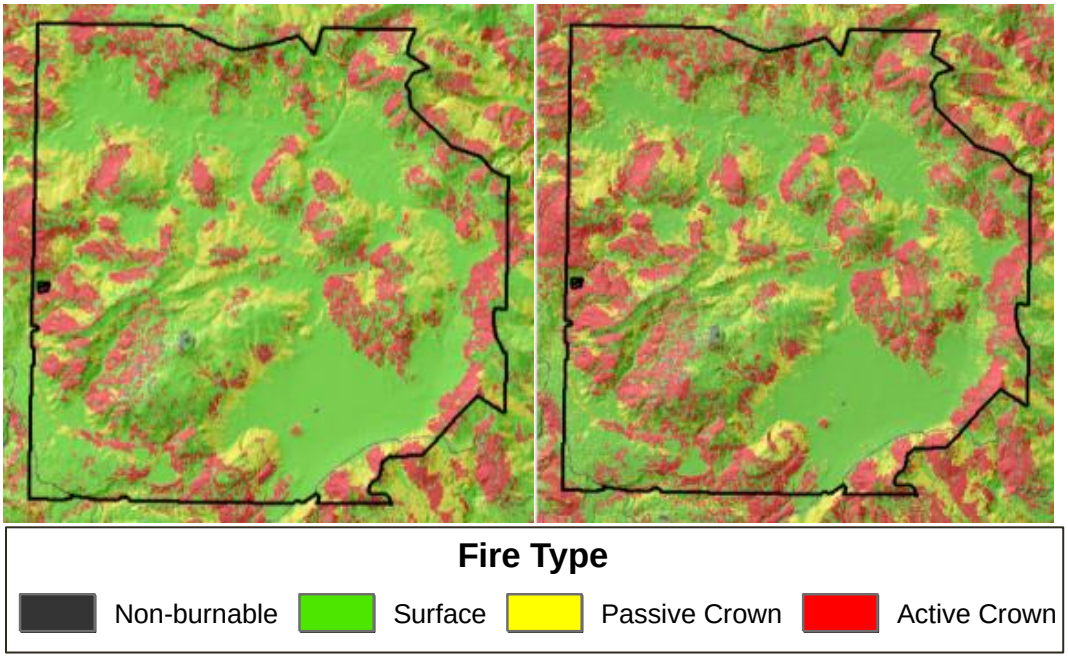


Figure 4-37. Potential fire type under the two fuel moisture scenarios. The figure on the left was modeled under the dry scenario. The figure on the right was modeled under the max scenario.

Fire behavior refers to the intensity and rate of spread of a fire while fire severity is a measure of impact. While fire severity and intensity can be related it is not technically correct or appropriate to assume a relationship i.e. that a severely burned forest burned with a certain intensity. Further passive and active crown fires burn with measurably different intensity and rate of spread but can produce similar degrees of severity. With that caveat it is still quite interesting to see the burn severity mapped following the Las Conchas fire (Figure 4-38) in comparison with crown fire behavior predicted using standard methodology and data.

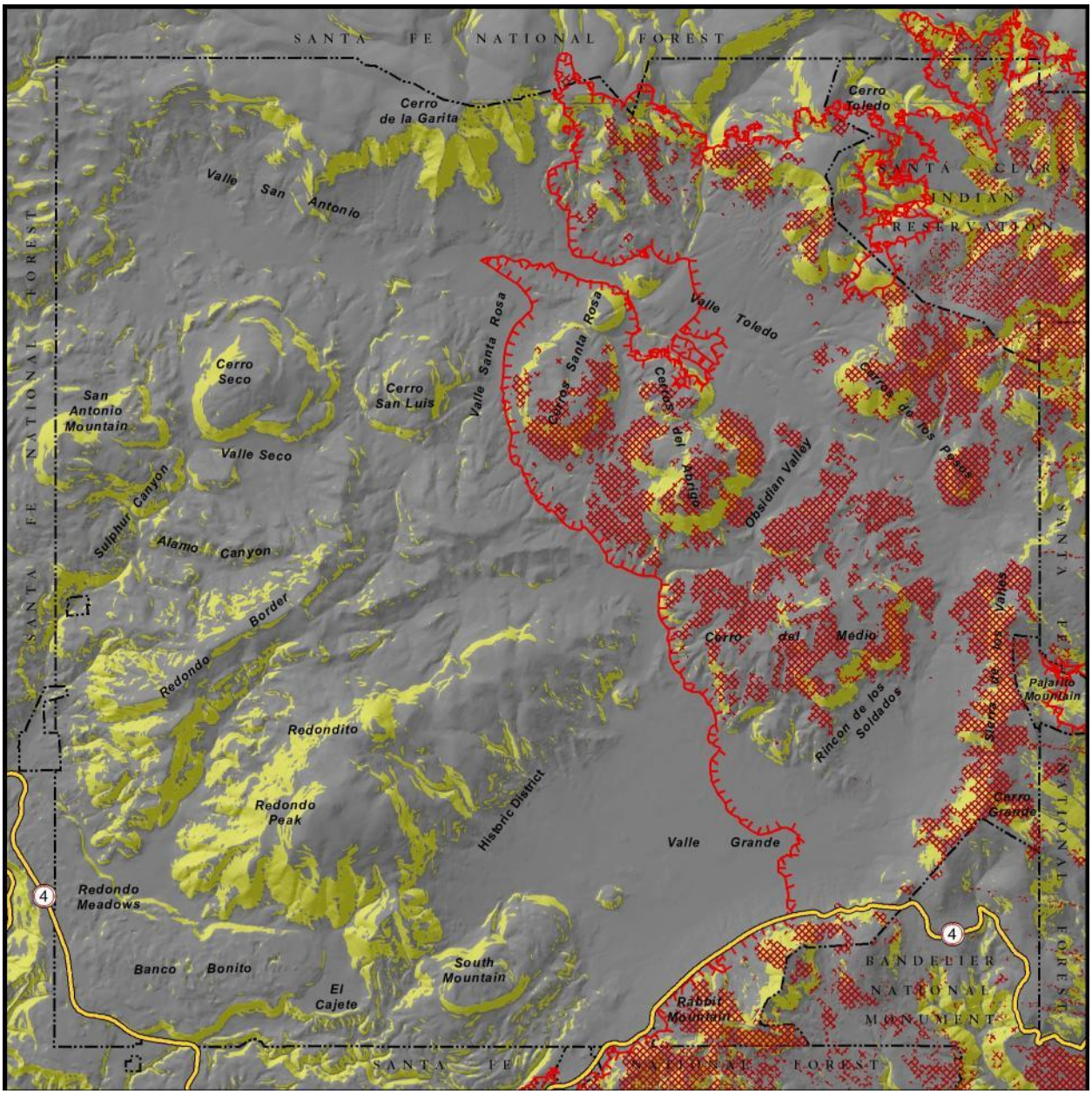


Figure 4-38. Burn severity within the Las Conchas fire perimeter. The red indicates severe burning (primarily crown fire), the yellow represents steep slopes (greater than 40 percent).

4.4 Watershed Condition

4.4.1 Hydrology

Nearly 75 miles of perennial stream meander through the *valles* of the Valles Caldera. The headwaters of the East Fork of the Jemez River and the Rio San Antonio originate within its boundaries. These tributaries converge below Battleship Rock in San Diego Canyon to form the Jemez River, a tributary to

the Rio Grande. The preserve was established based on watershed boundaries. At the time of acquisition, Santa Clara Pueblo acquired the lands comprising the headwaters of the Santa Clara watershed and the lands comprising the headwaters of Frijoles watershed went to Bandelier National Monument. Ninety eight percent of the preserve lies within the Jemez River watershed with its waters draining into that river.

Hydrologic Connection with Uplands

With few exceptions (e.g. Rito de los Indios) the upland slopes of the Valles Caldera have no perennial or even seasonally flowing channels into the valleys. The uplands are hydrologically connected with the valley bottoms only through swales or first order draws that lack scour channels except where gullied. These features seldom have any expression in the steep slopes of the domes and rim rock. The mountainous slopes erode by weathering of parent material into a mantle of overburden that moves down slope under influence of gravity as creep or slumps

Although road density is very high in the caldera and on the eruptive domes in particular, there are few instances of deep or persistent rilling and fill failure above the slope deposits. Logging roads run up many of the swales and connect to the uplands through radiating skidding trails. Many larger swales have stock tanks and roads that were used for logging access.

In post-Las Conchas fire investigation for this report, there were no observed scour of the roads, or failure of fill unrelated to gullying initiated on the natural slope above. Nor was there any exceptional rilling on natural slopes observed that could be attributed to roads. Because they contour, lack drainage ditches and are only a small fraction of a slope's area, roads generate little scour and mostly served to dissipate energy of upslope runoff. Typically a road prism served as a deposit point for upslope, eroded material rather than as a significant source of sediment.

Streamflow

The Southwest is influenced by two general climate patterns. The first, a semi-permanent high pressure system off the coast of California that produces a pattern of wet winters and dry summers east and west of the Cascades/Sierra Nevada mountain ranges. The second, an Atlantic sub-tropical high pressure system extending into the Gulf of Mexico that creates a flow of moist air onto the plains and eastern Rockies throughout the summer, the so-called "monsoon" season characterized by intense short rainstorms (Arkell and Richards, 1986)). There is a modifying influence of high elevation with typically cool summers and cold winters that induce prolonged snow pack.

Hydrograph of mean daily flow for 2010 on San Antonio Creek and East Fork Jemez shows flow is typically driven by snowmelt rather than summer rains (Figure 4-39). The annual peak flow occurred in April from snowmelt, with virtually no expression from the monsoon rainfall in August and September.

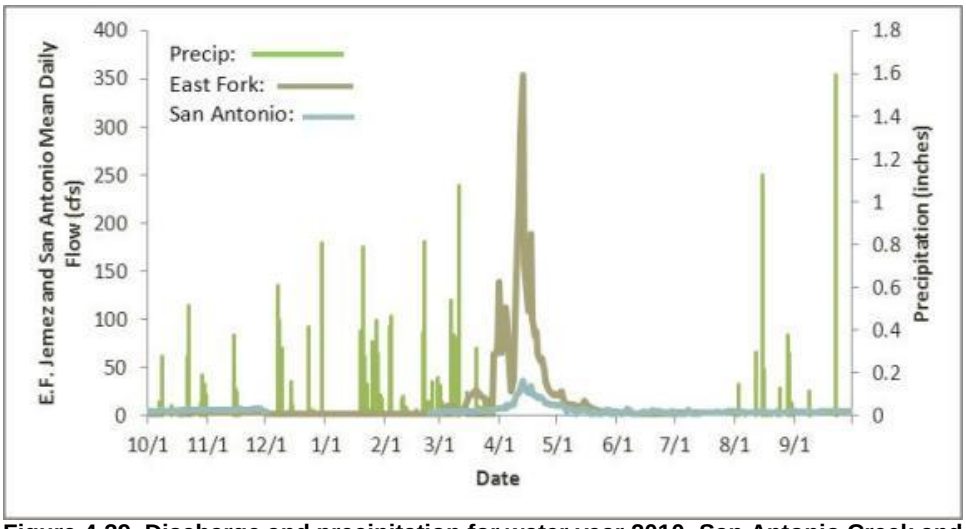


Figure 4-39. Discharge and precipitation for water year 2010: San Antonio Creek and East Fork Jemez River

Figure 4-40 shows flow duration curves for Redondo Creek and Jemez River using data from USGS gages that operated on Redondo Creek and East Fork Jemez River (USGS website: http://waterdata.usgs.gov/usa/nwis/sw.) The very steep portion of the lines on the left-hand side of the graphs, are high flow events, mostly snowmelt. The long shallow tail is base during the dry months flow. For Redondo Creek, which drains steep hillsides with minimal storage in shallow soils, the tail portion has a constant and significant decline, showing that base flow over summer is in steady decline as limited soil water storage is depleted. Conversely, the tail for the Jemez River is virtually flat indicating very slow decline in summer base due to large groundwater storage.

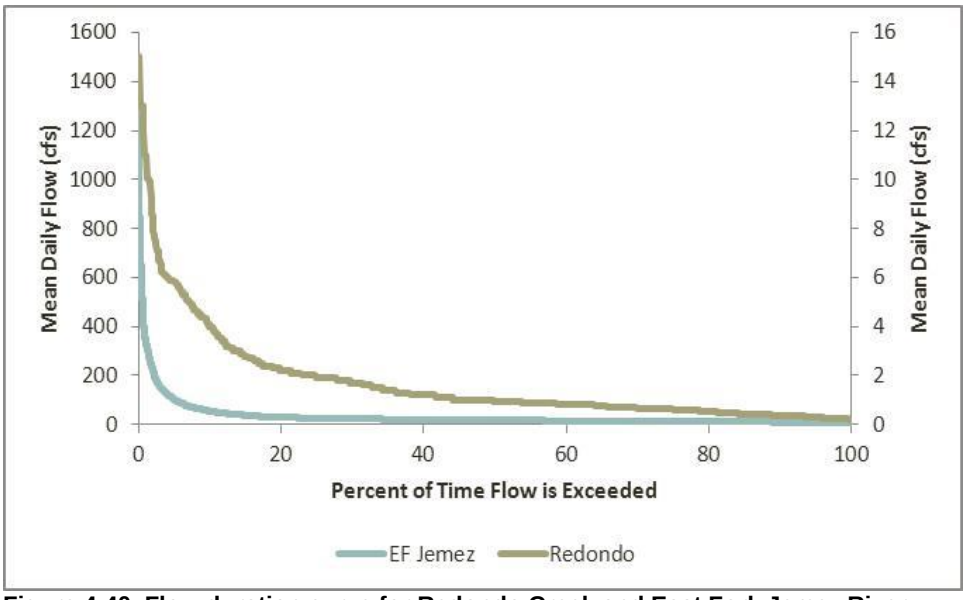


Figure 4-40. Flow duration curve for Redondo Creek and East Fork Jemez River

It is interesting to note that the low percentage end (left side) of the Jemez River graph is atypically steep and constricted, which we believe also indicates a tenuous surface flow connection to upland recharge area.

Sources of Stream Flow

Following the above argument the Valles Caldera may be considered as a spring-fed system regulated by a composite of shallow and deep groundwater sources with low response real-time from precipitation events. Residence time of water in the ground before emerging as stream flow is between weeks in the mountain streams such as Redondo and Los Indios, and months to decades in the Valles of San Antonio and East Fork Jemez River (Goff and Grigsby, 1982). Stream source water is largely snowmelt. The monsoon season of late summer may in fact provide the strongest precipitation events in terms of intensity but these have only small effect on annual hydrograph. Over 80 percent of the annual yield occurs during spring snowmelt, though summer baseflow is most important for sustaining aquatic habitat and providing water to downstream beneficial users. Figure 4-41 shows that increases in flow are temporally disconnected from precipitation events.

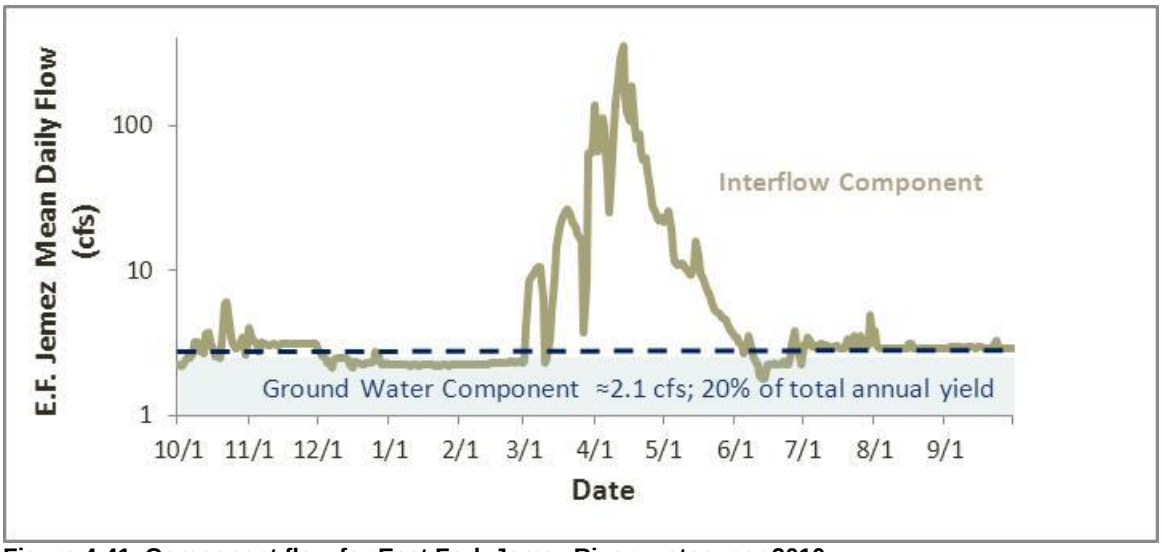


Figure 4-41. Component flow for East Fork Jemez River, water year 2010

Hewlett and Hibbert (1967) first described a mechanism for stream flow response to a precipitation event in areas of natural cover as displacement of soil water by newly infiltrated precipitation water. Precipitation enters soil pore spaces creating pressure head that acts downward and laterally as the pores become more occupied. After soil moisture recharge in the early wet season, further infiltrating water will place hydraulic pressure on resident water forcing it into the channels (Harr, 1977).

Liu et al (2008) partitioned the stream flow on East Fork Jemez River and San Antonio Creek into three components based on geochemical signature: overland flow, interflow and deep groundwater flow. Interflow is through shallow subsurface routes, usually within the soil column, and can be considered shallow groundwater flow. Figure 4-41 shows the partition of interflow versus deep groundwater for East Fork Jemez River basin, one of the two major basins for the caldera. Ground water flow is a consistent proportion for streams, drawing on aquifers with long-term recharge water and the constant effect of gravity. Shallow interflow varies intra-annually, but on average is the largest part of stream flow for both

basins. Residence time before emerging as surface flow is measured on order of weeks from Redondo Peak (Veatch, et al., 2009) and a few months for the larger valleys (Vuataz and Goff, 1986). Deep artesian groundwater in the valles is much older; analyses by scientists at Los Alamos National Laboratory of the water flowing out of the old well in the center of the Valle Toledo indicate an age of 1,500-2,500 years old. Little of the streamflow contribution is from overland flow runoff either during snowmelt or during the monsoon (Liu, et al., 2008).

Overland flow has a minor contribution to stream flow, and probably occurs mostly in saturated soil zones in valley bottoms. This portion of flow is stronger in the East Fork Jemez River than the San Antonio because considerably more area is near saturated condition in summer due to a relatively complete clay layer at shallow depth (Conover, et al., 1963).

Channel Morphology

The general character of perennial streams is of high sinuosity, low width to depth ratio (USDA - Forest Service, 2002; USDA - Forest Service, 2003), low to moderate gradient, and consistent base flow. Banks are sometimes undercut and present vertical faces, where stable. Bank stability in East Fork Jemez River, and San Antonio Creek ranged from 80 to 95 percent ratio (USDA - Forest Service, 2002; USDA - Forest Service, 2003). Elsewhere they have collapsed, probably over the one-time pervasive undercuts because of trampling by livestock. Mostly the slumped banks have re-vegetated with grasses or forbs and are now considered stable. Channel bed margins in deposit areas (such as the inside portion of bends) are often grown over with sedges.

A consequence of the bank slumping has been an increase in channel width. Imposed sediment load from the collapsed banks can also lead to channel widening, as the load is dropped out and deposited at bends, constrictions and various irregularities in channel pattern and form.

A channel widened by any means has an increased capacity to carry flow, which frequently leads to scour of the bed. Nevertheless, there appears to have been only moderate scour to the channels. The dominance of bed materials that are resistant to movement under average conditions of peak flow limits scour. When a channel widens, the flow is shallower for a given volume and has greater area of contact with resistant bed material.

The outside of bends frequently have active vertical bank cuts, which is consistent with streams working in cohesive alluvium. The inside bend of an unconstrained alluvial channel typically would have accreting point bars that would rise to the level of the valley bottom. Instead this deposition area is frequently occupied by slack water and sedge growth that catch silt and clay size sediment. Recovery of channel form and function within the Valles Caldera appears to be slowed by a lack of bedload transport from a limited peak flow duration and magnitude, and/or meager input of new material from upland slopes.

Fish habitat surveys (USDA - Forest Service, 2002; USDA - Forest Service, 2003) of the East Fork Jemez and San Antonio Creek noted a high proportion of fines in riffles, and lack of pool habitat. Particle size distribution for the bed is shown in Figure 4-42 for reaches of these streams in the preserve. Particle distribution is skewed to sand (≤ 2 mm) in the East Fork Jemez River. Distribution is closer to normal for San Antonio Creek, though slightly bimodal, weighted towards each end.

The shape of large particles in the streambed ranges from sub-angular to sub-rounded, and are not well packed, but loose, indicating (we believe) that particle size greater than small gravel is not frequently transported by flow. Most of the competent native rock types weather to flat, platter shapes with thin cross-sections, and so do not project up into the water column. Density of ash tuff or pumice types is quite low, but for the more common rhyolite and andesites it is high. Calculations of critical shear force necessary to move median grain size is problematic as the resistance force of even mildly packed particles with irregular shapes (not spherical) is difficult to account for.

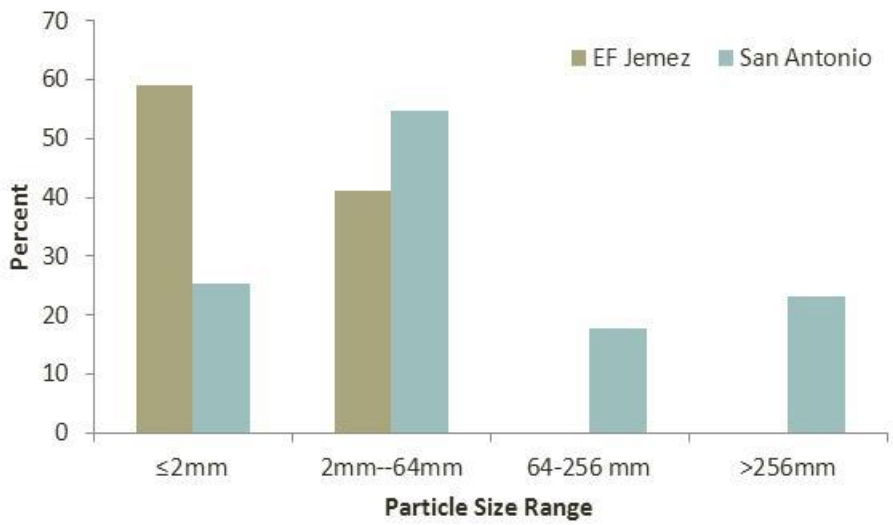


Figure 4-42. Streambed particle size for East Fork Jemez River and San Antonio Creek

The larger particles seem to be entirely contributions from recently eroded banks, which have intercepted gravel/cobble lenses that were once buried below the level of the streambed, but are now exposed. Given the degree of recent widening it is possible that particle sizes ≤2 mm still entrained in the channel are largely from the one-time erosion of loamy banks.

Evidence of channel widening in early 20th century

Comparisons with 1996 DOQ images and the 1935 aerial photographs show that channel erosion was far more prevalent in the past (Figure 4-43). The most striking differences are in Jaramillo and San Antonio Creek valleys. The San Antonio channel in the 1935 photographs shows a wide, fresh (bright in image) flood plain of point bars and medial bars in places giving a somewhat braided appearance (Figure 4-43, left). The more contemporary 1996 photo shows a single threaded major channel that has less valley bottom wetness (Figure 4-43, right). Clearly the 1935 channel was overburdened with sediment. Some of the sediment is from the numerous active gullies, which intrude far enough into the valley to physically alter stream pattern and obviously connect to channels.

Grazing, particularly of sheep, compacted topsoil, and reduced surface resistance to overland flow. Once a nick point starts in the form of a rut or rill - perhaps along an animal path - a gully can develop. The gully cuts extended the surface flow network s up fan slopes and swales.

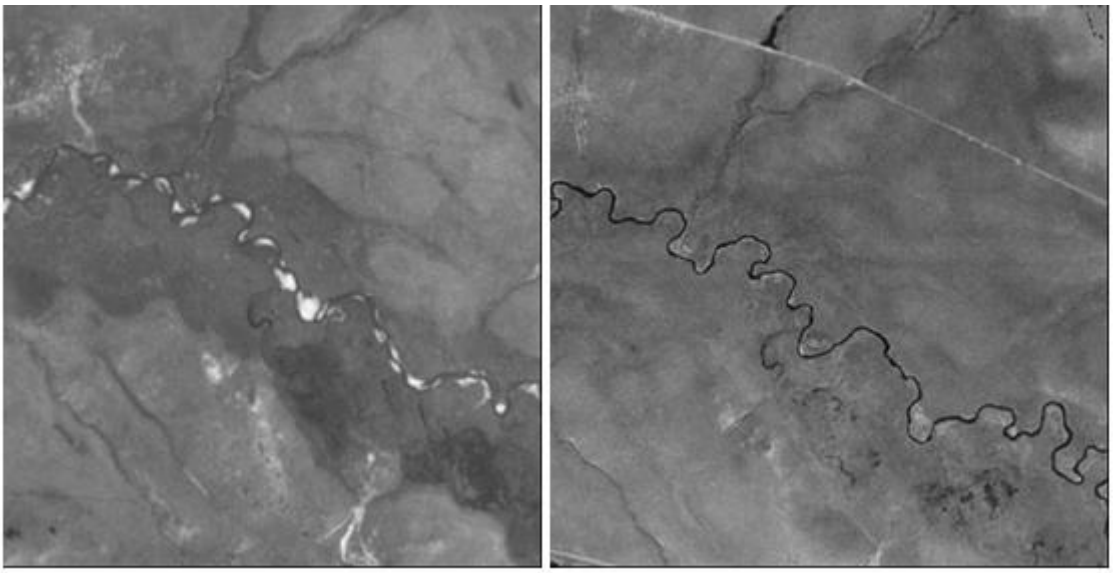


Figure 4-43. San Antonio in 1935 (left) and 1996 (right). Bright spots are fresh deposits.

Surface runoff from gullies may have initiated scour in the valley channels. High sediment input causes channel bar deposits and widening as flow, diverted around deposits, push against the banks. Runoff peaks in the valley channels increased with the expanded surface channel network, but the grazed valley bottoms may also have contributed to overland flow. The effect was simultaneous with or exacerbated by livestock trampling of banks. The lowering, and widening channel had increased capacity for flow, a positive feedback to degradation. This process would continue until channel boundary (the bed and banks) offered resistance equal to the stream power. Channel bed resistance was eventually provided by a clay layer, that at least partially underlies the valleys, and accumulated cobbles freshly exposed and winnowed from eroded banks.

Measurements of channel length from images in lower San Antonio Valley show that the 1996 channel path is 25 percent longer than the 1935 path. This is a very large change and in agreement with general observations that aggraded channels usually straighten (and shorten) their pathway.

Pre-settlement channel geometry

In pre-settlement condition the valley channels likely emerged from marshy, foot slope areas. These included prominent swales whether within well-developed valleys such as Santa Rosa, or unnamed tributary features within a greater fan slope.

Peak flows were likely smaller and summer baseflows larger than the current condition because of greater retention of water within the floodplain. Channel pattern was very different from the present state being multi- rather than single-threaded. Individual channels in a reach had smaller capacity than the present single thread, but also lower width to depth ratio, persistent undercut banks, and water surface (at baseflow) much closer to floodplain surface. Water temperature was likely lower throughout the summer than present. Currently, water temperature closely follows daytime air temperatures.

Lower Jaramillo Creek valley in the 1935 photographs shows a broad wet bottom, with discernible dark channel traces indicating a more dispersed flow through many channels, possibly with partially vegetated bottoms. Flow through the valley may have been more as groundwater than in surface channels Figure 4-44. By 1996 the valley section has a single thread channel.

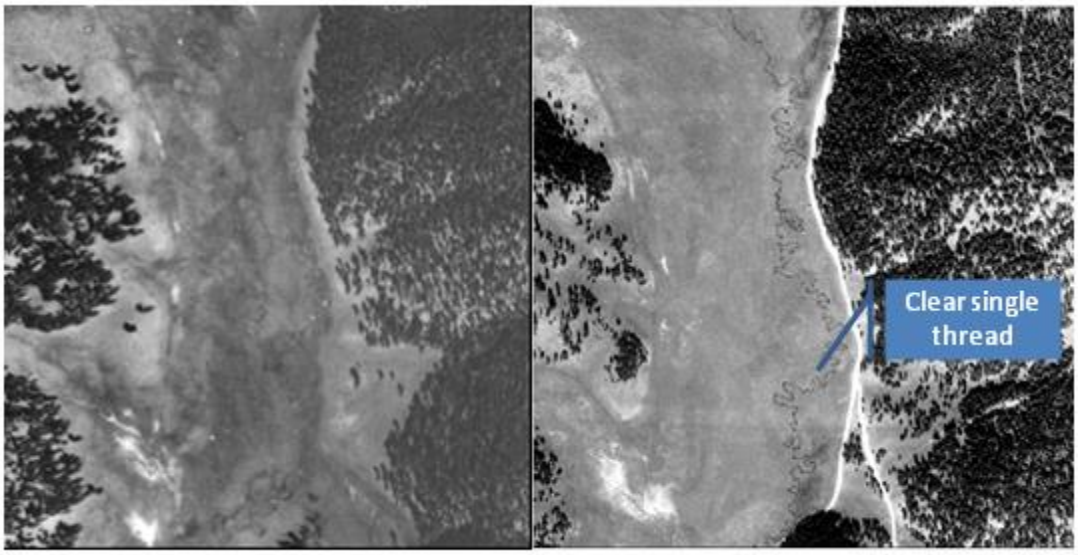


Figure 4-44. Jaramillo Creek in 1935 (left) and 1996 (right); dark areas are saturated ground

Similar differences in channel morphology were found in the upper section of San Antonio valley. The 1935 photographs show wetland-like valley bottoms with dispersed flow compared to the incised channeling in the 1996 photos. These observations suggest the extent of perennial wet valley bottoms (fens do still exist) was much greater and surface flow was more dispersed. Though the present single-threaded channel overall shows recovery, the very pattern may be a significant departure from the original.

A suggested sequence for degradation is:

1. Lower valley slopes gully from grazing pressure.
2. Increased runoff and sediment is delivered to the valley that scours channel beds, eventually directing flow into a single channel.
3. In time, because of recovery of the slopes, runoff and sediment delivery is decreased or ceases. Because these stream systems did not have high sediment load to begin with, recovery of channel width is very slow, accomplished mostly by capture of fines by marginal sedge growth.

To further investigate the departure in the valley bottoms, cross-sections of Jaramillo and San Antonio Creek valleys were surveyed, and soil pits dug along survey transects. Cross-sections were chosen where one-time marshy ground was indicated in 1935 photographs. Faded, iron-rich mottles (Figure 4-45) in the upper soil mantle at both locations and current presence of upland vegetation species suggest floodplain drying. Soil mottling indicates a fluctuating water table. The mottles were from 9 to 23 inches depth across valley bottoms, though did not occur on the adjacent foot slopes.

Figure 4-45. Iron-rich mottle collected from the Valle Jaramillo valley bottom, outside the floodplain

The survey showed many smaller and abandoned channels across the valley bottoms at both sites. In Jaramillo Valley the present channel follows a higher elevation grade than old channels (Figure 4-44). The convex upwards shape of the valley bottom matches what might be expected from a distributive channel pattern on a deltaic fan, and suggests that the major valleys of the caldera are deposit rather than sediment transporting valleys. This convex upwards valley form was also measured at the San Antonio valley cross-section, and observed elsewhere within the wet valley bottoms.

4.4.2 Water Quality

Water quality is described below in sections related to sediment, the effects from the Las Conchas fire, stream condition, and water temperature and chemistry.

Sediment

Though identified as a major impairment by previous channel assessments, turbidity, presumably from suspended mineral sediment may be overstated. The clay pan observed in many places on the stream bottom, either lacustrine in origin or a remnant of past marsh conditions, controls down cutting. Gravel and cobble accumulation on the bed are from eroded banks rather than transport from valley slopes. These particle sizes further armor the bed from scour though force the stream to widen.

New floodplain development will likely be a very slow process. The bright areas within the channel in the 1935 photographs were recent sand and gravel deposits. These deposits are there still, though now vegetated with grass and sedge that have established where typically point bars might develop.

Most of the peak flow and sediment effects were likely from within valley bottoms themselves or foot slopes and not from the steep hillslopes of the domes and rim. Theoretically, the upslope timber roads would intercept shallow groundwater flow and re-direct it as surface flow. However, rills on road or slopes below roads that would indicate concentrated flow were not found despite most of the roads

being in place for decades. There is a distinct lack of channels on the upland slopes, perhaps because of the very permeable character of volcanic rocks. The greatest effect of roads is those few access routes that run up the long axis of swales. When rutted they will capture flow, with little possibility of draining and may cause severe gullies in the unconsolidated material.

Las Conchas Fire Effects

The recent scouring events from the sever burning of the Las Conchas Fire and subsequent monsoon rains did not re-activate old gullies, nor did they scour the major channels. The energy was generated entirely on the upper slopes of the domes and rim, and dissipated across the vegetated fans and valley bottom. Sediment greater than silt size was overwhelming deposited on fans, and only in a few instances reached the valley channels (in the ephemeral East Fork Jemez River and upper San Antonio Creek in Valle Toledo). Despite impressive depths of flow indicated by the debris line there was virtually no scour in the main channels, and relatively little deposition of material sand size or greater.

Why the channels did not scour may have something to do with alignment of the under-fit channel to the flow path of the flood water, which was as perpendicular as it was parallel. Also, overbank flow was spread out over the grassy valley bottom and probably at quite low velocity—presenting high shear resistance at the boundary between channel and overbank flows

The scouring of hillsides resulted in dense rilling. Most material carried off was ash, unburned fine organics and silts. Much of the mineral sediment appears to be only displaced and re-deposited on the hillside behind tree boles and downed coarse wood, large stones and micro-topographic depressions. Most of the large material carried out onto the foot slope fans and into the valley bottoms was eroded colluvium from the newly created gullies and not carried down from the contributing slopes.

The largest impact occurred in Los Indios Creek, because of earthen berms that had been erected across the valleys. The stream aggraded and adopted a braided, shallow pattern that probably would not have occurred otherwise. The removal of these berms was proposed as part of a suite of restoration and range management activities (Valles Caldera Trust, 2009) and was completed in September of 2009.

Stream Condition

Streambed character is likely changed from one that is transported by the existing flow regime to a gravel/cobble, which is largely not. The incised channels have drastically reduced off channel refugia for juvenile fish and amphibians. The only reach we have seen in relatively pristine condition is a ¼ mile section upstream of the San Antonio artesian well. This reference reach is multi-threaded in a valley bottom saturated even in late summer. Channel water temperatures ranged from 13 to 15 degrees C when the degraded channel below the well was in excess of 20 degrees C. The channels had an unusual form: relatively straight and shallow with deep pools, like beads on a string. The channels are interwoven and though any given segment may be discontinuous the entirety presents a continuous path downstream. Smaller channels provide rearing away from adult trout. The pools, 2 to 5 feet deep, also have a strong thermocline of 3 or more degrees from top to bottom, as measured by hand on field trips.

Habitat substrate in the East Fork Jemez River and San Antonio valleys may be misclassified by previous surveys, which found 80-90 percent riffle habitat, the balance as pools. Although we quantified only very short sections of the stream, our observations of longer reaches were that of a more typical and fairly

regular sequence of riffle-glide-pool habitat, with 30-50 percent riffle habitat. The difference may be in what classifies as a pool, or what criterion is used. While each meander bend of the major streams appears to have a form of scour hole they may not meet the depth criteria (≥1 foot), at bankfull (Qb) flow.

The natural state may have had characteristics more closely resembling Rosgen DA (anastomosing) classification channel than the E channel assumed by the surveyors (Figure 4-46), in which case pool development of the type envisioned may not be applicable. Also, identification of Qb stage can be problematic; making pool depth estimates and what classifies as a pool similarly uncertain.

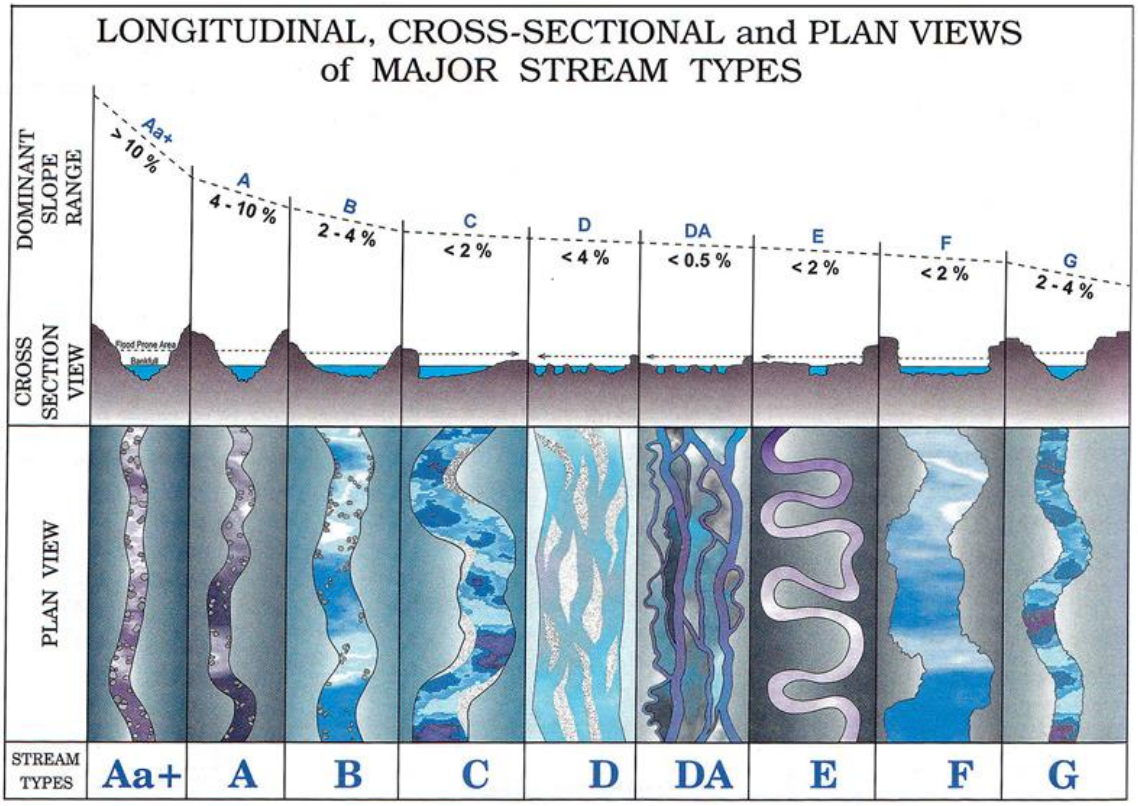


Figure 4-46. Key to Rosgen Classification of Natural Rivers (From: Endreny, T.A., 2003, Fluvial Geomorphology Module, UCAR COMET Program and NOAA River Forecast Center, http://www.fgmorph.com, Syracuse, NY.)

Water temperatures

Water temperature of the perennial streams may be influenced by an unusual geothermal gradient known to exist at least in the western portion of the caldera (Goff and Grigsby, 1982). Springs with a water-table source typically have temperatures close to the mean air temperature at the time the precipitation water infiltrated the soil. High elevation water table springs in our experience are 2-6 degrees C. We found however, temperatures ranged from 8 to 12 degree C in measurements of San Antonio, Jemez, and Rio de los Indios springs.

In the wide shallow channels typical to the valles, temperature follow diurnal swings, lagging by only a few degrees the outside air temperature. The reference reach in Valle San Antonio is too short a distance to confidently judge by, but a system that can maintain temperatures over distance at or below 18 degrees C is sufficiently cool for trout. These temperatures may be achieved largely in the deep pools, where cooler temperatures prevail at the bottom.

During their 2002 and 2003 inventories SFNF fishery staff monitored stream temperature at 2 and 5 discrete locations on the East Fork Jemez and San Antonio Creeks, respectively, (USDA - Forest Service, 2002; USDA - Forest Service, 2003). Both locations on the East Fork Jemez were found to be not properly functioning (exceeding state water quality standards) for cold water fish habitat, on both a seven and three day moving average during summer months. Two of the San Antonio Creek sites were not properly functioning, and three functioning at risk. The upper location measured was influenced by Rito de los Indios.

In 2001 numerous water chemistry parameters were measured at 17 sites in the Valles Caldera, as well as flora, fauna and channel morphologic indicators of stream health (NMED-SWQB, 2006). The sites were on the East Fork of the Jemez River, Jaramillo, La Jara, and Redondo, Rita de los Indios, San Antonio and Sulphur Creeks. Samples were taken at all or some of the sites on 23 occasions between May 2001 and April, 2002. As well thermographs were deployed in the streams which automatically recorded water temperature every hour. There were minor numbers of occurrences of temperatures above standards on Redondo Creek and Rito de los Indios (1 to 2 percent of the period of record), which are steep gradient, fast running streams in narrow steep sided valleys. Incidences were much higher on the other streams (10-20 percent of the record), all of which are entirely or predominately in broad, meadow valleys.

Water Turbidity and Chemistry

On a site visit of 9/26 and 9/27, 2007 several springs were observed on the margins of Valle San Antonio and Valle Grande. There was no observable turbidity. Springs were all within alluvium valley fill, and at the foot of slopes. The perennial main stem flow of East Fork Jemez River, San Antonio Creek and Jaramillo Creek, however, all had noticeable cloudiness, which appeared to increase in the downstream direction. Conversely Rito de los Indios and Redondo Creek run clear. The difference may be the extensive fill of the main valleys containing lacustrine deposits of clay or volcanic ash. While this type of material is present on the domes and Redondo Peak, the residence time of the water as ground interflow before emerging at foot slopes may be much less than in the lower valleys.

Monitoring for turbidity and temperature was conducted spring through fall 1998 on East Fork Jemez River, San Antonio Creek and Redondo Creek by the New Mexico Environment Department (NMED-SWQB, 2002). Turbidity was measured 7 times at each station, between April and November.

The upper threshold for turbidity, 25 Nephelometric Turbidity Units (NTU), were exceeded during what appears as a snowmelt runoff events, a monsoonal event, and a mid-fall rainstorm (see emboldened values in Table 4-19). The sediment origins for East Fork Jemez River appeared to the data collection field crews as lacustrine in origin from the Valle Grande valley floor.

Table 4-19. Values of Nephelometric Turbidity Units (NTU) on selected dates for major streams. The standard upper limit is 25 NTU; exceedances are bold

Dates	Streams		
	E.F. Jemez R.	San Antonio Crk.	Redondo Crk.
4/22/98	18.6	26.5	17.2
4/23/98	20.0	27.5	29.5
7/13/98	42.6	8.4	42.1
11/2/98	31.5	34.7	11.9

Table 4-20 summarizes the data collected during the 2001 to 2002 water quality surveys (USDA - Forest Service, 2002; USDA - Forest Service, 2003). Dissolved aluminum, an element which is naturally high in the rock type of the caldera, consistently exceeded state water quality standards in all the streams. There were also numerous instances when parameters of dissolved oxygen (DO), water temperature and pH standards were exceeded (see Table 4-20). DO and pH are controlled by aquatic plant's growth rate and respiration, which is somewhat influenced by relatively high phosphorus levels also measured.

Table 4-20. Results of 2001-2002 water chemistry surveys. Values are percent of samples that exceeded standards.

Watershed	Parameters			
	Turbidity	Temperature	pH	Dissolved Oxygen
Jaramillo	40	10	0	14
E.F. Jemez R.	14	21	37	35
La Jara	0	N/A	N/A	N/A
Redondo	5	2	0	0
Indios	1	1	0	0
San Antonio	1	23	51	39
Sulphur	11	N/A	N/A	N/A

Streams in the caldera were assessed in 2004 by the State of New Mexico (NMED-SWQB, 2006) for impairment to designated uses as required under the Clean Water Act (1972). The assessment indicated these streams do not fully support designated use of high quality aquatic life because of high turbidity and temperature. Since 2004 Total Maximum Daily Load (TMDL) has been established for temperature and turbidity for the Jemez River within the preserve. The high aluminum levels and stream acidity in the VCNP are considered natural background rates, and under review by State of New Mexico for appropriate/attainable levels. Impacts to aquatic life are still unclear (NMED SWQB, 2010).

Flood flows following the Las Conchas Fire caused fish kills in San Antonio Creek. The floodwaters contained very high concentrations of suspended sediment, but also ammonia (NH_3) in amounts lethal to fish. Table 4-21 shows results of water samples for San Antonio Creek below the confluence with Rito de Los Indios. The cause is suspected high concentrations of nitrogen in ash and post-fire microbial activity (see Soil Productivity in this report).

Table 4-21. Samples of San Antonio Creek runoff water after Las Conchas Fire

Stream Water Component	Normal	Floodwater (Post-Las Conchas fire)
Total Suspended Solids (mg/L)	4	10,9000
Conductivity (umhos)	72	352
Phosphorus (mg/L)	3	13
Nitrogen (mg/L)	0.3	23
Ammonia (mg/L)	<0.1	1.65

Accidental applications or spills of fire retardant into streams have been known to kill fish (Buhl and Hamilton, 1998; Fisher and Arteburn, 2002; Carmichael, 1992). The fire retardant formulations react in water to form hydrogen phosphate and hydrogen sulfate and predominantly ionized ammonia, or ammonium. In alkaline waters however ammonia may reach toxic levels (Norris, et al., 1991). There were no reported retardant drops or spills in streams of the preserve, nor is it speculated here to have happened. But research of ammonia in water and toxicity to fish has been the result largely of inadvertent fire retardant applications and thus is the basis of comparison.

Water sampling collected from streams where fish kills occurred due to the accidental exposure found NH_3 levels ranged from 0.13 to 1.0 milligrams per liter (Table 4-22). Experimental application of 237 mg/l to 435 mg/l of retardant concentrations into natural streams resulted in 50- percent mortality rates (LC50) within 4 hours for rainbow and cutthroat trout (Finger, et. al. 1997; Poulton 1997). Estimated NH_3 content in stream water samples ranged from 0.003 to 0.16 mg/l for various test runs. Laboratory tests focusing on NH_3 toxicity alone for fish and amphibian species result in LC50 96h concentrations of 0.08 to 1.1 mg/l (Thurston and Russo, 1983; Buhl and Hamilton, 1998; Schuytema and Nebeker, 1999).

Table 4-22. Lethal ranges of un-ionized ammonia concentration to fish

Data for Acute Toxicity of NH3 Experiment and Accidental Exposure		
Experimental Data		**Accidental Exposure in Streams**
Laboratory	Test Streams	
0.08-1.10 mg/l	0.003-0.16 mg/l	0.13-1.0 mg/l

4.4.3 Soils

The soils of the preserve mirror its geology. Scientists from the USDA Forest Service, and Natural Resources Conservation Service (NRCS), mapped nearly 80 soil series that fall into forest and grassland groups (USDA - NRCS, 1999; USDA - Forest Service; USDA-NRCS, 2011). Forest soils are primarily mountain soils (Andisols, Alfisol and Inceptisol soil orders) derived from volcanic rocks and gravel (rhyolites and andesites, with some dacites and latites, tuffs and pumices) along with windblown deposition. Forest soils tend to be rocky with loamy textures in the matrix. Grassland soils are mostly Mollisols that developed in the volcanic alluvium of the alluvial fans and piedmonts or in recent water-deposited sediments of the valle bottoms. They are deep with rich organic material and fine textures in the top layers and few rocks (Muldavin and Tonne, 2003).

Soil samples collected in 2001 on the preserve by the Jemez Pueblo Department of Resource Protection had elevated concentrations of radioisotopes-12 Although Gross Beta radiation could be naturally occurring, Cesium-137 and Plutonium-239/240 are fission products (man-made nuclear materials) and

their presence in the soil above regional background levels could indicate airborne deposition from Los Alamos National Laboratory.

Productivity

The productivity for the preserve's soils is driven in part by the soil biotic conditions. The soil rhyzosphere could be considered a partnership between plant roots, soil and soil organisms. Production from plants provides sugars for soil microbes from leaf litter, roots, and detritus. Soils in turn give stability and a resource clearinghouse for soil microbes and plants. Soil organisms mineralize nutrients to plant available forms and create symbiotic associations that effectively extend the rooting network.

Nutrient dynamics in soils are essentially a biogeochemical cycle, with air temperature, water availability and food source (carbon) key elements for production. Nitrogen (N) is a critical element for forest growth, although these forest environments are N limited (Vitousek and Howarth, 1991; Fenn, et al., 1998). The vast majority of this ecosystem level N is bound in organic forms, and unavailable for plant uptake. Soil biota are the factory that creates available N, fixing and transforming unavailable N forms into inorganic mineral N for plants, soil bacteria and fungi (Stevenson and Cole, 1996). The cryic conditions outlined for the domes and rimrock limit not only the growing season for plants, but soil biota as well. Soil biotic potential is constrained from cold conditions in addition to saturated soils after spring thaw (Brooks, et al., 1996) and excessive drying. In the lower elevations, elsewhere on the preserve, low moisture constrains soil biotic function where soils have strong evapo-transpiration losses. Plants influence the soil microbial composition with their leaf litter, root excretions and overall detritus; conifer forest soils typically have higher fungal to bacterial ratios than grassland soils. All the project area conifers are known to depend on soil mycorrhizae networks to gain access to scarce nitrogen, phosphorus and water.

The forest environment has roughly half of all forest carbon tied to organic matter (Heath, et al., 2003; Hicke, et al., 2004). The amount of belowground carbon decreases moving from grassland to forest, but also shifts in carbon type.

Soil organic matter transitions from deep accumulations in the mineral soil rich in grassland roots and fine litter to forest soils with less readily decomposed leaf litter and humic layers compressed at the top of the soil profile.

Soil development and classification is a surrogate for gaging soil productivity using soil physical traits to infer growth attributes. Mollic soils are considered productive since these soils have deep accumulations of organic matter from either deciduous leaf-fall or grassland and understory herbs. The soil organic matter increases water holding capacity and cation exchange capacity that allows for binding nutrients. Soils with finer texture have higher water holding capacity from silt and clay fractions. Deep soil development and horizonation creates abundant plant available minerals from decomposed parent rock.

Currently, forest (tree) cover accounts for roughly 56,000 acres of the preserve. Forest soils are generally rocky throughout the preserve compared to the deep loamy grassland and footslope soils of the valles. The soils are well drained, though may have enhanced water-holding capacity from atypical organic accumulations. Water holding capacity is enhanced from the volcanic ash accumulation in the topsoil

and clay accumulation in the subsoils. Grassy understories or montane meadows have high productivity from built up organic matter in subsurface soils.

Hillslope soils favor coniferous or shrubland species given the relatively rapid drainage. Lower slopes with shallower gradients, swales, or broad ridges may have rich herbaceous undergrowth given the more advanced soil development and higher water holding capacity. In addition, some spring areas or old grassland patches on caldera rims support higher herbaceous growth than the slope setting would imply.

Using understory vegetation as an indicator of soil productivity, figures from the Santa Fe NF Terrestrial ecosystem survey put production from 25 to 250 tons/acre (USDA 1993) for forested areas. Monitoring during the last decade on the VCNP shows that open woodlands may have from 100 to 2,300 pounds/acre (Keller, 2009), and is positively correlated to annual precipitation. Therefore the ability of soils to retain moisture during the growing season is critical.

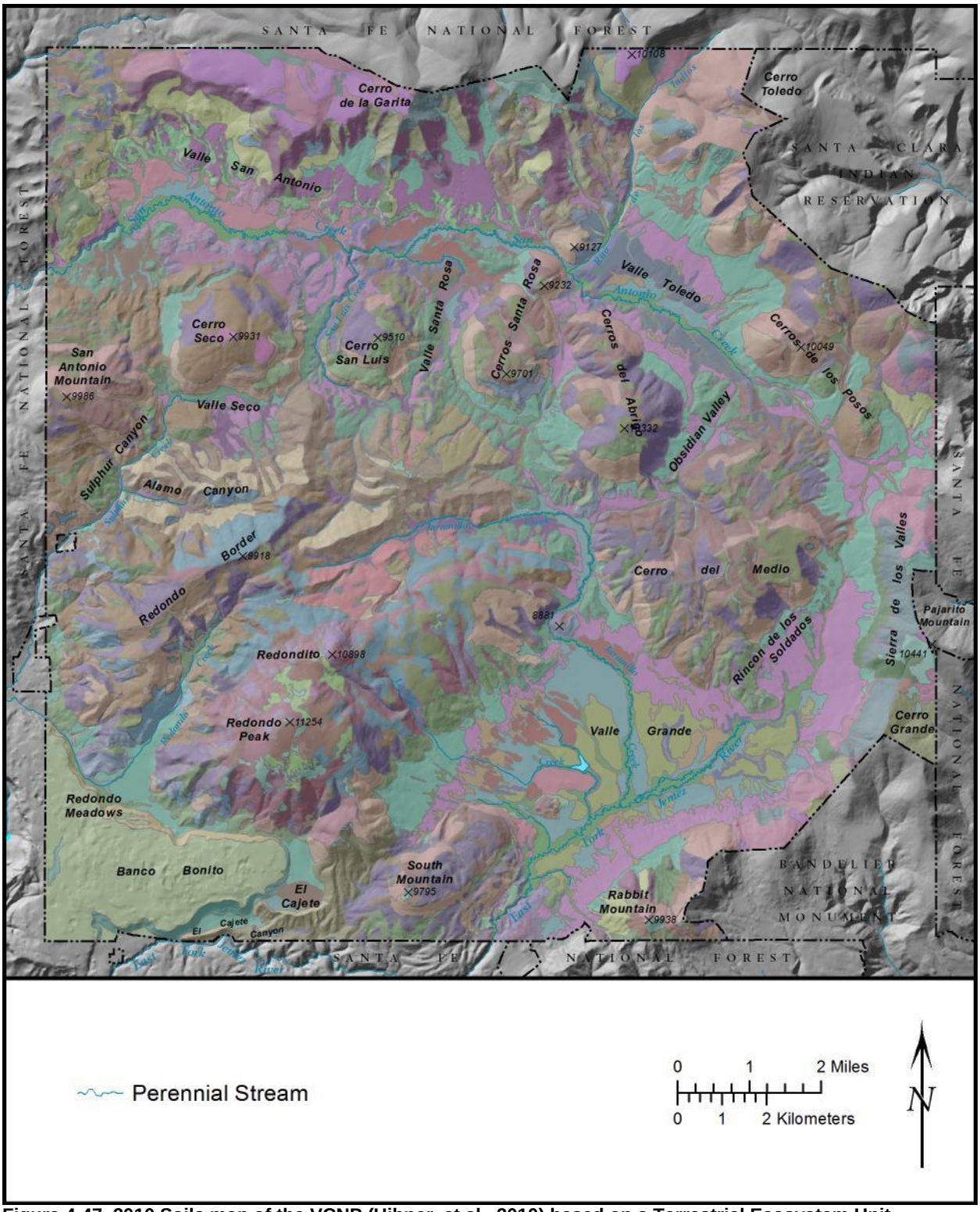


Figure 4-47. 2010 Soils map of the VCNP (Hibner, et al., 2010) based on a Terrestrial Ecosystem Unit Inventory that included detailed field sampling. These data support all planning and environmental analysis for the preserve.

Figure 4-47 shows the distribution of major soil types. The dark mollic soils, which are the most productive, are associated with grassland vegetation and woodlands where grass and forbs are abundant. Volcanic ash dominated soils are found in the southwestern corner of the preserve. The ash itself has little nutrient value, but increases moisture-holding capacity and serves as an excellent growing substrate for soil microbes and plants (Garrison-Johnston, et al., 2005). Most of the preserve has ash influence, although these particular soils in the southwest corner of the preserve can have ash greater than 18 cm in the upper solum. In particular, pumice dominated soils are found around Cerro la Jara, southwest of headquarters and within El Cajete.

Forest soils could be lumped into two broad categories based on geomorphic positions: (1) moderate to steep rimrock slopes and those of the domes, and (2) the alluvial/colluvial fans that shoulder the valles. The steep slopes of the Quaternary post-resurgent domes and those of the older, Tertiary, caldera rim are mainly composed of rhyolite and dacite flow rock and welded or non-welded ash flow which all form well drained conditions. The footslope fans that in some cases are extensive, such as in San Antonio Watershed, have very thick sequence of landslide, alluvial, and colluvium material derived from the upper slopes. Water holding capacity on the steep hillslopes of the rimrock and domes is roughly one-third that of the grassland soil bottoms, using information from the soil survey (Hibner, et al., 2010). Soil textures are dominantly sandy loams and thus well drained. Despite these drainage conditions, topsoils are dark from fine rooted understory grasses and forest herbs that create conditions for organic matter buildup. Where they occur, quaking aspen’s typically highly concentrated roots, and leaf litter's quick decay rate further incorporates organic matter to build dark topsoil.

Intrinsic to growth is amount of radiation from sunlight, the soil temperature that corresponds to length of growing season, and the amount of moisture on site. Using plant species and soils metrics, these characteristics are grouped into lifezones (see Figure 4-48). The Terrestrial Ecosystem Unit (soil survey) criterion outlines 8 lifezones for Arizona and New Mexico (USDA and NRCS 2011). The VCNP environment consists of lifezone 6 and 7 for the upslopes, and lifezone 5 for the valley bottoms. The low sun areas are where snow is the dominant precipitation input while high sun areas indicate where monsoon rains has higher influence.

In general, soils are less productive where slopes are steep and where cold conditions limit soil biotic function. The preserve is stratified into two cold regimes: frigid and cryic according to average annual soil temperature. Cryic are the most extreme with an average soil temperatures below 8 degrees C. These conditions are mapped as lifezone 7, colored cyan in Figure 4-48. Colder conditions are also found within cold pocket drainages, north aspects and higher elevations on the domes and rimrock. Finer details of dry to wet to ranges within the lifezones are shown by degree of shading. Darker shading shows the wetter sites within each lifezone. The dark shading highlights the effect of drainage geometry and geomorphology influence to site moisture. Concave drainages that accrete moisture and landslide mantles have higher moisture and are more productive (Swanson., et al., 1988).

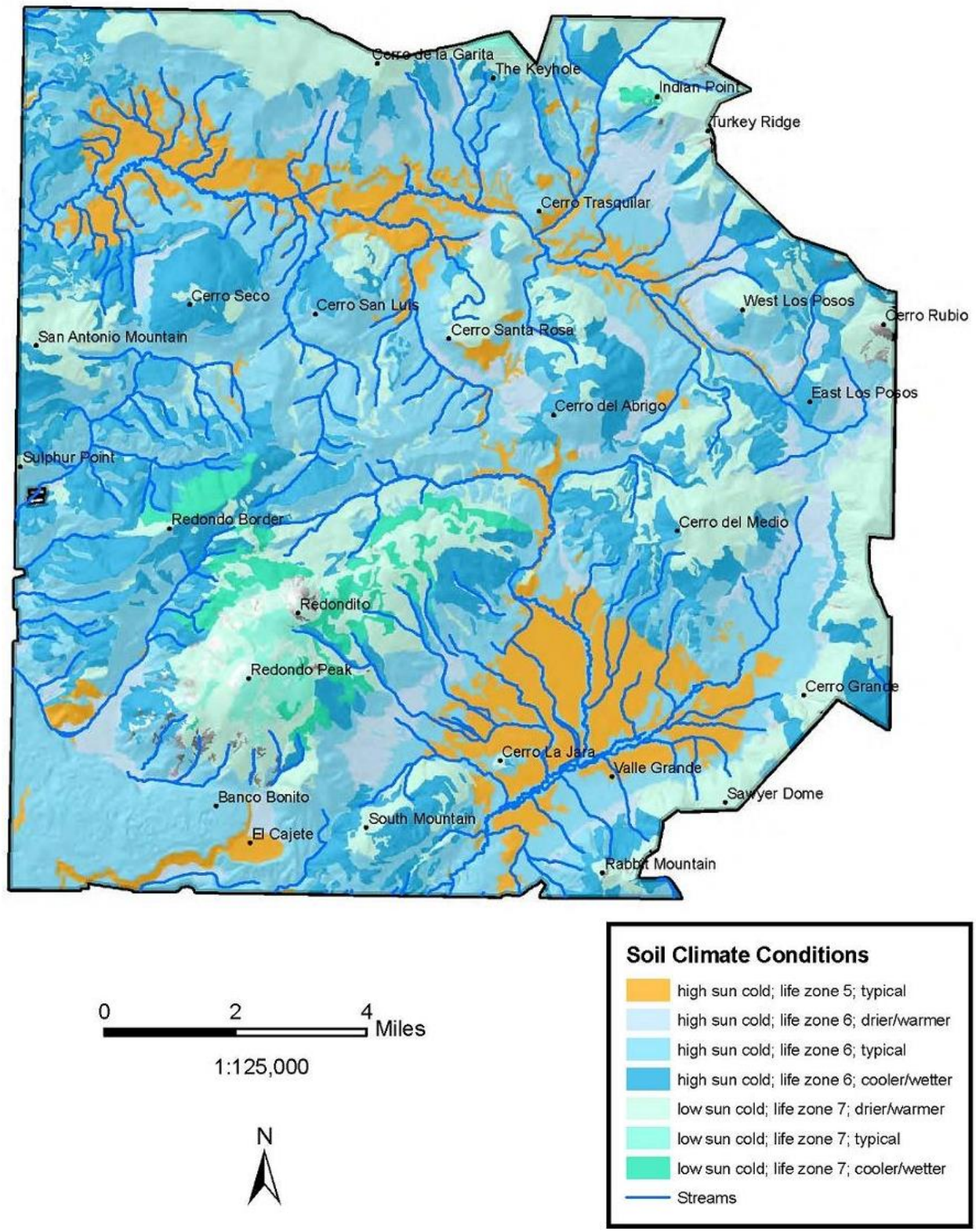


Figure 4-48. Climatic zones that influence growing conditions based on sun exposure; dominant temperature and moisture availability

Because of weather resistant rhyolite parent material the volcanic domes have sandy loam textures and rocky, skeletal soil matrix that facilitates drainage. Water holding capacity in these soils can be some of the lowest on the preserve due to the rapid drainage. The forest floor, accumulated organics in the profile, and soil aggregation in the topsoil, are important to retaining moisture in the upper soil profile. Water holding capacity is from 0.05 to 0.07 in/in using NRCS output for these soil series. Concave draws or areas of grassland vegetation are the most productive areas on these domes. Dark mollic ash soils make up roughly a fifth of the soils on the forested domes. These have the highest potential water holding capacity for herbaceous vegetation. Clayey subsurface soils, including those with mollic surface soils, make up two-thirds the dome soils. These soils increase potential water holding capacity for deep-rooted trees and shrubs.

The high elevation peaks have very little water retention within the Felsenmeer rock fields and are altogether a harsh growing environment given the limited growing season. Felsenmeer rockfields have somewhat active downslope movement and lack soil development (Muldavin and Tonne, 2003). Along the lower elevation near flat benches and hillslope grasslands, productivity is appreciably higher; soils have very strong mollic components with deep accumulation of soil organic matter in mineral soils. Soil water holding capacity is from 0.1 to 0.13 in/in (USDA - Forest Service; USDA-NRCS, 2011).

Soils derived on the northern rimrock include some very sandy members where drainage is likely excessive. Slopes break distinctly and active soil creep and slumping were apparent in several locations along the northeastern rimrock of the caldera (Figure 4-49). Exposures of Bandelier tuff had particularly poor soil development. The subsequent fans adjacent to the rimrock contrast sharply with robust productivity where surfaces are stable. However, active drainage development was frequent leading to shallow or no soil development. Water holding capacity on the footslope fans of the domes and the rimrock is high because of thick organic topsoils, robust grass and forb growth, and the layered colluviums/alluvial materials. Buried soils have strong subsurface clay layers that increase water-holding capacity. Water-holding capacity is listed as 0.19-0.21 in/in for the dome and rimrock fans.

Figure 4-49. Hummocks showing active soil movement on northern rim of the VCNP

4.4.4 Erosion

Erosion - Las Conchas Fire Effects

Viewing the results of the monsoon season on the slopes burned by the Las Conchas fire, it is apparent that the energy imparted by intense rainfall was the dominant cause of erosion on the VCNP. The latest soil survey does map the preserve as mostly low to moderate erosion hazard, even on the steep upland slopes of the volcanic domes. But with the ground bare of forest litter and understory vegetation the hazard increases dramatically. The high hazard estimations incurred by loss of groundcover is either because of slope gradient, or weakly cohesive soils and bedrock.

A fan slope soil bound by grassy roots or a forest floor cover of thick leaf litter is nearly invulnerable, but they often protect weakly cohesive soils or rock such as ash fall tuffs, loamy sands, and unconsolidated colluvium. Even on the moderate gradients of the fan slopes substantial loss of grass cover, and livestock trailing resulted in the massive gullies of the last century and the ruin of the valley bottom wetlands. The steep sided rhyolite domes are extremely stable showing little evidence of historic mass wasting, as if to underscore an impermeable nature. However, after the fire exposed the thin stony soils to the monsoon rains, sheetwash and rilling was pervasive and swept incalculable tons of fine sediment down slope onto the grassy fan slopes and valley bottom. Ironically, long recovered from grazing pressures and robustly

vegetated the once fragile grassy valley slopes absorbed and dissipated the runoff energy and sediment load from the steep uplands.

In the post-Las Conchas Fire environment swales that collected runoff from steep severely burned slopes were most vulnerable. In a few instances these swale drainages were deeply eroded, gully channels, cut down as much as 15 feet deep (see Figure 4-50). The walls of the gullies revealed a chaotic mix of sand to boulders colluvium that had probably resided since the last time the sequence of fire and monsoon had occurred. Most significantly the gullies cut no further than a somewhat indurate and impervious clay layer that almost certainly acted as a failure plane—a zone of reduced shear resistance. Runoff water wetted the swale down to the clay layer where it pooled. A point was reached when the sodden weight above could no longer be held in check by the relatively slick clay surface. The degree of final degradation depended on the amount of material lying above the clay layer; for every failure there might have been more that did not for lack of overburden.

At rainfall intensity above 0.4 inches precipitation per 30 minutes (0.8 in/hr), burned slopes become very unstable (Cannon, et al., 2001; Wonzell and King, 2003). The monsoon season following the Las Conchas wildfire had at least four storms capable of severely eroding slopes and triggering debris flows (Western Regional Climate Center, 2012). Substantial storms occurred in late July through late August. Comparing these intensities to the return interval from Cannon et al. (2001) for Cerro Grande storms and Reneau et al (2007), most of 2011's thunderstorms range in the one to two year recurrences.

Based on a review of precipitation totals for the five climate stations in the preserve, the Los Indios and north rim sites had substantially less intense storm cycles than Cerro del Medio (Western Regional Climate Center, 2012). Thunder cells rarely extend over 5 square miles, with a radius of 1.25 miles (Kuyumjian, 2011). Flooding incidences started with the late July storm set. Precipitation amounts are stored hourly but this scale does not reveal a precise estimate of intensity for downpours.

Figure 4-50. Post Las Conchas fire gulley in swale meadow on Cerro del Medio (right); debris flow deposit on fan slope of Cerro del Medio (left).

Debris flows following the Las Conchas fire initiated in 2nd order draws, similar to those Cannon describes after the Cerro Grande wildfire (2001). No debris flows were observed outside of the wildfire perimeter, underscoring the importance of canopy and groundcover. The failed draws observed all had accumulated material from creep, ravel, and possible previous mass wasting, which had essentially preloaded the system for the Las Conchas and subsequent rain events. Prolonged rainfall can saturate this stored sediment in the upper draws leading to masse failure within the channel that runs until the channel gradient decreases. Deposits drop out proportional to their mass along the alluvial fans. Meyer and Wells (1997) reasoned that runoff converging in the upper draws, laden with soil fines and wood ash material, is an important factor in the bulking of sediment and subsequent debris flow release. We believed that Meyer and Well's assessment, applied well to the apparent circumstances of failure in the swales we observed.

The wildfire, storm and erosion sequence may be the dominant mechanism in mountain landscapes. Meyer et al. (2001)and Kirschner et al (2001) partitioned this pattern into more frequent sheet flow events (33-80 year interval) and longer term, large-scale geomorphic responses from debris flow events (100-1000 year interval). Following the Cerro Grande fire, three meters of sediment was deposited in the Los Alamos Reservoir compared to 0.2 meters over 57 years prior to the wildfire (Lavine, et al., 2006).

The shallow surface erosion appeared to occur within the ash and finer topsoil fraction. Ash creates a distinct layer that can saturate quicker than the underlying soil. We observed pervasive surface erosion on steep slopes where the ash and some thin amount of topsoil separated from the rest of the soil column. Moisture weakens the binding force holding soil particles together. Friction between the saturated ash layer and mineral soil is reduced to the point where the ash layer slips. Wells (1987) described contributing sediment in the upper reaches as soil slips of saturated ash over water repellent subsurface that lead to rills.

Hydrophobicity of burned soils and the plugging of soil pores by ash are two factors that can lead to overland flow (DeBano, et al., 1998; Robichaud, 2000; Larsen, et al., 2009). This results in conditions where rainfall rates can exceed the soil's ability to infiltrate water. We speculate that the difference in moisture content between ash surface layer and the lower mineral soil could be yet another mechanism for generating surface erosion.

The infiltration capacity of soils depends on its initial water content. Dry soils tend to resist infiltrating water due to natural hydrophobicity of particles and/or air entrapped in pore spaces. As soils wet up, the ability to take in water increases. Near the saturation point, however, soil pores fill to the extent that soils can no longer take in water. Soils are therefore most prone to resisting infiltration when completely dry or saturated. Based on flooding after Las Conchas wildfire, the worst case occurred when back-to-back storms pushed soils toward saturation from an initially very dry condition.

Erosion – Gully Formation

Forested floors and grassy slopes do not generally produce overland flow except under the most extreme precipitation events. Such events are typically localized and short-lived. The extent of gullying in the

valles, and the relatively even-aged appearance suggests a more consistent and pervasive cause. Gullying is historical, likely formed in the nineteenth and early twentieth century, caused by intensive livestock grazing (Denevan, 1967; Anschuetz and Merlan, 2007). Many of the current gully systems were visible in the historical 1935 aerial photos.

The 1935 aerial photographs show most if not all present gullying is not obviously connected to vehicular roads. These features appear as bright spots on valley bottoms and deposit fans indicating active scour as previously illustrated in Figure 4-43. Many gullies also reached farther down slope into valley bottoms than the 1996 digital ortho-quads show. The 1935 photos predate the industrial logging and road building and 1960's stock tank construction. In absence of other evidence, the historic sheep grazing was the single most important management activity that contributed to gully starts. Based on the recent accounts of the preserve history (Anschuetz and Merlan, 2007), the sheep grazing was magnitudes greater than any of the livestock numbers in the past 30 years. Also, conditions in 1935 would include the impacts of 70 years of grazing by sheep and other ranching.

Locations of gullies have specific characteristics:

- Gully starts were most often at breaks in slope, particularly where there were seeps.
- Down-cutting proceeds either down-slope or up-slope as head-cuts.
- Gullies occur in fan slope deposits, particularly those with exposed lacustrine sediment. Soil differences in the area soil survey (USDA - Forest Service; USDA-NRCS, 2011) do not necessarily explain varying risk to gully formation.
- Slope deposits from certain formations or formation members appear to be the most susceptible to gully formation: rhyolite tuffs of the Valle Grande member of Valles Rhyolite Formation in the lower Valle San Antonio, around San Antonio Mountain, Cerro Seco and Cerro San Luis; a vitric member of the volcanic dome rhyolite forming Cerro del Medio, also of the Valles Rhyolite. Lastly a cliff exposure of the Bandolier Tuff, at the upper end of Valle de Los Posos (and precisely where the gas pipeline crosses) is a remarkably unstable slope that has induced massive land sliding about 150 years ago judging from the age of trees growing on the sediment fans.
- Gullies resulting from the Las Conchas Fire were in swales with abundant colluvial fill above a clay layer and with sufficient headwater slopes above to generate flow. These were large swales usually with associated stringer meadows.

Topsoil in the gully bottoms and gully deposit fans are typically light colored, sandy or gravelly indicating very recent, historic deposit. Thin layers of organic accumulation at the surface suggests at least 30 years of time for soil development and cessation of erosion.

The banks of gullies and incised channels in draws are predominantly re-vegetating, appear at stable angle of repose, and have often floodplain development, all indications of a degree of healing and decreasing impacts. Very often the gully form does not directly connect to a perennial or intermittent channel if it ever did, but ambiguously ends in an alluvial fan within a large valley margin.

Only in the foot slopes of Cerro del Medio can gullies be positively connected to logging access or skidding trails as a primary cause. Several prominent draw-like gullies, already re-foresting in ponderosa pine can be traced to vehicle tracks. This ground is underlain by an obsidian-containing member (map unit Qvdm4) of Cerro Del Medio Rhyolite (Gardner, et al., 2006) like a belt at low elevation around the

mountain. The gully starts seemed confined to this zone. Also, the most active slumping on the preserve is within this member—outside exposures of the Tshirege member of the Bandolier Tuff in Los Posos Valley. The slumping is in the form of small benches or terraces on the lower slopes of Cerro del Medio, just above Obsidian Valley.

We speculate on several causes of the gullying though are unsure of the exact mechanism. They may form from convergent surface flow, and in some cases, alongside obvious vehicle trails. Formation is common from stock tank spillways. Collapsed soil piping may cause another form of gully. Soil piping occurs when preferential groundwater flow paths become enlarged enough to transmit flow not under a positive hydraulic pressure; similar to surface channel flow (Wilson, et al., 2008). The pipes can grow vertically close enough to the surface so that if the soil mass above is saturated by intense rainfall or snowmelt it might collapse into the pipe, leaving a channel or pit open to the sky. While no direct evidence of collapsed pipes exists, observations in the field suggest that shallow groundwater flow may be contributing factor. Circumstantial evidence of collapsed soil pipes was found in upper Valle de los Posos and Upper Valle Toledo. In Valle de Los Posos, the evidence takes the form of depressions that either elk or livestock have wallowed in, that are not connected with surface channels. In Valle Toledo, the evidence is a continuous very shallow surface channel, with deep pothole like pools.

Some criteria for piping or at least pervasive factors across research findings are:

- Existence of a layer restrictive to downward percolation of water
- Loss of vegetation cover, or conversion to agriculture or pasture
- Concave slopes that serve to converge water either as surface flow or shallow groundwater flow

It has been conjectured in this report that clay bearing lacustrine sediment inter-fingering with coarser deposits is a controlling factor in spring sites. In several gullies examined during spring 2011 field visit, water seeping from head cut faces was noted just above the contact of clay layers with overlying soil. Groundwater piping along this contact plane, day lighting at head cut walls, may advance the head cut up slope by so-called ‘pop-out failure’ alone, or when hydraulic pore pressure overcomes the soil cohesive strength. Most of these gullies were in swale drainages, which generally have a flat or slightly concave lateral and longitudinal profile. It was mentioned previously that loss of cover on the foot slopes is a likely cause of gully starts by inducing overland flow, but it may also have led to increased groundwater flow and soil piping.

Erosion Potential

Potential erosion is highest on steep slope gradients and where soils lack protective groundcover. On mixed severity fire slopes where groundcover is below 60-70 percent, surface erosion potential increases dramatically (Johansen, et al., 2001). Wildfire setting where consumption of cover is complete leads to erosion potential that is at least two to seven times that of pre-fire conditions (Cannon, et al., 2001; Shakesby and Doer, 2006). Storms in the realm of 1 to 5 year recurrence can produce erosive overland flow from the reduced ability of the soil to take in rainwater, lack of canopy protection to intercept rainfall, and lack of forest floor to soak up rainfall and regulate infiltration.

Outside of a wildfire environment, surface erosion is rare in the upper hillslopes even within heavily roaded areas. Generally, soil losses are considered most extreme on steep slopes when groundcover is lost from disturbance (Elliot, et al., 1998). However, field observations found the preserve's roads to have caused limited soil erosion on the steep hillslopes of the domes, most likely because of the combined effects of surface rock armoring and high infiltration rates.

Across the preserve, groundcover is well maintained with rock armoring the soil surface and robust vegetation. Erosion is mostly confined to disturbed areas where the underlying substrate is prone to gully erosion. Most of the gully erosion observed on the preserve was found on finer textured footslope soils where soils have inherently higher erosivity and rainfall and snowmelt runoff is concentrated. The main erosive materials are associated with the slope deposits from rhyolite tuff, and lakebed sediments. These materials are not strongly cohesive and unravel easily once gullying is initiated.

To compare the relative risk for surface erosion across the major 6th code HUC watersheds on the preserve, the risk for crown fire was super-imposed over soil erosion hazard. Surface erosion was predicted assuming a severe wildfire and used the same Disturbed WEPP (Water Erosion Prediction) model and parameters as the Las Conchas Burned Area Emergency Rehabilitation effort (Kuymunjian and Schwab, 2011). Disturbed WEPP is a hillslope process model that generates erosion rates based on locally adapted climate information, soil texture, slope gradient, length, coarse rock content on the soil surface and the high severity fire treatment condition (USDA - Forest Service, 2011). Groundcover in a severe wildfire setting is assumed as 1 percent from standing tree boles. The modeled crown fire uses the driest conditions from nearby climate stations established for measuring and predicting fire weather (see Fire Behavior section). Qualitative risk ratings were assigned by comparing soil tolerance rates from the soil survey (USDA - Forest Service; USDA-NRCS, 2011)with predicted erosion values.

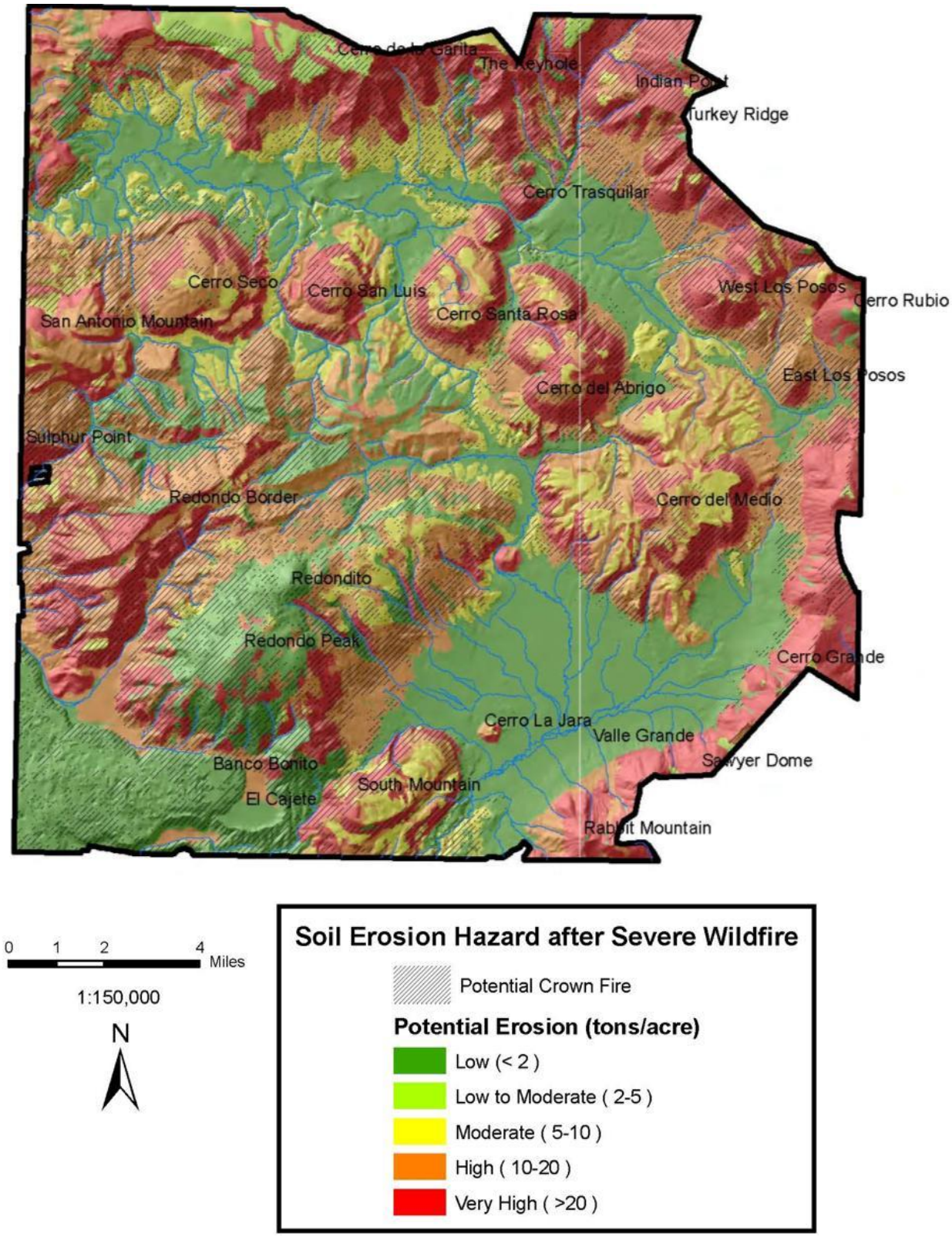


Figure 4-51. Soil erosion hazard after severe wildfire. Hatched lines indicate potential crown fire hazard

As expected, steep slopes were a major factor in erosion. The greatest risk for crown fire on erosive slopes is in the Redondo Creek drainage, localized areas on the domes, and along the northern rim of the caldera. Figure 4-51 overlays crown fire potential with soil erosion potential.

4.5 Air Quality

The preserve is within the 5000-square mile Albuquerque-Mid Rio Grande Intrastate Air Quality Control Region (AQCR) 152. Natural factors affecting air quality in the AQCR include spring dust storms and frequent winter inversions. Air quality on the preserve can be assessed in the smaller air shed defined by the fire weather zone 102 in north central New Mexico shown in Figure 4-51.

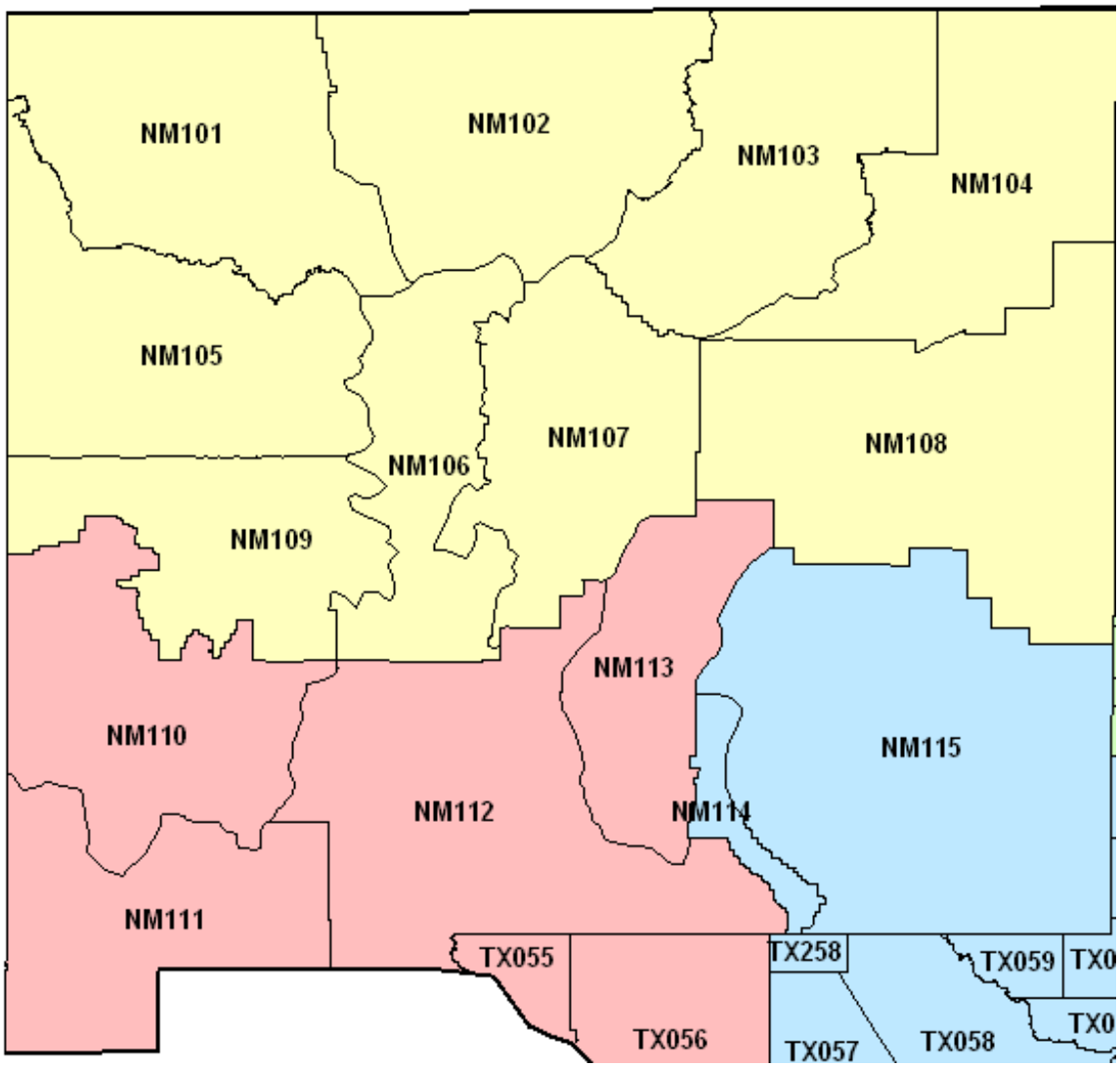


Figure 4-52. Fire weather zones for New Mexico; the preserve is within zone 102 (courtesy of the National Weather Service.)

Figure 4-53 shows ventilation data from zone 102 for 2008. Spring and summer show the greatest number of days with good to excellent ventilation with autumn and winter showing the greatest number of poor ventilation days caused by the characteristic inversions. While the actual number of days where ventilation is excellent versus very good or poor versus fair varies annually, the seasonal distribution of conditions is fairly constant. The topography of the caldera influences sight specific dispersal conditions.

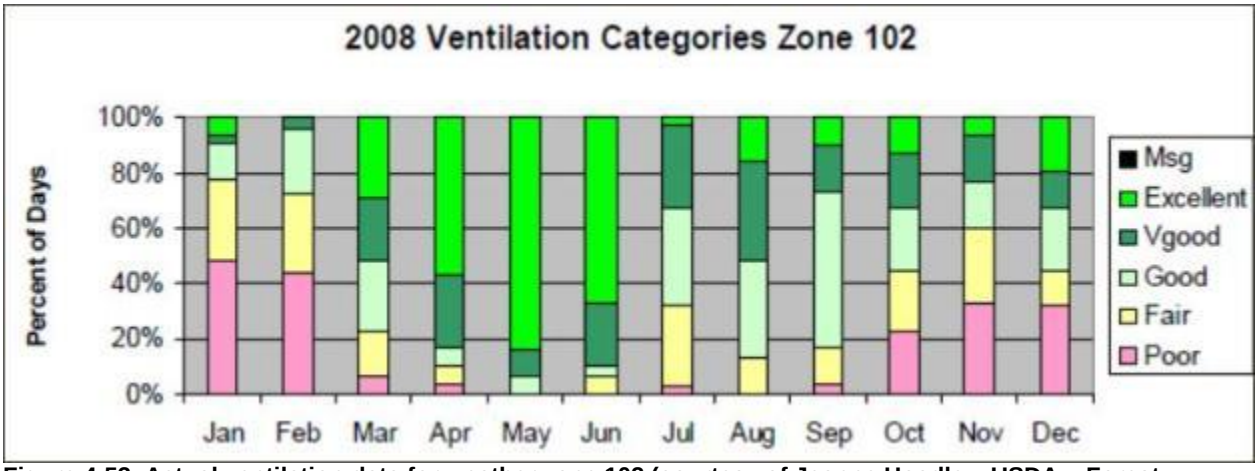


Figure 4-53. Actual ventilation data for weather zone 102 (courtesy of Jeanne Hoadley, USDA – Forest Service.)

The preserve is not within any non-attainment areas but seasonal air quality issues do exist in the Jemez Valley. Based on the index rating used by EPA the air quality in the Jemez Valley is *Good,* with a mean index of 42.6 (0-50 is *Good)* (USA.com, 2010). Generally, the air quality is perceived to be excellent based on people's perceptions of the clarity of the sky and views in the Jemez. Smoke is not perceived as part of the character for the most part however, in the winter months, smoke from wood burning stoves is visibly trapped in the Pueblo of Jemez until warming airs lifts the typical inversion. The air quality index from Jemez Pueblo is right at 50, the breaking point between *Good* and *Moderate.* Occasionally smoke from wildfires or prescribed burns create localized affects but do not contribute to the overall character of the air quality. For example in 2011, the year that the Las Conchas fire burned in Sandoval County 76 days were recorded where particulate matter less than 2.5 microns (PM 2.5) was the main pollutant present in the county's air. In 2010, there were zero days where PM 2.5 was the main pollutant (U.S. EPA, 2012). Particulate matter is the primary health concern from fire (smoke) (Sandberg, et al., 2002). Air quality alerts were issued during the Las Conchas fire but these short duration nuisance events were not recorded as days in Sandoval County when air quality was recorded as meeting the standard for "unhealthy" or even "unhealthy for sensitive groups" (U.S. EPA 2012). However in Albuquerque 14 days were found to be "unhealthy for sensitive groups" in 2011 versus only 3 in 2010 (U.S. EPA 2012) . In 2011 the city was impacted by the Wallow fire in Arizona as well as the multiple fires in New Mexico including the Las Conchas fire.

4.6 Terrestrial Wildlife and Habitats

The diversity of the vegetation and riparian communities within the Valles Caldera extends to its wildlife as well. This section addresses the state of species that have a special legal status under the Endangered

Species Act (ESA), are being considered for special status, landbirds including neotropical migratory birds (NTMB), and species that are of particular interest in management.

4.6.1 Methods

The Fish and Wildlife Service (FWS) is the government agency dedicated to the conservation, protection and enhancement of fish, wildlife and plants and their habitats. The FWS identifies maintains lists of special status species and defines the various types of status as follows (U.S. Fish and Wildlife Service, n.d.):

- **Endangered**: Any species that is in danger of extinction throughout all or a significant portion of its range.
- **Threatened**: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
- **Candidate**: A species for which there is sufficient information to propose that they be added to the list of threatened or endangered species but the administrative procedure is not complete or has been precluded.
- **Proposed**: A species where a proposal for listing has been announced in the Federal Register. The proposal could be for either threatened or endangered.
- **Species of Concern**: A species for which further research or field study is needed to resolve their conservation status. Species that are considered sensitive, rare, or declining on lists maintained by Natural Heritage Programs, state wildlife agencies, other federal agencies or professional, academic, or scientific societies may also be on this list.

We also consider the state of categories of species not identified by the FWS including:

- **Sensitive Species:** an animal or plant species identified by the USDA - Forest Service Regional Forester for which species viability is a concern either a) because of significant current or predicted downward trend in population numbers or density, or b) because of significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution, but not identified on the FWS list of species of concern.
- **Species of Interest:** Species of interest are not listed or sensitive and, in fact may be quite common. However they are either important to the management of the preserve (elk), are indicators of ecological health (Abert's squirrel), or may be important regionally (predators such as coyotes, mountain lions and bobcat).
- **Neotropical Migratory Birds (NTMB):** NTMB are discussed because many species are experiencing downward population trends. NTMB were analyzed based on review from wildlife databases for the preserve and local scientific knowledge.

Table 4-23 below summarizes special status species or species of interest that are deemed to have suitable habitat identified, and have either documented or suspected occurrence within the preserve. Sensitive habitats are displayed in Figure 4-54. Species presence/absence determinations were based on habitat presence, wildlife surveys, and recorded wildlife sightings, and literature reviews.

Table 4-23. Threatened, endangered and sensitive (TES) species and species of interest with populations and/or habitats on the VCNP

Species		Status
Canada Lynx	*Lynx canadensis*	Candidate
Gunnison's prairie dog	*Cynomys gunnisoni*	Candidate
Jemez Mountain salamander	*Plethodon neomexicanus*	Candidate
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	Candidate
Goat Peak Pika	*Ochotona princeps nigrescens*	Species of Concern
Northern goshawk	*Accipiter gentiles*	Species of Concern
Pale Townsend big-eared bat	*Corynorhinus townsendii*	Species of Concern
Peregrine falcon	*Falco peregrinus anatum*	Species of Concern
American marten	*Martes americana origenes*	Sensitive
Bald eagle	*Haliaeetus leucocephalus*	Sensitive
Boreal owl	*Aegolius funereus*	Sensitive
Dwarf shrew	*Sorex nanus*	Sensitive
Ermine	*Mustela erminea muricus*	Sensitive
Long-tailed vole	*Microtus longicaudus*	Sensitive
Northern leopard frog	*Lithobates pipiens*	Sensitive
Pika	*Ochotona princeps*	Sensitive
Southern red-backed vole	*Clethrionomys gapperi*	Sensitive
Spotted bat	*Euderma maculatum*	Sensitive
Water shrew	*Sorex palustris navigator*	Sensitive
Abert's squirrel	*Sciurus aberti*	Species of Interest
Black bear	*Ursus americanus*	Species of Interest
Blue grouse	*Dendragapus obscurus*	Species of Interest
Bobcat	*Lynx rufus*	Species of Interest
Coyote	*Canis latrans*	Species of Interest
Elk	*Cervis elaphus nelsoni*	Species of Interest
Gray fox	*Urocyon cinereoargenteus*	Species of Interest
Merriam's turkey	*Meleagris gallopavo merriami*	Species of Interest
Mountain lion	*Puma concolor*	Species of Interest
Mule deer	*Odocoileus hemionus*	Species of Interest

Five species that occur near the preserve or in similar habitats have been determined to be absent and not likely to occur on the preserve. These species are no longer considered in our environmental analyses. Several occur at lower elevations in the Jemez Mountains, but do not actually occur on the VCNP. Others do not occur in the Jemez Mountains, but may occur in other nearby habitats in northern New Mexico.

- **Black-footed ferret** (*Mustela nigripes*): has never been recorded on the VCNP or in the Jemez Mountains. Even the early expedition by Vernon Bailey in 1906 (US Biological Survey) did not record any observations of this species (Bailey 1931). While the VCNP does host a number of Gunnison's prairie dog populations, these colonies are of insufficient size and spatial extent (<200 acres) to support a population of black-footed ferrets. Hence, given the lack of a current ferret population, no historic records of ferrets on the VCNP, and insufficient prey resources within the VCNP, we will not consider this species further in our analyses.

- **Southwestern willow flycatcher** (*Empidonax traillii extimus*): has not been documented on the VCNP. Extensive breeding bird surveys (BBS) have been conducted annually since 2001 by Stephen Fettig, Wildlife Biologist with Bandelier National Monument, and his colleagues, and none has been observed. Southwestern willow flycatchers are found below 8,500 feet elevation (USDI-Fish and Wildlife Service, 2011), which means that only the extreme southwestern corner of the VCNP (which is below 8,500 feet) could possibly support this species; however, there is no critical habitat listed in the VCNP for the flycatcher (USDI-Fish and Wildlife Service, 2011). One of the goals of the VCNP's restoration program is to collaborate with other organizations to restore woody riparian vegetation (including willows) to VCNP streams, and work accomplished to date with the WildEarth Guardians has begun to re-establish willows and cottonwoods on Redondo Creek in the southwest region of the VCNP. We hope that through these actions, we will create suitable habitat so that future colonization of this portion of the VCNP by flycatchers will be feasible. However, as there are currently no Southwestern willow flycatchers on the VCNP and no listed critical habitat, we will not consider this species further in our analyses.
- **Mexican spotted owl** (*Strix occidentalis lucida*): We have conducted five separate surveys for the Mexican spotted owl in 2001, 2002, 2004, 2005, and 2009 (Johnson 2001, Johnson 2002, Hathcock et al. 2004, Hathcock and Keller 2005, Keller 2009a), and no spotted owls were found. In addition, there is no critical habitat listed for the owl on the VCNP. The forest restoration program described below is designed to improve habitat conditions for Mexican spotted owls, and coupled with future climate warming, we would hope to eventually observe colonization of the VCNP by Mexican spotted owls at some point in the future. However, as there are currently no known owls present on the VCNP, and no designated critical habitat, we will not consider this species further in our analyses.
- **Boreal toad** (*Anaxyrus (=Bufo) boreas boreas*): In New Mexico, this toad has only been found in the San Juan Mountains of north-central Rio Arriba County (Williamson et al. 1994, Degenhardt et al. 1996); the species has not been recorded in the Jemez Mountains or on the VCNP, although extensive surveys have been conducted throughout the VCNP (Cummer et al. 2002, Cummer et al. 2003). In addition, VCT biologists have worked extensively in the VCNP's uplands, and riparian and wetland areas since 2003, and have been specifically looking for any additional species of amphibians, including the boreal toad; none has been observed during the past 10 years of fieldwork. Given that there are no known populations on the VCNP or in the Jemez Mountains, and that the Jemez Mountains are not within the known historic geographic range of this species, we will not consider this species further in our analyses.
- **New Mexico silverspot butterfly** (*Speyeria nokomis nitocris*): This butterfly has also has not been recorded on the VCNP, although an extensive survey of butterflies was conducted by Dr. Paula K. Kleintjes, University of Wisconsin, Eau Claire, WI, in 2001 (Kleintjes 2001). The New Mexico silverspot is an alpine species, and feeds exclusively (as a caterpillar) on *Viola nephrophylla* (Arizona Game and Fish Department 2002). The VCNP does not have any alpine ecosystem habitat, and does not have any populations of the host plant, *V. nephrophylla* (Hartman and Nelson 2005). Therefore, the New Mexico silverspot is not likely to occur on the VCNP. As such, this species will not be considered in further analyses.

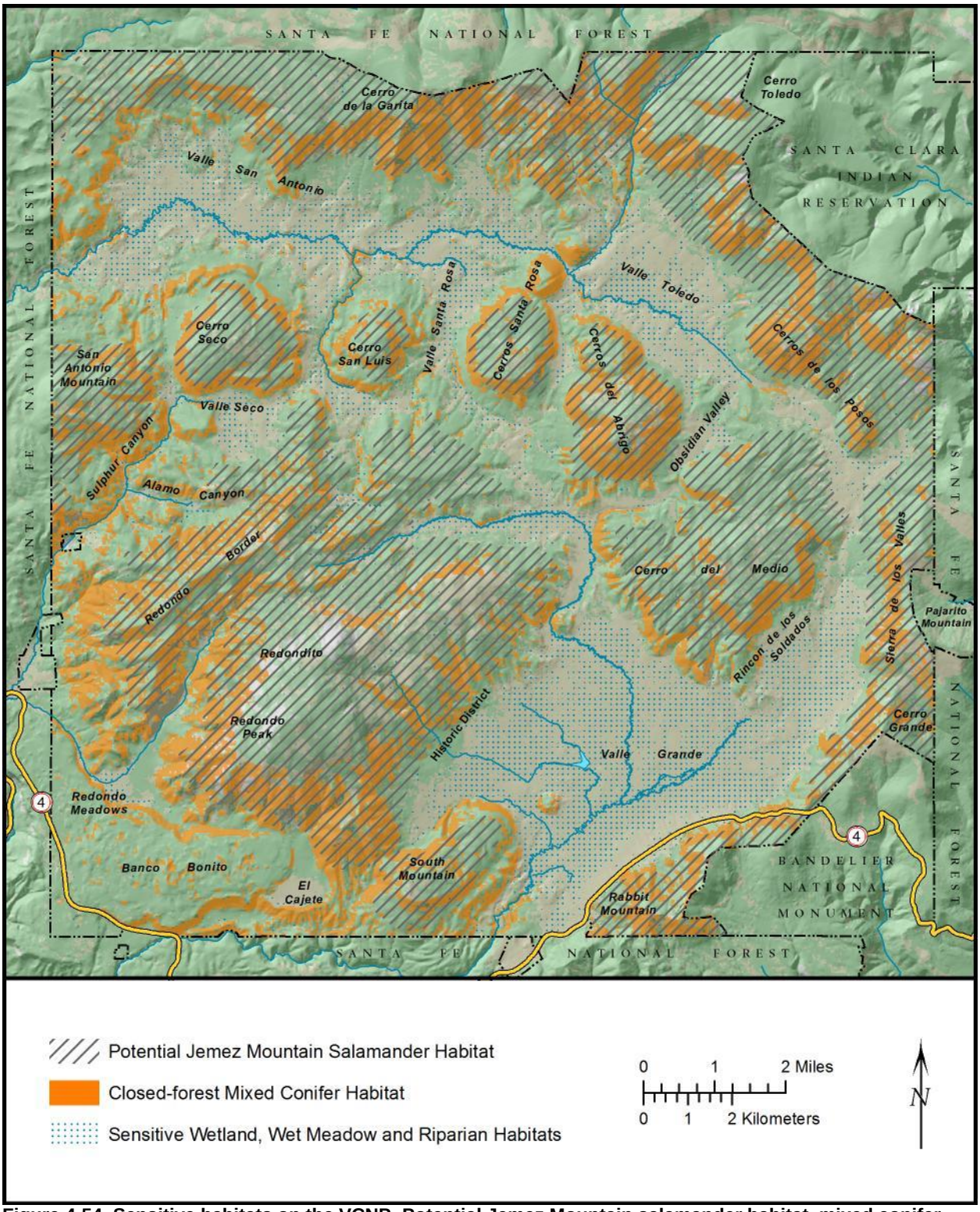


Figure 4-54. Sensitive habitats on the VCNP: Potential Jemez Mountain salamander habitat, mixed conifer habitats, and sensitive wetland, wet meadow, and riparian habitats

4.6.2 Candidate Species

There are three species that are candidates for listing that occur on the preserve or have suitable habitat on the preserve: the Canada Lynx, Gunnison's prairie dog and New Mexico meadow jumping mouse. As such, these species are for all practical purposes treated as listed species with regard to preserve management.

Canada Lynx (*Lynx Canadensis*)

Canada lynx is only known to occur on the VCNP as dispersing individuals from a radio-telemetry study during a reintroduction effort in Colorado (details below), and does not appear to have any historical records of existing populations. It is very likely that the Canada lynx does not have a sustainable, breeding population in the Jemez Mountains, and this has influenced our analysis of the forest restoration impacts on this species. The support for this comes from several lines of evidence. First, the VCNP is generally south of the historic range of lynx (Tumlinson, 1987). The lynx is not currently a resident species on the VCNP or anywhere in the Jemez Mountains, nor has it been since initial wildlife surveys of the area were conducted beginning in 1906. At that time, Vernon Bailey (Senior Biologist, Division of Biological Investigations, Bureau of Biological Survey, Washington, D.C.) conducted an extensive survey of the Jemez Mountains and the area that would become the Valles Caldera National Preserve (Bailey, 1931). He did not record the lynx among the species encountered at that time. Similarly, a wildlife assessment of New Mexico, conducted in 1926-27 by J. Stokley Ligon of the New Mexico Department of Game and Fish, also failed to list lynx as a resident species in this area (Ligon, 1927). More recently, wildlife surveys of Bandelier National Monument (Geluso and Bogan, 2005) and the Valles Caldera National Preserve (Long, 2002) have not detected lynx in this area. A confirmatory check of university research museum mammal archive collections via Arctos (http://arctos.database.museum/home.cfm) also failed to produce any lynx specimens for the Jemez Mountains (Sandoval and southern Rio Arriba Counties). As such, there appears to be no verifiable historical record that the Valles Caldera National Preserve has supported native lynx populations. In contrast, a distributional analysis using a number of factors to predict suitable lynx distributions has concluded that northern New Mexico should be considered as potential natural range of the lynx (Frey, 2006).

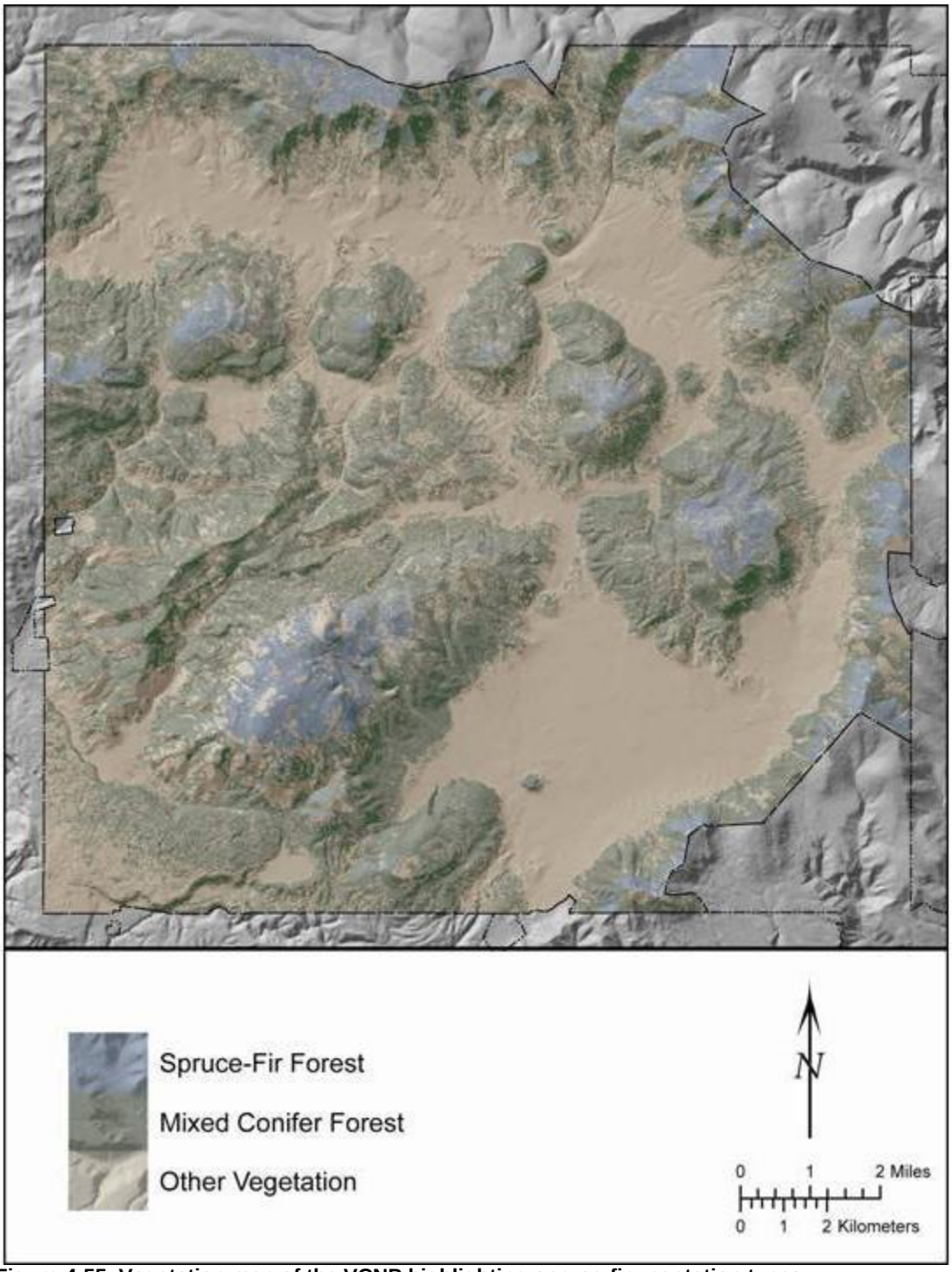


Figure 4-55. Vegetation map of the VCNP highlighting spruce-fir vegetation types

In 1997, the Colorado Division of Wildlife (CDOW) began a reintroduction campaign to restore lynx populations in southern Colorado. During 1999-2007, 218 radio-collared lynx were released and monitored, and a number of these animals have dispersed southward into New Mexico (Shenk, 2008).

Several radio-telemetry locations of lynx have been recorded in the Jemez Mountains (including one individual that was present during the Cerro Grande fire near Los Alamos in May 2000). This indicates that dispersing lynx from Colorado can reach the Jemez Mountains, although these individuals apparently do not remain the in the Jemez Mountains for very long.

The availability of sufficient suitable habitat is the potential limiting factor for supporting a sustainable resident breeding lynx population in the VCNP. Based on the high-resolution vegetation map of the VCNP (Figure 4-55) and prior to the Las Conchas fire in 2011, there were 7,004 acres of spruce-fir habitat, and 35,790 acres of mixed-conifer habitat (and approximately one third of these habitat acreages burned in the Las Conchas fire). Lynx prefer spruce and spruce-fir habitat, which is relatively limited on the VCNP. In addition, these habitats are not contiguous, being split into isolated "islands" on top of the volcanic domes within the main caldera. Given a home range size of approximately 7,500 ha for female lynx, and 10,200 ha for male lynx (Shenk 2008), we estimate that, at most, the VCNP could support only one or two (assuming overlap of home range) breeding pairs in primary and secondary habitats.

A second constraint on establishment of a resident, breeding lynx population is the lack of snowshoe hares (*Lepus americanus*) in the Jemez Mountains. The snowshoe hare is one of the major prey species for lynx (Tumlinson, 1987), and is virtually required to support successful breeding of lynx. Snowshoe hares were not recorded in the Jemez Mountains in early wildlife surveys (Bailey, 1931; Ligon, 1927), and no archived voucher specimens exist in research museum collections. More recent surveys and habitat analyses corroborate the lack of snowshoe hare in the Jemez Mountains (Long, 2002; Geluso and Bogan, 2005; Malaney, 2003; Frey and Malaney, 2006; Malaney and Frey, 2006). Thus, without its primary food source, it is unlikely that successful breeding would occur with dispersing lynx pairs.

In summary, while some individuals of lynx may disperse from the core reintroduction site in southern Colorado to the Jemez Mountains of New Mexico, it is unlikely that the Valles Caldera National Preserve could successfully support a sustainable breeding population.

Gunnison's Prairie Dog (*Cynomys Gunnisoni*)

Populations of Gunnison's prairie dog can be considered to occur in two separate range portions – higher elevations referred to as montane populations and lower elevations referred to as prairie populations. The montane habitat found in the northeastern portion of the range (central and south-central Colorado and north-central New Mexico) consists primarily of higher elevation, cooler, and moister plateaus, benches, and intermountain valleys. This habitat comprises 35-40 percent of the species' total current range. (BISON-M). Gunnison's prairie dogs occupy grass and shrub vegetation types in low valleys and mountain meadows within this habitat. A field survey of the VCNP by USGS biologists in 2002 mapped the colonies that were both existing at the time or showed habitation in the past but were currently unoccupied (USDI - NPS, 2002). This survey demonstrated that Gunnison's prairie dog is common on the preserve, with some activity recorded in approximately 75 areas on 4,428 acres total, and past activities noted on 2,444 acres; mean active colony area is estimated to be approximately 60 acres.

Diseases such as plague have been known to devastate prairie dog colonies, and the VCNP populations were subjected to a plague epidemic in 2005 (Friggens, et al., 2010); populations have since recovered in most areas of the VCNP (Parmenter, 2009). Regionally in the Southwest, prairie dog populations have

declined since the settlement period due to poisoning, disease, and habitat loss (BISON-M). Diseases such as plague have been known to devastate prairie dog colonies. Prairie dog populations have declined since the settlement period due to poisoning, disease and habitat loss (BISON-M, n.d.).

Gunnison's prairie dogs feed most extensively on grasses, forbs, and sedges, but they will also eat insects, probably when necessary (BISON-M). While they are sometimes reported as being in direct competition with livestock for grazing forage though some of the literature shows bias and lack data supportive of specific claims about the degree of competition (BISON-M) and a lack of consideration regarding the role that disturbance by prairie dogs may have on the ecosystem.

Jemez Mountains Salamander (*Plethodon Neomexicanus*)

Jemez Mountain salamanders (JMS) are primarily found in habitats between 7,200-9,600 feet in specific microhabitat conditions and only in the Jemez Mountains. Preferred microhabitat is characterized by relatively high humidity and soils that contain deep, igneous, subsurface rock that is fractured vertically and horizontally to allow the species to retreat underground to below the frost line. Habitats where pumice is the dominant subsurface structure are generally not occupied. JMS are rarely encountered on the surface or under bark, litter, or in aspen logs. Much of the life cycle occurs underground, with surface activity occurring inside rotted coniferous logs or under rocks during a brief period of the summer (typically June through August) when conditions are warm and wet. Individuals are rarely found exposed on the surface. The microhabitat is coniferous forest dominated by Douglas-fir, blue spruce, Engelmann spruce, ponderosa pine, or white fir. Other trees in the area may include aspen, Rocky Mountain maple, New Mexico locust, oceanspray, and various shrubby oaks.

Surveys were conducted on the preserve from July to September of 2002. Three out of ten locations revealed positive results Most of the forested areas (47 percent or approximately 41,500 ac) of the preserve have been identified as potential habitat (Figure 4-54, above). The majority of the suitable habitat is in denser mixed conifer. The FWS is in the process of designating critical habitat.

Breeding likely occurs in the spring, with eggs laid beneath the soil surface in interstitial spaces between fractured rocks, in rotted root channels, or in the burrows of rodents or large invertebrates. Ants of at least three species make up approximately 74 percent of the diet. Other important prey items for the JMS include beetles, mites, spiders, earthworms, and other small invertebrates found in rotting logs and under rocks.

Forest management practices that lead to drier habitat conditions are thought to negatively affect JMS abundance and detectability. These woodland salamanders lack lungs and gills, and exchange gases almost entirely through cutaneous respiration. Thus, JMS, as well as other plethodontids, seek moist micro-environments and are sensitive to silvicultural treatments that modify the prevailing temperature, humidity, soil moisture, soil surface cover, and soil porosity.

Threats to the species include activities that may impact individuals or populations and or alter habitat conditions in the following manner: 1) ground disturbance such as excavation, churning, compaction, or any activity that reduces interspaces and subsurface channels; 2) vegetation modification to the extent

that ground surface microclimate is made drier or otherwise altered through increased exposure to sun and wind; and 3) suppression of populations of ants and other surface-dwelling invertebrates, which are the primary prey of the JMS.

Individual JMSs are very difficult to detect at a site because of their fossorial habits and intimate dependency upon exacting moisture conditions. Even when environmental conditions are ideal for surface activity, it is believed that only a small percentage of the individuals that occur at a site are surface active and therefore detectable using high-grade survey protocol. Therefore, data collected during high-grade surveys are believed to significantly underestimate the actual numbers of JMS present at a site.

Surveys were conducted on the preserve from July to September of 2002. Three out of ten locations revealed positive results; most of the forested areas (47 percent or approximately 41,500 ac) of the preserve have been identified as potential habitat.

New Mexico Meadow Jumping Mouse (*Zapus Hudsonius Luteus*)

The New Mexico meadow jumping mouse is a candidate for listing as threatened. This species is considered to be an extreme habitat specialist that relies on riparian areas that have tall, dense herbaceous vegetation, especially sedges, on perennially moist soil (Frey, 2006). Frey (2006) only found the New Mexico meadow jumping mouse in areas with two to three feet of vertical cover types. No formal surveys have been completed within the preserve although wildlife data received from the adjoining Santa Fe National Forest show two locations of this species along the San Antonio Creek within the preserve.

Montane populations use both persistent emergent herbaceous wetland (i.e. beaked sedge and reed canary grass) and scrub-shrub wetland (i.e. willow and alder) riparian communities, specific capture sites in scrub-shrub wetlands were nearly always restricted to small patches and narrow strips of herbaceous, usually sedge-dominated, microhabitats found between the water's edge and the shrubs. Tall dense sedge on moist soil appears to be the key microhabitat utilized by New Mexico meadow jumping mouse, regardless of the community type. Preferred habitat in the Jemez Mountains contains permanent streams, moderate to high soil moisture, and dense, diverse streamside vegetation of grasses, sedges, and forbs (Morrison, 1985).

Zwank et al. (1997) found that the breeding period for this mouse is June through August, nesting on the surface or beneath brush, logs or stumps. The meadow jumping mouse may produce two litters per year in lower elevations but only one in montane populations, given that mouse hibernates up to nine months a year in montane populations. It has a home range of .5 to 2 acres. It feeds on seeds, insects, and fruits; when seeds are unavailable or limited, insects may compose of up to half of its diet.

The New Mexico meadow jumping mouse is not dependent on the beaver for suitable habitat but Frey (Frey, 2006) has found that the loss of beaver and beaver dams in areas could have a negative impact on the mouse habitat in two ways: 1) the dams create the moist soils need for the microhabitat and, 2) can provide barriers to people and livestock in using the habitats favored by the New Mexico meadow jumping mouse. The preserve has historically had beavers in Sulfur and Indios Creek and personnel have

recently observed an individual moving through the area but currently there are no beaver populations located on the preserve. A beaver restoration project in Indios Creek is ongoing to restore beaver to the area within the next 3 to 4 years (Parmenter, 2009).

The meadow jumping mouse apparently requires dense vegetation for population persistence, and its scarcity may be related to livestock overgrazing in streamside habitats (BISON-M, n.d.). Periodic severe flooding may also contribute to its rarity. In more mesic areas the subspecies may be favored by the opening up of forests and similar ecological changes (BISON-M, n.d.). Habitat alteration, such as ungulate grazing, loss of beaver, water diversion leading to drying out of habitat, and various recreational activities within the habitat are the chief threats to the species. The meadow jumping mouse has shown a sharp decline in recent years, up to 91 percent in the Sacramento Mountain populations, and 67 percent in the Jemez Mountains (Conservation Services Division, NMDGF, 2008). The continued proper herding of livestock and reducing cattle use of streamside habitat for extended periods could increase the quality of riparian zones by increasing the woody vegetation and thus ensuring good stream bank stability.

4.6.3 Species of Concern

The FWS have identified four species of concern that may occur, or have habitat, within the planning area: American Peregrine falcon, Goat Peak pika, northern goshawk, and Pale Townsend big-eared bat.

American Peregrine Falcon (*Falco Peregrinus Anatum*)

Peregrine falcon usually inhabits open country, preferably where there are rocky cliffs with ledges overlooking rivers, lakes or other open water and an abundance of birds. Nesting habitat includes cliffs or platforms near water and an abundance of prey. Peregrines are primarily aerial hunters; small to medium sized birds are usually captured in flight; birds too large to be carried are knocked to the ground. Peregrines feed on a wide variety of birds but they occasionally also take mammals, insects and fish.

In New Mexico, breeding habitat is provided locally by cliffs in forested habitats in mountain and river canyons statewide. They prefer elevations from 6,500-8,600’ but may be found from 3,500-9,000’. Data from NMDGF show that although productivity in the state had recovered from historic lows by the 1980s, it began trending lower after 1984. The goal for recovery is sustained occupancy of 85 percent of known territories. In New Mexico, pairs occupied 81 percent of known falcon territories in 2004 however; productivity was slightly below recent averages and below historic levels (Terrell and Williams III, 2004). There is no suitable peregrine nesting habitat within the preserve. Peregrines do nest on the cliffs just to the west and use areas within the preserve as foraging habitat (Parmenter, 2009).

Goat Peak Pika (*Ochotona Princeps Nigrescens*)

In New Mexico these animals are confined to talus slides and boulder fields in Alpine and sub-Alpine areas. Goat Peak pikas occupy virtually every patch of appropriate talus in the Jemez Mountains. Specimens have been collected from Chicome Mountain, Pajarito Mountain, Cerro Grande, Rabbit Mountain, the head of Frijoles Creek, Redondo Peak, and Cerro del Abrigo. Additional sightings have been made on Cerro Toledo and Shell Mountain (BISON-M, n.d.). Although no formal surveys have been conducted Goat Peak pika are thought to occur within the preserve (Parmenter pers. comm.).

This species of pika breed in late April through early July. They nest under rocks and rock outcrops use grasses, forbs, sticks and leaves for nest material.

Pikas do not hibernate, but are active beneath the snow all winter, foraging out from talus in snow burrows (Smith and Weston, 1990). Loss of appropriate Goat Peak pika habitat can occur by increasing moisture in dry areas which promotes invasion of vegetation that fills the talus slopes (BISON-M, n.d.).

Northern Goshawk (*Accipiter Gentiles*)

The northern goshawk is a forest generalist that uses a variety of forest types, forest ages, structural conditions, and successional stages (Reynolds, et al., 1992). The principal forest types occupied by goshawks in the Southwest are ponderosa pine, mixed conifer, and spruce-fir. Goshawks seem to prefer mature forests with large trees on moderate slopes with open understories (Squires and Reynolds, 1997). The northern goshawk reaches the southern limits of its breeding range in the highlands of Arizona, New Mexico and possibly western Texas southward to at least Jalisco, Mexico. The small New Mexico population occurs locally in mature coniferous forests of mountains and high mesas. The goshawk is a predator of small birds and mammals. Snags, downed logs, woody debris, openings, large trees, herbaceous and shrubby understories and interspersion of vegetation structure are important features contributing to the presence of prey populations (BISON-M, n.d.).

Northern goshawks nest in coniferous, deciduous, or mixed-pine forests, depending on availability. A nest area is composed of the nest tree and stand(s) surrounding the nest that contain prey handling areas, perches, and roosts. Reynolds *et al.* (1992) stated that nest areas are often on mesic sites (northerly facing slopes, along streams). However, La Sorte *et al.* (2004) found that aspect was not a factor in nest location; rather the average nest site was centered in a forested area with small non-forested areas dispersed around the perimeter of the territory (La Sorte, et al., 2004). The forested area around the nest site corresponded well with the size of a post-fledgling family area (Reynolds, et al., 1992). Numerous studies have documented that goshawk nest sites are associated with characteristics of mature forest structure such as high canopy closure, mature trees, and open understories (Reynolds, et al., 1992), (La Sorte, et al., 2004).

A goshawk's nesting home range is about 6,000 acres (Reynolds, et al., 1992). A breeding pair usually occupies its nest area from early March until late September. The nest area is the center for all activity associated with breeding from courtship through fledging of young (Reynolds, et al., 1992). Nest trees

are usually one of the largest trees in the nest area. Most territories contain several alternative nest trees. Most goshawks have two to four alternate nest areas within their home range. Alternate nest areas may be used in different years, and some may be used for decades.

No formal surveys have been conducted and no known nests occur on the preserve but several designated foraging areas overlap onto the preserve from the Santa Fe National Forest. These areas are located on the east, west and northwest edges of the preserve. Goshawks have been observed foraging on the preserve. Breeding, roosting and foraging habitat is available on the preserve within the mixed conifer and ponderosa pine forests. Although historic logging targeted large trees and clear-cut all trees leaving a dearth of these important habitat characteristics.

Pale Townsend Big-Eared Bat (*Corynorhinus Townsendii*)

Townsend's big-eared bat is distributed broadly throughout all western North America, and it occurs in two disjunct, isolated populations in the central and eastern United States (Gruver and Keinath, 2006). The pale Townsend's big-eared bat is apparently secured both globally and within the United States and is the most widespread subspecies of the *Corynorhinus townsendii* (NatureServe). Although Townsend's big-eared bat is geographically widespread, it exists in relatively low density throughout its range (Gruver and Keinath, 2006), likely due of the relative scarcity of suitable roosting habitat. Within New Mexico, the subspecies is listed as vulnerable to extirpation or extinction. There is habitat for this species within the preserve although local distribution is limited to the presence of caves and similar structures, most of which are not distributed evenly across the landscape. Limited bat surveys have occurred in this part of the state and it is unknown the local distribution and density for this species.

Of the five recognized subspecies of Townsend's big-eared bats, three are found in the western states including the *Corynorhinus townsendii pallescens*. Due to the taxonomic uncertainty and morphological and ecological similarities within the western group (Gruver and Keinath, 2006) this assessment looks at all three of the western group and simple refer to these bats as Townsend's big-eared bat. This bat is a colonial species and forms aggregations ranging from one to several hundred individuals (Gruver and Keinath, 2006).

Reports indicate that Townsend's big-eared bat is a moth specialist with more than 90 percent of their diet consisting of lepidopterans (Gruver and Keinath, 2006). Preferred prey items include small moths; however appear to forage opportunistically on other prey items such as beetles and flies as well (Gruver and Keinath, 2006). Townsend's big-eared bat forage in woodlands, canopy gaps, vegetated stream corridors, and other linear landscape elements but avoid foraging and traveling in open areas and grazed lands (Gruver and Keinath, 2006). Individuals or colonies show high fidelity to particular foraging sites as well as to routes to travel between roost and foraging grounds, and tend to follow same linear features (e.g. stream corridors, forest edges) around which it forages. Connectivity of habitat patches may greatly influence the accessibility of foraging sites (Gruver and Keinath, 2006).

Some of the major threats facing this species are loss, modification and disturbances of roosting habitat by closures of abandoned mines, human activity in roost sites, and renewed mining at historical sites.

Loss, modification, and disturbances of foraging areas have occurred from the elimination of forest canopy, elimination or alteration of wetland habitat, conversion of native shrub and grasslands especially to urban agricultural uses. Activities that reduce the productivity of wetlands likely impact local populations of the Townsend's big-eared bat by reducing the quality of important foraging and drinking sites. The alteration of surface and subsurface hydrology of wetlands and removal of shrub and overstory vegetation ultimately reduce the value of wetlands to this species. In addition, activities that increase sediment loads into the wetland likely alter wetland soil and water chemistry and therefore, have the potential to decrease the value of the wetland to the Townsend's big-eared bat (Gruver and Keinath, 2006).

4.6.4 Sensitive Species

There are 11 terrestrial species on the Regional Forester's Sensitive Species list (USDA - Forest Service, 2007) that could potentially occur on or have habitat within the preserve that are not identified as *species of concern* by FWS. These species and the likelihood of occurrence for or their potential habitat within the preserve or in an adjacent area in this analysis area is noted below.

American Marten (*Martes Americana Origenes*)

American martens inhabit forest of spruce, fir, Douglas-fir, and associated trees in northern New Mexico. Optimum habitat appears to be mature, old-growth spruce-fir communities with more than 30 percent canopy cover, well-established understory of fallen logs and stumps, and lush shrub and forb vegetation supporting microtine and sciurid prey (BISON-M, n.d.). Course woody debris on the forest floor, including logs, rock piles, stumps, windthrow trees, and slash are thought to be important in providing winter access to subnivean (under the snow) rodent populations. Martens breed in late summer/early fall, and bear offspring in the spring. The birthing site is usually under the snow or in old squirrel nests.

Martens eat insects, mice, voles, red squirrels (*Tamiasciurus hudsonicus*), pikas, and snowshoe hares. They also feed on carrion. During certain times of the year (mostly in the fall), a significant portion of their diet is comprised of berries.

Martens typically will prey along the edges of meadows surrounded by forests keep to within about 25-75 feet of the forest edge (Buskirk, 2002). They will cross open meadows across distances of 350 feet. It's possible that marten prey species are not abundant and do not provide for energetic efficiencies to hunt beyond the ecotone of the forested edge and meadow openings. Hadley and Wilson (Hadley and WIlson, 2004) found cleared ski runs had low densities of red-backed voles and that captures of red-backed voles only occurred in or near the forested edges.

Home range for martens range from .4 to 5 square miles and are influenced by home ranges that are negatively correlated to the fluctuation of small mammal prey base abundance (Buskirk, 2002). Marten populations may fluctuate by a factor of more than 10 in response to fluctuations of prey populations (Buskirk, 2002). Current research indicates martens are adaptable to human presence. Marten attraction

to human structures has been observed due to the presence of mice and voles taking advantage of created habitat and forage found in and adjacent manmade structures.

Bennett and Samson (1984) found marten population size and condition, and dispersal rates are correlated to small mammal populations (Bennett and Sampson, 1994). Microtine rodents, particularly red-backed voles (*Clethrionomys spp.*), other voles (*Microtus spp.*), red squirrels (*Tamiasciurus spp.*), snowshoe hare (*Lepus americanus*), birds, insects and berries comprise the most common foods for marten (Buskirk, 2002). Red-backed voles are often associated with habitat that includes high basal areas of Engelmann spruce, large diameter CWD in older coniferous forests (Ruggiero, et al., 1994). Red squirrels are also important food source and provide important resting and denning habitat for marten; 40 – 50 percent of marten resting/den areas contained red squirrel middens (Ruggiero, et al., 1998). Snowshoe hare are an important large bodied prey in winter and energetically important to martens during winter metabolic stress (Buskirk, 2002). Red squirrels share a unique relationship with marten since middens provide resting sites, natal/den sites and subnivean access (Ruggiero, et al., 1994).

Surveys were conducted in 2002 within the preserve; fourteen sites were surveyed with negative results.

Bald Eagle (*Haliaeetus Leucocephalus*)

Wintering bald eagles begin to arrive on the preserve in October and leave by May, with peak numbers only during the coldest period of January (Johnson, 2003). The location and abundance of wintering eagles is dependent on food and availability of appropriate roosting and foraging habitat and can change year to year. Concentrations occur around reservoirs and along rivers, with a scattering of birds in terrestrial habitat (Johnson, 2003).

Nest trees are usually larger than those trees in the surrounding stands (USFS 1990), primarily conifer (Anthony and Isaacs 1989), and have thick, stout limbs. Bald eagles often construct alternate nests within a territory and vary use between them from year to year (USDI 1986).

There are no large water bodies to provide breeding/foraging habitat within or near the preserve. The Jemez Mountains do not contain known breeding habitat. The main areas in which bald eagles are found are along the San Antonio creek, although individuals can be observed during the day at numerous locations throughout the preserve. Most individuals seen away from water are feeding on elk carcasses as a result of hunting activities on the preserve. Eagles typically use the trees near the creek as overnight roosts (Parmenter, 2003).

Dr. Robert Parmenter, our chief scientist and biologist, noted that hikers and vehicle traffic from two roads near the roost sites along San Antonio creek were the main causes of disturbance for bald eagles in that area.

Boreal Owl *(Aegolius Funereus)*

Boreal owls are primarily found in mature, multilayered spruce-fir forest. In 1996, NMDGF surveys found this species to be resident in very small numbers in spruce-fir and similar habitats in the San Juan, Sangre de Cristo, and Jemez mountains (BISON-M, n.d.). Boreal owls tend to occur at higher elevations in the summer, and move to lower elevations during the winter. This owl roosts in dense cover by day, in cool microsites in summer, and frequently changes roost site (NatureServe, 2009).

The Boreal owl may forage day or night, although most hunting occurs at night. It eats mainly small mammals (voles, shrews, mice) also sometimes birds and insects (NatureServe, 2009).

This owl nests in tree holes, natural cavities or old woodpecker holes; sometimes in artificial nest boxes. Nest sites may be used in consecutive years. Nests are initiated from mid-April to late May or early June. Clutch size is usually four to six; young fledge at four to five weeks. Home range size is larger in the winter than summer and averages 3,775 ac (NatureServe, 2009).

Surveys conducted in September, 2012 found multiple Boreal owns in the Redondo and Redondito mesic spruce-fir.

Dwarf Shrew *(Sorex Nanus)*

This shrew lives in the mesic forest types from about 7,000 to 9,000 feet. The preferred habitat is talus and other rocky areas primarily in sub-alpine coniferous forest. Various other habitats including sedge marsh, subalpine meadow, dry brushy slopes, arid shortgrass prairie, dry stubble fields, and pinyon-juniper woodland (BISON-M). Although no formal surveys have been conducted, dwarf shrews have been found within the preserve (Hope, 2009).

At higher elevations breeding begins in late June – early July. Two litters are produced with the second one occurring in early September. At lower elevations breeding may begin earlier (NatureServe, 2009).

The shrew feeds primarily on insects, spiders, and other small invertebrates (worms, mollusks, centipedes, etc.), but may also consume vegetable matter as well as some small vertebrates such as salamanders (NatureServe, 2009).

Ermine (*Mustela Erminea Murices*)

The ermine is a weasel of high altitudes (7,800-11,000 feet) in northern New Mexico in association with small rodent populations in montane meadows, and avoids dense forest. Habitat includes forest-edge, grassland, shrub, wet meadows, and riparian areas. The ermine den in hollow logs or under logs, stump, roots, brushpile, or rocks (NatureServe, 2009).

Swickard, Haas, and Martin (Swickard, et al., 1971 (1972)) took five specimens in the Valles Grande in the Jemez Mountains, four of which came from a meadow and one from a rock slide. All were surrounded by

mixed coniferous forest at altitudes of 8,100-8,550 feet. No formal surveys have been completed within the preserve although wildlife data received from the adjoining Santa Fe National Forest show eleven locations of this species within the preserve.

Encroachment of trees into meadows, due to fire suppression or changes in climate, may reduce ermine habitat (Buskirk, 2002).

Long-Tailed Vole (*Microtus Longicaudus*)

Long-tail vole is found in coniferous forests, but are most abundant where there is at least some grassy vegetation present on the forest floor. They are also found from time to time in rockslides (Frey, et al., 1995).

Long-tailed voles in Arizona live in the meadows, grassy valleys, grassy clearings in forests, sagebrush flats, and rocky slopes near or in coniferous forests. Elsewhere in the Southwest where long-tailed voles live with or near montane voles, the former species occupies somewhat drier situations. While the relationship of long-tailed voles to water is not known precisely, in New Mexico long-tailed voles require water for daily sustenance (Frey, et al., 1995; BISON-M). No formal surveys have been completed within the preserve although wildlife data received from the adjoining Santa Fe National Forest show fourteen locations of this species within the preserve.

Long-tailed voles feed mostly on green vegetation, as well as on fruits and seeds. During winter, bark buds, and twigs of most locally common trees and shrubs, including spruce, aspen, oak, and snowberry are also consumed. Fescues, sedges, yarrow, and Oregon-grape are also commonly used (Fitzgerald, et al., 1994; Frey, et al., 1995). Nests are typically in underground burrows or under logs/rocks, and young are born at least from late April through September.

Northern Leopard Frog (*Lithobates Pipiens*)

The northern leopard frog is typically associated with streams and rivers, although lakes, marshes and irrigation ditches are also occupied. Much of the river valley habitat of these frogs has been modified by human activities, including draining of wetlands, channelization and damming of rivers, and the development of irrigation systems (Degenhardt, et al., 1996). In New Mexico, they occur at elevations of about 3,500 to 11,000'. Their habitats include cattail marshes, beaver ponds and other water sources with aquatic vegetation. Breeding can occur at any time of year following heavy rainfall or in higher elevations later in the season. Egg masses are attached to emergent vegetation or lie on the bottom of the pond in shallow slow moving or still water (AmphibiaWeb, 2008). In New Mexico Scott and Jennings (Scott and Jennings, 1985) reported eggs and small tadpoles of this species from April through July and September through October.

It will be important for breeding habitat to maintain water in most areas from July to October. Initial breeding activity is related more to temperature than precipitation (Degenhardt, et al., 1996). Threats to

local populations include alterations in wet areas, stocking of predatory fish; local extinctions as water dries up during years of low precipitation, and predation and competition by bullfrogs.

Food habits of northern leopard frogs are unknown but undoubtedly feed on a wide variety of invertebrate prey (Degenhardt, et al., 1996). The frog may forage long distances from water in upland habitat during wet periods (Degenhardt, et al., 1996).

No formal surveys have been completed within the preserve although wildlife data received from the adjoining Santa Fe National Forest show four locations of this species within the preserve. Approximately 45 miles of potential habitat is present along riparian corridors within the preserve.

Pika (*Ochotona Princes*)

North American pikas are rather narrowly restricted to mountainous areas where talus slopes provide suitable cover. In New Mexico these animals are confined to talus slides and boulder fields in Alpine and sub-Alpine areas. In the Jemez Mountains pikas have been taken on Goat, Santa Clara, and Pelado peaks, where they live in lava rocks as low as 9,000 feet. Not just any rock pile will suffice - the rock must be sufficiently large that the spaces between provide corridors for movement, the slide must be of sufficiently recent origin that the spaces have not filled with debris from higher ground - the talus-meadow interface is the best habitat (BISON-M, n.d.). Although no formal surveys have been conducted, pikas have been observed within the preserve. The primary habitat being the talus slopes on Redondo Peak (Parmenter, 2009).

This pika feeds primarily on grasses and sedges but also eats some flowering plants and shoots of woody vegetation. In late summer and fall, they harvest and store food (forbs, grasses, and marmot pellets) for winter consumption. They may also forage in winter in snow tunnels. Ingests caecal pellets, either directly or after storage. They are generally active throughout the year but may be relatively inactive on warm days (NatureServe, 2009).

Home range size varies seasonally, being largest during spring breeding season. Home range size is about twice as large as its territory. Male and female territories average the same size, roughly 0.75-1.25 acres. Adjacent home ranges tend to be occupied by opposite sexes (NatureServe, 2009).

Pika do not dig burrows but may enlarge an existing den or nest site under rock. They are seasonally polyestrous and gestation lasts approximately 30 days. They produce one to two litters of young between May and September. There are usually two to five young per litter. The maximum lifespan for the North American pika is seven years (NatureServe, 2009).

Southern Red-Backed Vole (*Clethriomomys Gapperi*)

Southern red-backed vole are often common in mature lodgepole pine stands or in mixed spruce-fir forests with good cone production and an abundance of surface litter including stumps, logs, and exposed roots of fallen trees. Red-backed voles frequently use the middens of the squirrels for cover and as a food source. Other habitats include grassy meadows, willow riparian areas, talus, and krummholz (Fitzgerald, et al.,

1994; Frey, et al., 1995). Grass communities are generally unsuitable habitat for southern red-backed voles, probably due to lack of food and cover. No surveys have been conducted for this species within the preserve. Swickard, Haas, and Martin (Swickard, et al., 1971 (1972)) found them around the Valles Caldera in association with rocks and blue spruce.

These voles forage by grazing or browsing on the ground, in herbaceous vegetation, snags, stumps, rocks, or logs. They feed upon the ectomycorrhizal fungi found in older coniferous stands and also need the course woody debris for cover (Buskirk, 2002). They breed late winter through early fall. The nest sites can be a secondary cavity in a live or dying tree, hole in the ground, stumps, logs, or under rocks and are often the nests of other animals. The nests are made from grass, sticks, leaves, and moss and are close to ground level.

Spotted Bat (*Euderma Maculatum*)

Spotted bat is found in patchy distribution throughout central, west North America. They have been captured from British Columbia to Central Mexico. These bats are considered globally and within the United States to be secure although the population is deemed to be declining (NatureServe, 2009). NatureServe notes that abundance, population trend, and threats are essentially unknown. In New Mexico, this bat has been found in about 20 locations (NMDGF, 2009) however; the survey method used (mist netting) is not considered to be effective way to sample for this species (Luce and Keinath, 2007).

The spotted bat has been recorded in very diverse habitats up to 10,000 feet elevation (BISON-M). This species is more dependent on roost availability and water than on vegetation types. The ideal roost sites for this species is cliffs, rock outcrops, or caves that are near water (streams, pond, and tanks) and open areas for foraging of insects. Most of the recorded bats in New Mexico were caught over waterholes near a sandstone cliff with numerous vertical cracks for roosting (NatureServe, 2009).

This species of bat specializes it diet by feeding primarily on moths, and will typically travel 3-6 miles from roosting sites to foraging areas. The species prefers noctuid moths that are obligates of lentic vascular hydrophytes (a plant growing in waterlogged soil) (Luce and Keinath, 2007). Consequently, reduction or elimination of these host plants could affect the noctuid prey base of spotted bats.

One of greatest threats to spotted bats is from disturbance at roost sites. Spotted bats usually have little impact from human disturbance at its cliff-face roost sites. Modification or loss of foraging areas by the removal or changing of riparian habitat and/ or the alteration of native shrub and grasslands is the second greatest threat to this species (BISON-M, n.d.). Management activities that can affect the foraging site of this species are livestock and wildlife grazing, vegetation treatments, fire, and even-age forestry management.

Water Shrew (*Sorex Palustris Navigator*)

Water shrews are common inhabitants of northern forests. As the name suggests, water shrews are closely associated with water often found around streams and other aquatic habitats, areas of high humidity surrounded by heavy vegetation, logs and rocks are preferred. Stream banks often provide favorable cover including boulders, large stones, tree roots, overhanging ledges, willow, alder thickets, and spruce. Also found in lakes, bogs, and other lentic habitats (NatureServe, 2009).

In New Mexico, water shrews are confined, so far as known at present, to the Sangre de Cristo, San Juan, and Jemez Mountains where they occur in the vicinity of permanent streams, seldom descending below 8,000 feet in altitude. Findley observed one foraging in July of 1961 on the Rio Las Vacas in the Jemez Mountains (BISON-M, n.d.). Although no formal surveys have been conducted water shrews have been found within the preserve (Hope, 2009).

Both terrestrial and aquatic invertebrates are consumed by water shrews. The primary aquatic organisms consumed by shrews, including stoneflies, mayflies, and caddisflies are most abundant in streams with fast current and cobble substrate (Orrock, et al., 2000). Water shrew breeds from February through August. Nest sites are near water in underground burrows, rafted logs, beaver lodges, and other areas providing shelter (NatureServe, 2009). Common predators include fish such as trout, bass and pickerels, monks, otters, weasels, snakes and occasionally hawks and owls (NatureServe, 2009).

4.6.5 Species of Interest

There are an additional 10 species of wildlife that we are considering in this impact analysis. These are species that are have management implications and are either the subject of ongoing research, game species, popular for recreational observation, or where the preserve may serve a particular need such as breeding or refuge.

Abert's Squirrel (*Sciurus Aberti*)

The Abert's squirrel uses interlocking canopies in ponderosa pine. Tree density, diameter, and grouped distribution of trees are the most important components of Abert's squirrel nest cover. The right combinations of these factors provide squirrels with optimum conditions necessary for nest protection. The best cover conditions are found in uneven-aged ponderosa pine stands with trees spaced in small, even-aged groups within the stand. Average tree diameter for the stand is between 11 and 13 inches in diameter at breast height (dbh), but the presence of small groups of larger trees produces a mosaic of height groups (Patton, 1975).

Pine twigs, pinecones, pine seeds, pine bark, as well as truffles (underground mushrooms known to form mycorrhizal associations with ponderosa pine), are used by the Abert's squirrel (Farentinos, et al., 1981).

No surveys have been completed on the preserve. Based on observations by preserve personnel Abert's squirrel are present.

Black Bear *(Ursus Americanus)*

Black bears are highly mobile and readily disperse across many types of habitat. Bears prefer mixed deciduous-coniferous forests with a thick-understory. When inactive, they occupy dens under fallen trees, in ground level or above ground level tree cavities, hollow logs, in underground cave-like sites, or in dense cover.

The bear is an opportunistic omnivore and has a variable diet of plants and animals (vertebrate and invertebrate), commonly including fruits, insects, carrion and garbage. A current study on the preserve is an elk calve mortality study. The study is looking at what percent of calves die, as well as possible causes to the low recruitment, including the role of predators.

Large predators that occur in the Jemez Mountains include black bear and cougar, both species are hunted in the surrounding public lands but not in the preserve. Because of high road densities in the Jemez Mountains and a high occurrence of outfitters nearby, hunting pressure on the black bear and cougar populations is high. Despite heavy hunting pressure large predator populations are healthy according to model projections, harvest and general indicators. The preserve, Bandelier National Monument, Los Alamos National Laboratories properties and the San Pedro Parks Wilderness serve as *de facto* refugia in the region allowing hunted predators areas of escape and relatively light disturbance.

No surveys have been completed for bear on the preserve although sightings are frequent. (Parmenter, 2009). A 2008 assessment of trends in the area estimated 33 to 66 individuals exist within the boundaries of the Valles Caldera (Winslow, 2008).

Blue Grouse (*Dendragapus Obscurus)*

The blue grouse is native to New Mexico and occurs most commonly in the mountainous area of the north-central portions of the state. The Sango de Cristo, San Juan, and Jemez Mountains are principal areas of this species (BISON-M).

Structural diversity is a major determinant of habitat suitability for blue grouse. Structure of habitat is more important than species composition. Important forest cover types include spruce-fir, Douglas-fir, and ponderosa pine. Mixed-species forests are probably the most important habitat type in high elevation sites in Arizona (BISON-M).

Blue grouse forage in conifer trees, on the forest floor, along ridge tops, and in openings. Major food items in the spring are needles, buds, and new cones of conifers. In the summer and fall; grasses, forbs, and fruits of low growing plants; during the winter, they eat mostly conifer needles (BISON-M).

Blue Grouse selectively feed and roost in the oldest and largest Douglas-fir trees available. Douglas-fir trees repeatedly used within and between winters were typically growing under stressful conditions, such as on dry, steep, talus slopes, and had endured stresses such as lightning strikes or boulder impacts (Remington and Hoffman, 1996).

No surveys have been completed on the preserve. Based on observations by preserve personnel blue grouse are present.

Bobcat (*Lynx Rufus)*

Bobcat is found in various habitats including deciduous-coniferous woodlands and forest edges, brushlands, deserts and other areas with thick undergrowth. When inactive, occupies rocky clefts, cave, hollow log, or space under fallen tree. Young are born in den in a hollow log or space under fallen tree or in a rock shelter (NatureServe, 2009). Bobcats prey extensively on cottontails and jackrabbits. They also eat a variety of rodents.

Fire may improve the foraging habitat and prey base of bobcats. Fires that create a mosaic of burned and unburned areas including some open areas and some cover are probably most beneficial to bobcats. Fires that reduce vegetation height and create open areas probably increase hunting efficiency. Surface fires often open substrates for quieter stalking and easier capture of prey than can occur in closed forests. Periodic fire helps to maintain habitat for many bobcat prey. Several studies indicate that many small mammal populations increase rapidly subsequent to fire in response to increased food availability. Bobcats are very mobile and can probably escape most fires. There are no reports of direct bobcat mortality due to fire (Prescribed Fire and Fire Effects Research Work Unit, 1996)

No surveys for bobcat have occurred on the preserve, but occasional observations by personnel confirm their presence.

Coyote (*Canis Latrans)*

Coyote is found in a wide range of habitats from open prairies to heavily forested regions and even within cities. Coyotes are hunted for sport and pelts and regarded as a pest at certain times, in some areas, due to occasional predation on elk calves, deer, poultry or livestock. They are highly mobile and readily disperse across many types of habitats (NatureServe, 2009); populations tend to encompass huge areas.

Young are born in a den usually in a burrow (enlarged burrow of other mammal or dug by female), with the opening often oriented toward the south. Dens also may be above ground (e.g. at base of tree under low, overhanging branches; in hollow log or rock crevice), or under building. Commonly uses same den in subsequent years (NatureServe, 2009).

A recent study by Gifford et al. (2008) was conducted to describe the ecology and natural history of the coyote (*Canis latrans*) on the preserve. Preliminary diet assessment based on scat analysis suggests that coyote diet consisted primarily of rodents, followed by insects, and then elk. Preliminary habitat use analysis suggests a late summer avoidance of forest and preference for wet meadows compared with habitat type availability within home ranges. Future analyses will compare seasonal, annual and territorial differences in scat composition; describe space use, habitat use, and movement patterns of collared coyotes; describe population characteristics including population density, social organization,

age structure, disease prevalence, and causes of mortality; and finally, assess whether a relationship exists between social cohesion and body size of diet components (Gifford, et al., 2008).

Gray Fox (*Urocyon Cinereoargenteus)*

The gray fox is common and widespread in broken country, woodland, and lower forest zones. It is perhaps most common in pinyon-juniper and oak woodlands but seems to be absent from grasslands that are without rock outcrops or at least some encroachment of juniper. The species is essentially absent from well-developed mixed coniferous and spruce-fir forest. Gray foxes use brush and brushy woods in most areas. Fire that reduces brush cover will decrease gray fox habitat. Fire usually increases the productivity of early successional prey species and improves predator efficiency by reducing hiding cover for prey.

The fox is an opportunistic omnivore. Diet often chiefly depends on rabbits and other small mammals in winter, insects and fruit in summer. Fire often reduces fruit production in the short term, but edges of older burns are usually good regeneration sites for fruiting shrub species such as blackberries and blueberries; gallberry produces the most fruit a few years after fire pruning (Prescribed Fire and Fire Effects Research Work Unit, 1996). Overall diet may be dominated by plant material in some areas.

No surveys for fox have occurred on the preserve, but occasional observations by personnel confirm their presence.

Merriam's Turkey (*Meleagris Gallopavo Merriami)*

This upland game bird primarily utilizes ponderosa pine and pine-oak as well as the transition habitats between ponderosa and piñon-juniper woodland habitats and ponderosa and mixed conifer. There are three essential habitat components. These include surface water, roosting trees, and openings for summer brood areas (Kamees, 2002).

Turkeys prefer to roost in tall mature or over-mature ponderosa pines with relatively open crowns and large horizontal branches starting at 20-30 feet (6 to 9 meters) from the ground. Trees with a diameter at breast height (dbh) of over 14 inches are used as roosts. Preferred roost sites are often located just below a ridgeline. Hens normally nest within ½ mile radius of water (Boeker and Scott, 1969).

Although no surveys have been completed across the preserve, turkeys are numerous and are frequently seen by preserve personnel. In 2007 the Valles Caldera Trust, undertook a study of the ecology of the Merriam's Turkey in the preserve. The goals of the study are to map movements and home ranges on multiple time scales; identify preferred habitat for roosting, nesting, brooding and feeding; determine rates of mortality and natality; and to determine how these factors relate to fire history on the landscape and silvicultural treatments. Six walk-in traps were deployed across the preserve in the fall of 2007. Use of the trap sites by turkeys increased dramatically following snowpack and in February 2008 researchers successfully captured and marked two adult male turkeys in Redondo Meadow, in the southwest corner

of the preserve. The turkeys were fitted with radio-transmitters and marked with colored metal leg bands (Chipault and Parmenter, 2008).

Mountain Lion (*Puma Concolor*)

Mountain lions inhabit rough, broken foothills and canyon country, often in association with montane forests, shrublands, and pinon-juniper woodlands. (Fitzgerald, et al., 1994)

Mountain lion habitat can be enhanced or expanded by fires that improve habitat for prey species such as deer and elk. Mountain lions may change their home range in response to fire. The diet of mountain lions consists mainly of ungulates. A current study on the preserve is an Elk calf mortality study. The study is looking at what percent of calves die, when and which predator is responsible.

Prescribed burning programs designed to improve habitat for large ungulates such as deer and elk also benefit mountain lions. Information was not found in the literature regarding direct effects of fire on mountain lions. Kittens are probably most vulnerable to fire (Prescribed Fire and Fire Effects Research Work Unit, 1996) (BISON-M).

The Jemez Mountains are comprised of Game Management Units (GMUs) 6A, 6B and 6C. GMU 6B is the Valles Caldera National preserve. Large predators that occur in the Jemez Mountains include black bear and cougar, both species are hunted in GMUs 6A and 6C but not in 6B. Because of high road densities in the Jemez Mountains and a high occurrence of outfitters nearby, hunting pressure on the black bear and cougar populations is high. Despite heavy hunting pressure large predator populations are healthy according to model projections, harvest and general indicators. GMU 6B, Bandelier National Monument, Los Alamos National Laboratories properties and the San Pedro Parks Wilderness serve as *de facto* refugia in the greater GMU 6 allowing hunted predators areas of escape and relatively light disturbance. Cougar harvest could be sustainable in GMU 6B at a very light level. Cougar populations tend to replace losses rapidly, particularly from surrounding areas that are harvested lightly, and can be harvested fairly aggressively (Winslow, 2008).

It has been noted (BISON-M) that there is a large population of lions on Bandelier National Monument, which is adjacent to the preserve and undoubtedly migrate between the two areas. No surveys for lion have occurred on the preserve, but occasional observations by personnel confirm their presence. Approximately 5 to 8 individuals exist within the boundaries of the Valles Caldera (Winslow, 2008).

Mule Deer (Odocoileus Hemionus)

Mule deer inhabit most forest types with good forage and cover. They utilize a variety of habitats during the course of their lives. Certain vegetation types are of limited value due to aspect, elevation, snow depth, lack of water availability and/or vegetation components.

Mule deer utilize higher elevations in the spring and summer and migrate down to lower elevations in the fall and winter. They browse on wide variety of woody plants and grazes on grasses and forbs.

Surveys including capture have been initiated for deer in the SWJML. It is believed that the number of deer are limited on the preserve likely due to lack of open habitat and competition with elk (Parmenter, 2009).

Rocky Mountain Elk (Cervis Elaphus Nelsoni)

Elk inhabit most forest types with good forage and cover. They utilize a variety of habitats during the course of their lives. Certain vegetation types are of limited value to elk due to aspect, elevation, snow depth, lack of water availability and/or vegetation components.

The amount of grazing animals than an area can support depends not only on the amount of forage produced, but the access to that forage and availability of water. Across the preserve, the highest potential herbaceous productivity is located in the broad grassy valles. Climate, especially moisture, is the limiting factor of forage production on the majority of sites and rates vary widely depending on the timing and form of annual precipitation. As a result, average biomass production can change significantly in relatively short timeframes. For example, forage production doubled between a dry year in 2002 and a wet year in 2007 (TEAMS Enterprise Unit, 2007).

Another climate related condition involved the lack of snow in 2004 and 2005, which led to higher use by elk. Elk over-wintered in 2005 and only were gone a short time in winter 2004. This over-wintering may explain the higher usage measured in riparian areas. Riparian utilization was 45 percent and 34 percent for years 2004 and 2005 respectively.

The population trend for the Rocky Mountain elk is stable to increasing. Since 1995, the New Mexico Department of Game and Fish has conducted aerial elk counts over the Jemez Mountains. The most recent population estimate in the Jemez Mountains is 5,500 to 8,400 with an estimate of 3,500 that summers on the preserve. These estimates are pre-hunting season (Liley, 2008). The entire preserve is classified as critical summer range, winter range and calving area habitat. Historically, elk utilized the west side of the preserve and wintered to the south and west, but elk now concentrate on the east and north sections of the preserve, which are in or associated with the large grassland valles, and winter to the south and east (TEAMS Enterprise Unit, 2007).

Analysis of the preserve's elk population, based on data collected from hunter-harvested elk specimens, yields results that indicate caution for future elk management plans. First, the calf:cow ratios of the herd on the preserve appear to be too low (Figure 4-56), indicating potential problems with calf production keeping up with mortalities of adults through hunting, predators and other causes of fatalities. Normal calf:cow ratios in healthy herds should be around 40 to 50 calves per 100 cows. This ratio at the Valles Caldera has been running between 20 and 30 calves per 100 cows, although the most recent survey (September 2012) shows a higher value of 38:100. In addition, the bull:cow rations observed during the NMDGF aerial surveys are in the "normal" range of 30-50 bulls per 100 cows (Figure 4-57). Field surveys completed by the trust indicate lower ratios, but because bulls tend to remain in dense cover, ground surveys tend to under count bulls. Hence the aerial data collected by NMDGF is thought to be the most accurate source for estimating bull:cow ratios.

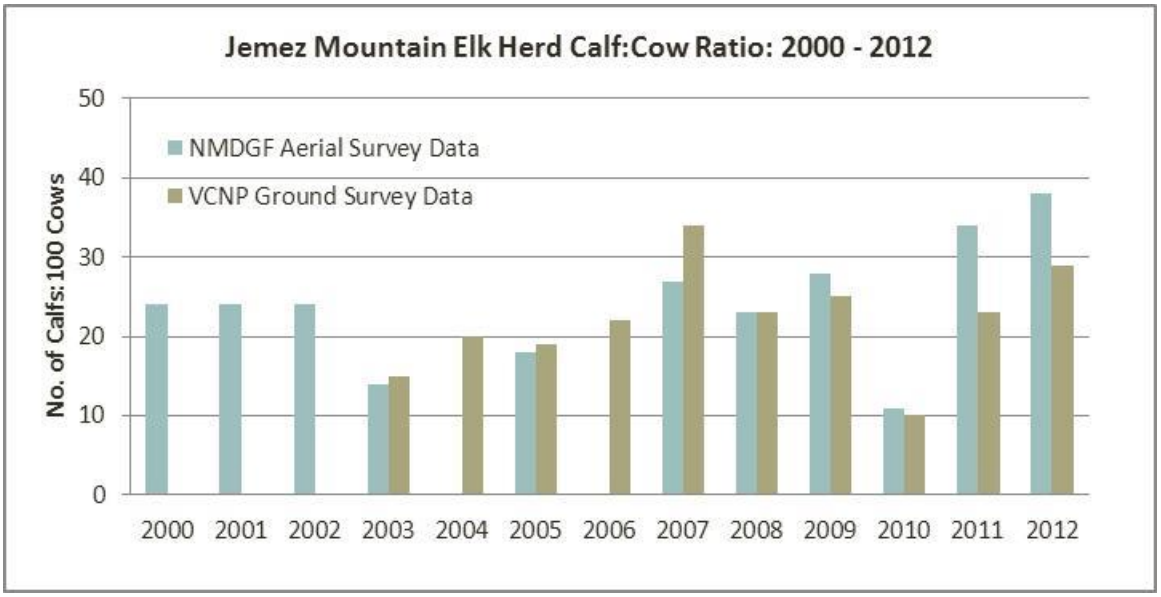


Figure 4-56. Jemez Mountain elk herd calf to cow ratios: 2000 – 2012

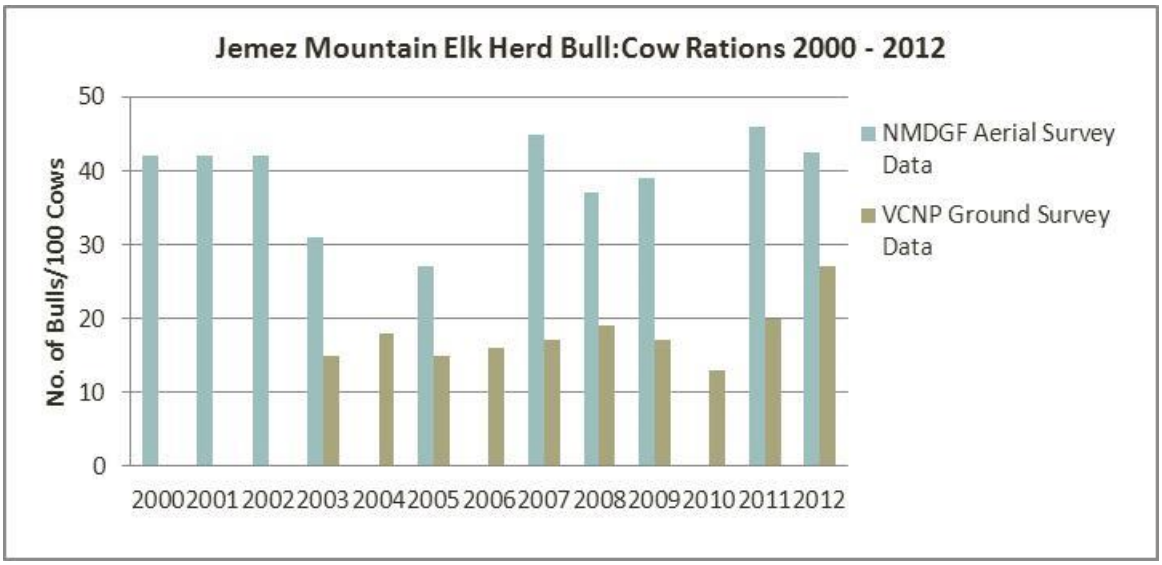


Figure 4-57. Jemez Mountain elk herd; bull to cow ratios: 2000 – 2012

In addition, the size of bull elk antlers is decreasing; antler size is measured using the Safari Club International (SCI) score, which is based on a composite number of length and breadth measurements. The average of these scores appears to oscillate up and down in alternate years, but the 10-year trend is clearly downward (Figure 4-58). However, this is not due to harvesting younger elk each year, as the age structure in the population appears stable (Figure 4-59). Thus, the reason for this trend in antler size is not clear at this time. A recent study has found this trend occurs in a variety of big game species across North America (Monteith, et al., 2013). Through their research, which included eliminating several potential causes, the investigators found moderate support for the intensive harvesting of males as the most likely explanation for the decline.

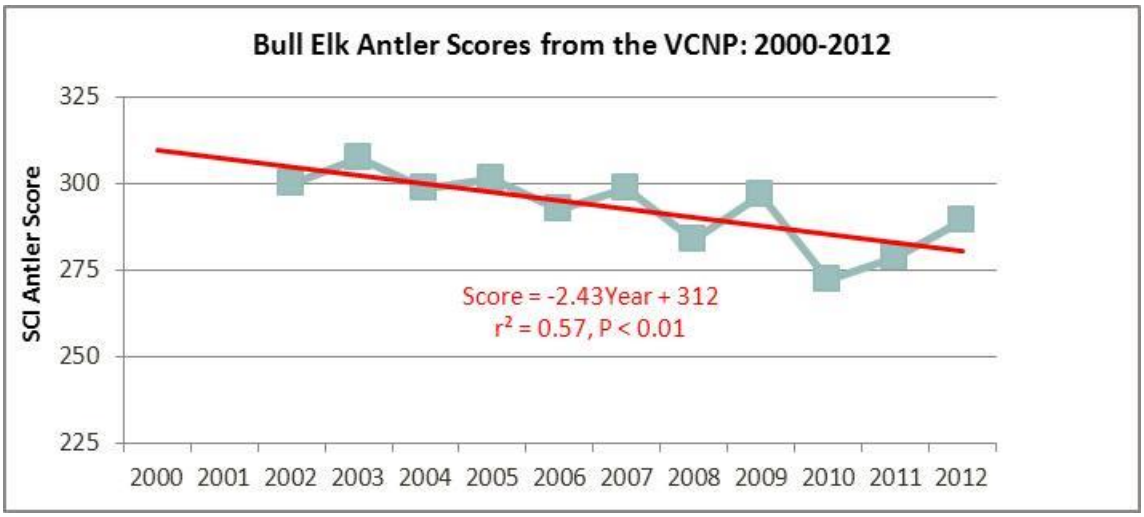


Figure 4-58. Antler scores from bull elk taken on the VCNP: 2000 -2012

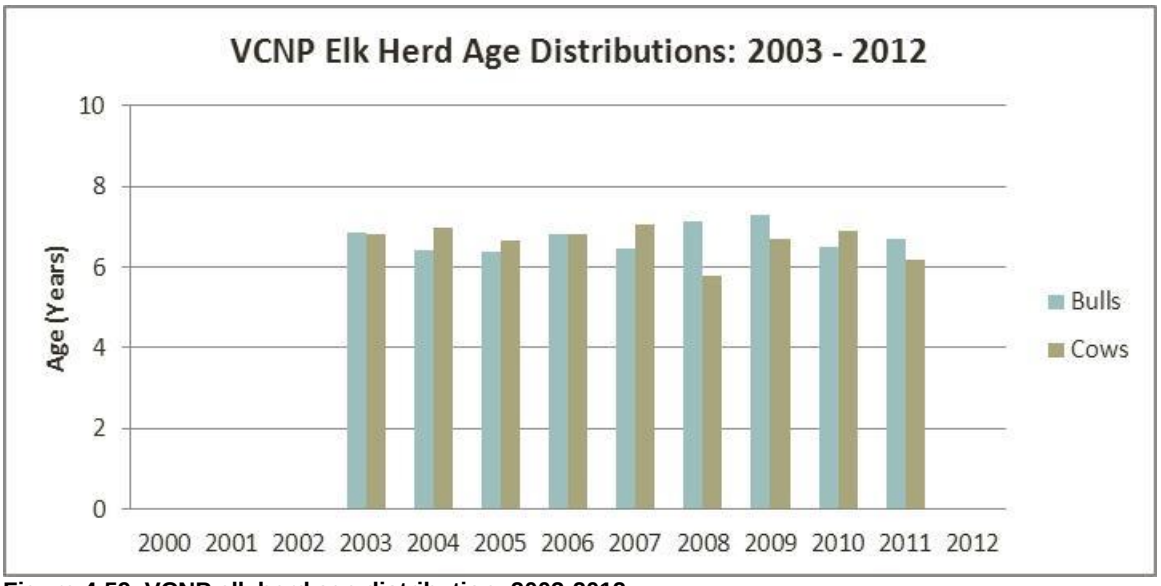


Figure 4-59. VCNP elk herd age distribution: 2003-2012

With respect to the low calf:cow ratios observed on the preserve, studies on the causes of calf mortality have revealed that ~50 percent of the calves born each year (in May and June) die before being recruited into the herd that autumn. This is within the range of mortality values found in other elk herds in the western United States having higher calf:cow ratios. Predators (principally bears, coyotes and mountain lions) capture about the same percentage of calves in the preserve as in other herds. As such, the calf mortality rate does not appear to be the prime driver of low calf:cow ratios, nor does it appear to be shifting the age structure of the herd. This leads to the hypothesis that the root cause of the low calf:cow ratios is related to calf production (pregnancy and parturition), not mortality rates. Tests for diseases that might influence pregnancy and parturition in adult cows have revealed negative results. Future monitoring will be needed to examine pregnancy and parturition rates in the preserve's elk herd, along with more intensive monitoring of the elk population size, movements and habitat use; such studies are currently being undertaken in conjunction with monitoring efforts for the CFLRP project.

4.6.6 Neotropical Migratory Birds

A neotropical migratory bird is a bird that breeds in Canada and the United States during our summer and spends the winter in Mexico, Central America, South America or the Caribbean islands. According to a more strict definition used by some scientists, neotropical migratory birds are Western Hemisphere species in which the majority of individuals breed north of the Tropic of Cancer and winters south of that same latitude. (The Tropic of Cancer is a line of latitude 23 degrees north of the equator, which marks the northern extent of the tropics.) (Smithsonian National Zoological Park, n.d.)

The USFWS identifies 386 species as neotropic migrants (U.S. Fish and Wildlife Service, 2011). The majority are songbirds (such as warblers, thrushes, tanagers, and vireos), but there are also many shorebirds (such as sandpipers, plovers, and terns), some raptors (such as hawks, kites and vultures), and a few types of waterfowl (such as teal) (Smithsonian National Zoological Park, n.d.) Habitats for these species include forest canopies, snags, understories, ground vegetation and structure, existing openings and a wide variety of structural types and successional stages.

Declines in the numbers of many Neotropical migratory bird species have been detected over the past several decades (Smithsonian National Zoological Park, n.d.). When scientists began to decipher the possible reasons for these declines, fingers were pointed at two main causes: 1) fragmentation of breeding habitat, and 2) destruction of tropical forests on the wintering grounds.

More recently, attention has been given to the importance of habitat during the intermediate stage in the annual, three-part life cycle of migratory birds. Migration naturally entails risks and has its costs. The phenomenon has evolved because the benefits have outweighed the costs whether by virtue of greater reproductive success in the insect-rich temperate zone or increased survivorship over the winter in the warm tropics.

Nonetheless, death during migration takes a heavy toll. It is estimated that half of all migrants heading south for the winter will not return to breed in the spring. Predation and bad weather are two natural causes of mortality during migration. Collisions with tall buildings, windows, and other structures; being shot or trapped by hunters; and getting struck by automobiles are a few of the numerous human-made dangers. The continued loss and degradation of stopover habitat, however, is potentially the greatest threat of all (Smithsonian National Zoological Park, n.d.).

The preserve is identified as an Important Bird Area in New Mexico because of the unique mix of grasslands, forested mountains, and geologic features. 104 species breed each summer in the extensive grasslands, forests and wetlands on the preserve. A large group of ornithologists based out of Bandelier National Monument and northern New Mexico (Stephen M. Fettig, Bruce P. Panowski, Lyndi A. Hubbell, Charles D. Hathcock, Bernard Foy, Christopher Rustay, David R. Yeamens, and Terry F. Hodapp) have monitored the bird populations in the Valles Caldera since 2001, using methods developed by the U.S. Fish and Wildlife Service along routes shown in Figure 4-60.

Following the method of the North American Breeding Birds Survey Protocols (BBS) protocols, each route consists of 3-minute observations at each of 50 stops along a 24.5-mile route, along existing open roads within the Valles Caldera. Stops are approximately 0.5 miles apart. During each 3-minute stop, all birds seen or heard are recorded. A route is started between 5:15 and 5:30 a.m. MDT and requires

approximately five hours to complete. In 2001, the eastern BBS route was established within the Valles Caldera followed by the western route in 2002.

The western route has been sampled for eleven years with 67 species encountered more than once for a total of 4,874 individual birds identified. The most commonly detected species based on accumulated relative abundance are violet-green swallow (11.9 percent), warbling vireo (8.7 percent), western tanager (6.1 percent), and American robin (6.0 percent). Species detected only twice include gadwall, Cooper's hawk, golden eagle, American coot, killdeer, olive-sided flycatcher, golden-crowned kinglet, lazuli bunting, red-winged blackbird and brown-headed cowbird. Species only identified once include American widgeon, dusky grouse, sharp-shinned hawk, spotted sandpiper, Wilson’s snipe, great horned owl, white-throated swift, black-chinned hummingbird, downy woodpecker, American three-toed woodpecker, dusky flycatcher, northern rough-winged swallow, Lincoln’s sparrow, and Cassin’s finch.

The eastern route shows no clear changes in species abundances during 2002-2012. The western route, however, suggests that a small number of species may be increasing or decreasing.

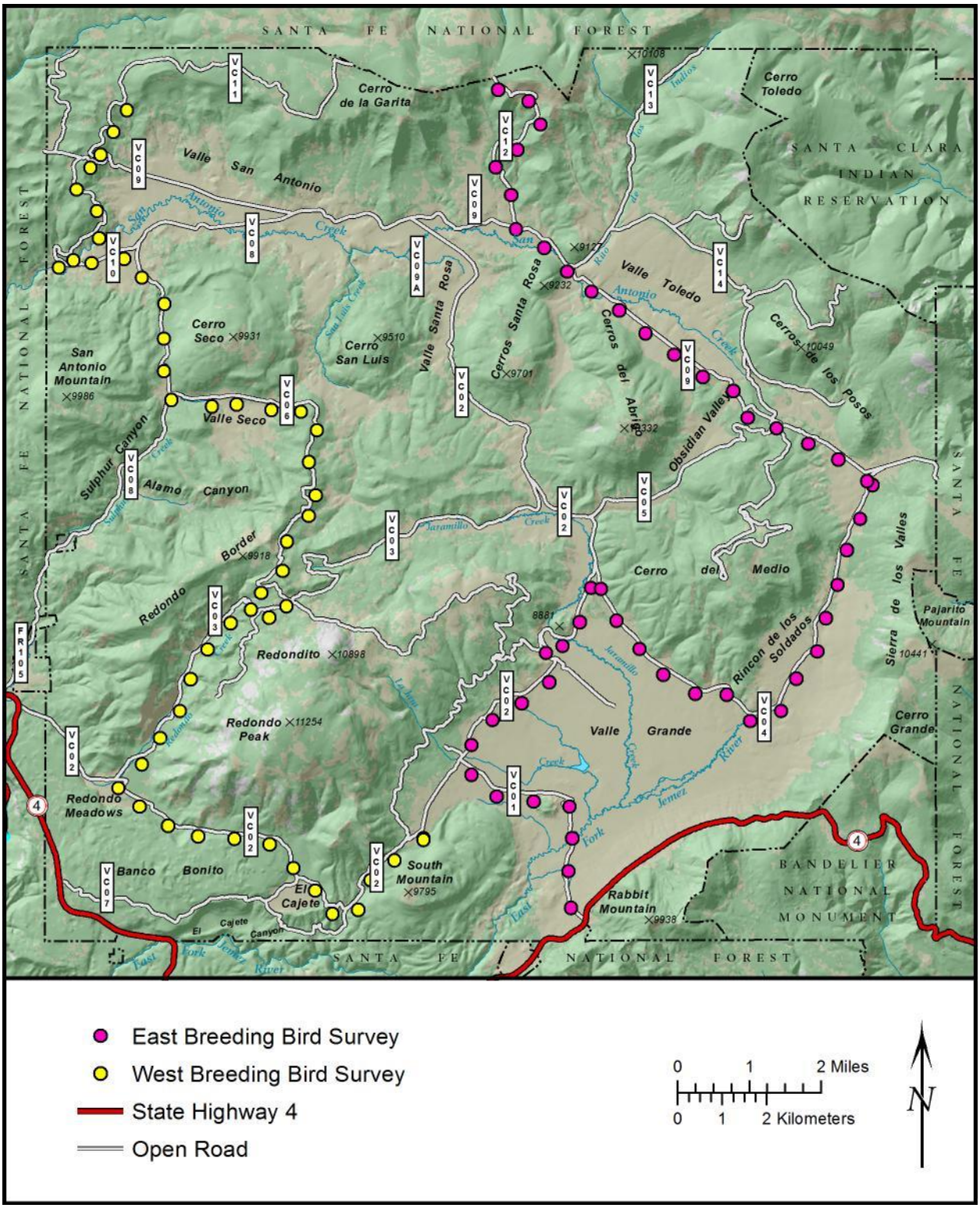


Figure 4-60. Breeding bird survey routes on the VCNP: 2001 – 2012

Observations suggest that Hammond's/dusky flycatcher (Figure 4-61, left) and Plumbeous vireo, orange-crowned and Grace's warblers (Figure 4-61, right) and green-tailed towhee may have increased over the eleven years of observations (Figure 4-62 and Figure 4-63). At the same time, the data suggest that

Steller's jay, American crow, mountain chickadee and red-breasted nuthatch may have experienced declining numbers over the same period (Figure 4-64 and Figure 4-65). Our analysis groups Hammond's and dusky flycatchers because separating those species can be challenging.

Figure 4-61. Hammond's flycatcher (left) and Grace's warbler (right) are two species that may have increased over the 11-year survey period

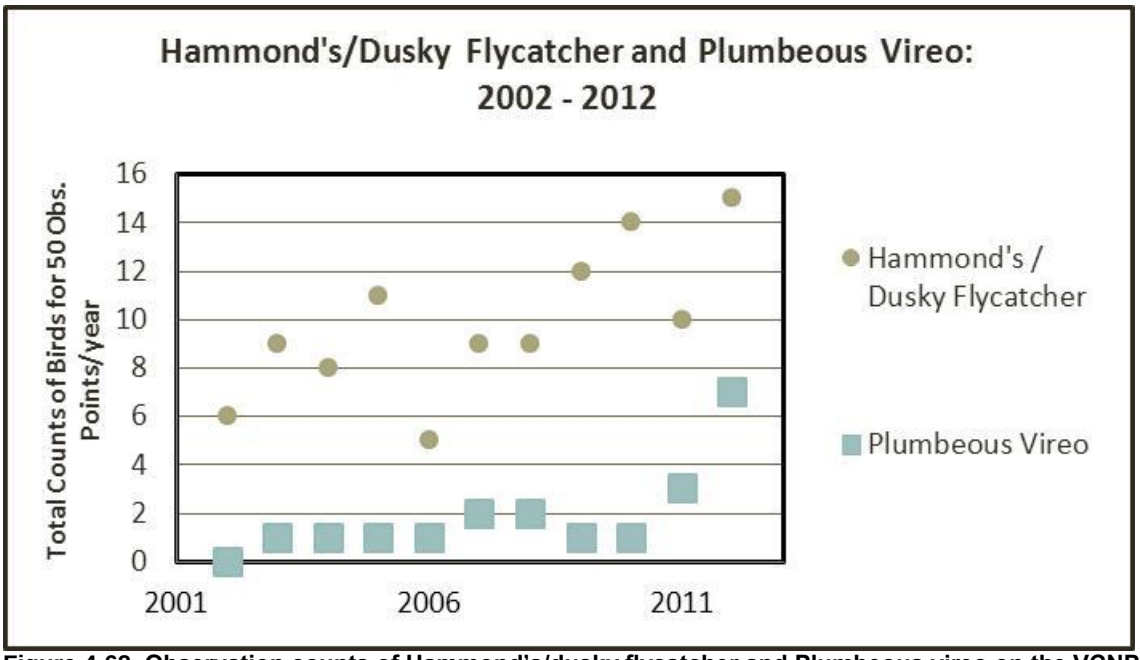


Figure 4-62. Observation counts of Hammond's/dusky flycatcher and Plumbeous vireo on the VCNP: 2001 – 2013

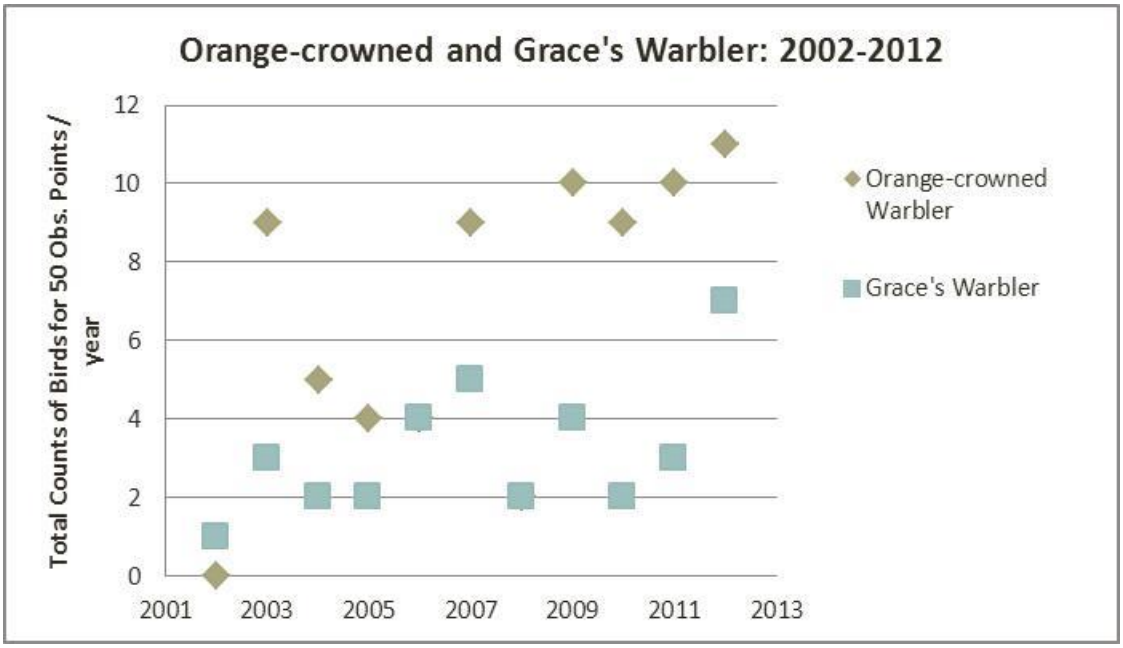


Figure 4-63. Observational counts of orange-crowned warbler and Grace's warbler on the VCNP: 2002 – 2012

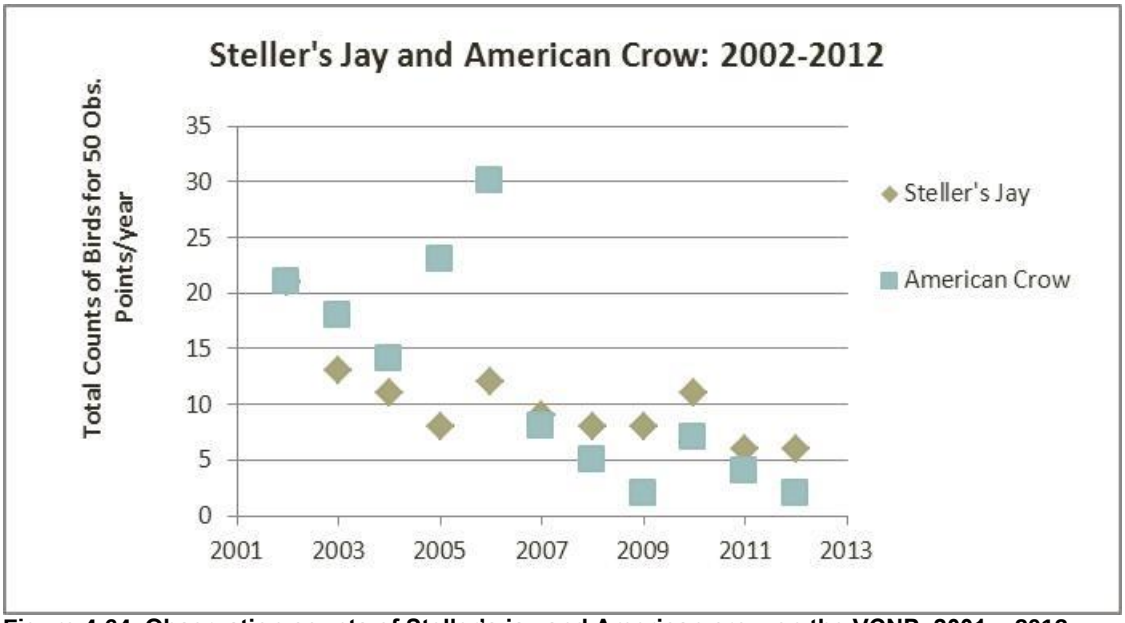


Figure 4-64. Observation counts of Steller's jay and American crow on the VCNP: 2001 – 2013

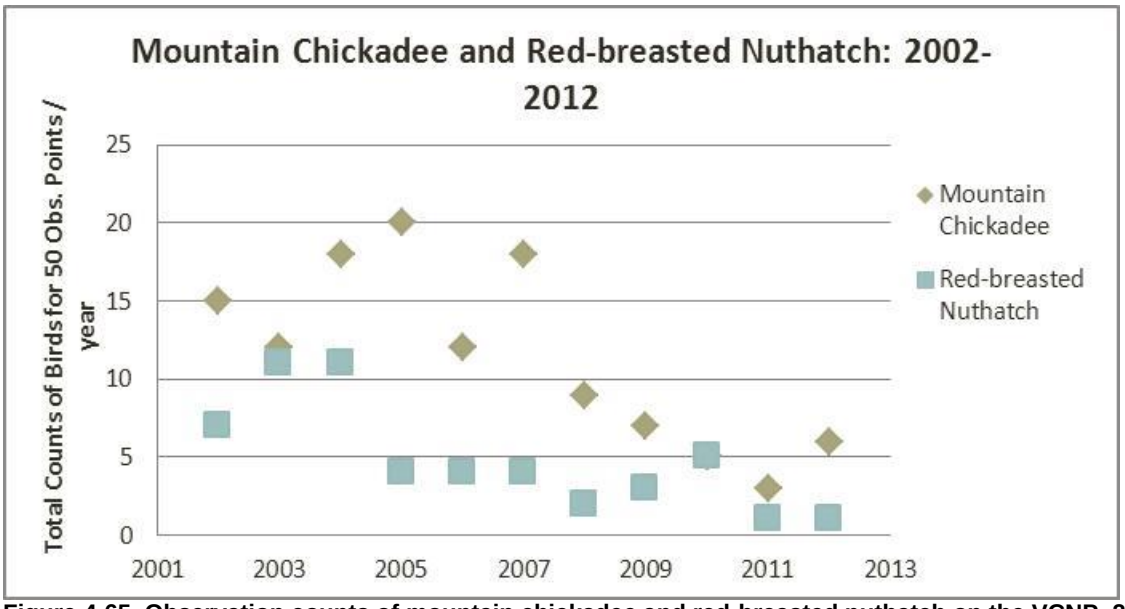


Figure 4-65. Observation counts of mountain chickadee and red-breasted nuthatch on the VCNP: 2002-2012

Overall, the number of bird species observed during 2001-2012 appears to have reached a maximum during the 2002-2004 period, and has been slowly decreasing during 2006-2012 (Figure 4-66). Data from BBS routes provide little if any information on the cause of changes in bird populations. To learn about the causal relationship between environmental factors and bird population numbers, techniques other than point counts must be used.

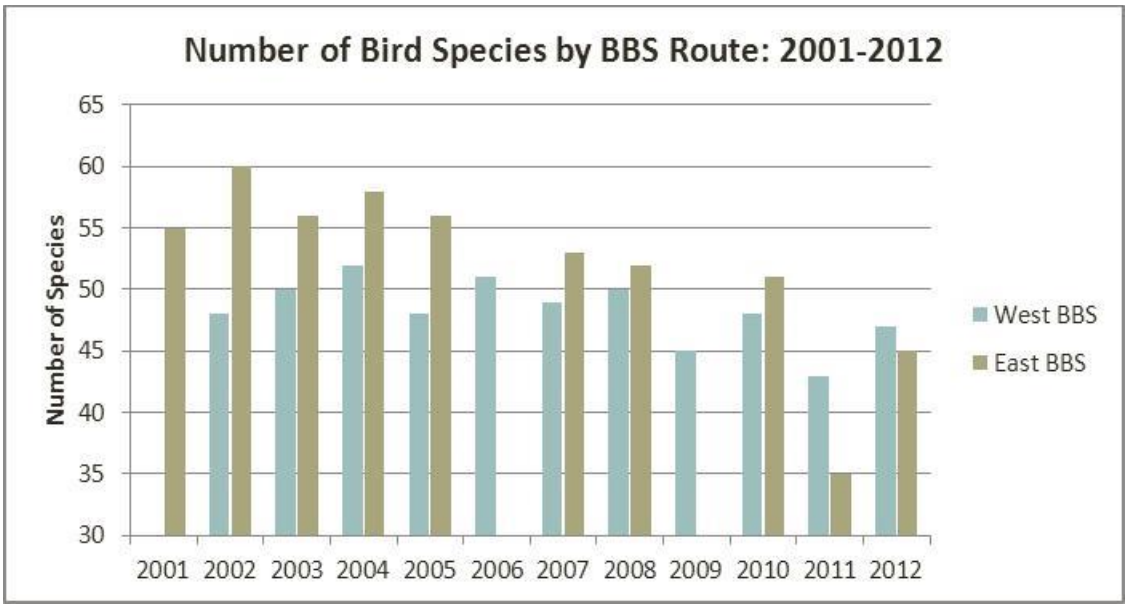


Figure 4-66. Number of bird species by breeding bird survey routes on the VCNP: 2001 – 2012

To adequately evaluate the health of bird populations, monitoring efforts need to focus on demographic information (Noon and Sauer, 1992 as cited by DeSante, et al., 2005). Sometimes this information is also called vital rates. This kind of monitoring measures life-history rates of a population, such as the number

of young produced per adult each year, the probability of a young bird surviving to its first breeding season, the probability that a surviving young bird will breed, the number of adults that survive each year, the probability that a surviving adult will return to the same site to breed the next year, and the probability that a surviving adult from a different site will immigrate to the study area. There are several reasons that these rates provide the information needed for management of bird populations.

First, while environmental conditions and management actions act directly on vital rates, they act only indirectly on population size or density (DeSante and Rosenberg, 1998) as cited by (DeSante, et al., 2005). The indirect relationship between environment conditions and population size decreases our ability interpret causation unless vital rates are examined. The indirect relationship between environmental conditions and population size can best be seen in the lag times.

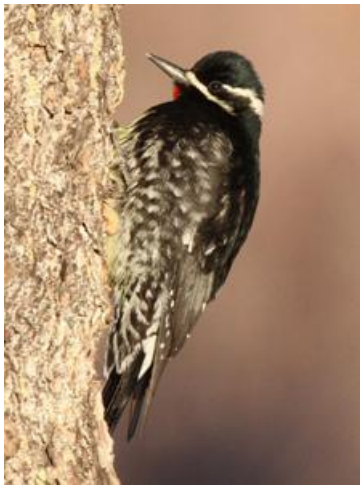


Figure 4-67. William's sapsucker (photo: S. Fettig)

Population change often has a relatively long lag time after a vital rate is affected, while environment change often affects a vital rate immediately or with small lag time (Temple and Wiens, 1989). Second, monitoring of vital rates allows a better understanding of climate effects on reproduction than with monitoring populations. This is because reproduction can show relatively high variability as a function of annual weather patterns (DeSante and O'Grady, 2000). Third, vital rates provide a clear measure of habitat quality without confounding effects such as population sources and sinks (Horne, 1983) or misleading habitat quality information based on relative abundance or population size (Pulliam, 1988). Fourth, monitoring demographic parameters or vital rates provides key information on what is controlling bird populations. Vital rates provide information on when and where in a bird's life cycle there may be problems. Without monitoring of vital rates, a clear understanding of the relationship between environmental conditions and population trends cannot be achieved.

In 2008, a constant-effort bird banding station approximately 0.5 mi (0.8 km) west of the ranch headquarters was established. To focus on breeding birds, this station has operated in July for 4-10 days during each of five years using 16 standard mist-nets. The project has banded 1,010 birds of 38 species, with just over 3,060 net-hours of effort. The four most numerous species by relative abundance have been Audubon's Warbler (18.0 percent) Gray-headed Junco (13.1 percent), Chipping Sparrow (9.7 percent), and House Wren (7.5 percent).

One of the most interesting findings is the relatively large number of Williamson's Sapsucker (6.1 percent) banded at the station, 62 over five years. Williamson's Sapsucker (Figure 4-67) was listed as a Species of Conservation Concern by US Fish and Wildlife Service in 2002. In 2005, it was listed as a priority species within the Jemez Mountains by the Intermountain West Joint Venture. The New Mexico Wildlife Conservation Strategy (2008) lists Williamson's Sapsucker as a Species of Greatest Conservation Need, ranking it vulnerable at both the state and national level. This is a cavity nesting-species that could be negatively impacted by changes to the abundance of aspen and other large-diameter trees suitable for nesting cavities within upper-elevation forests. Thus, decreases to the number and size of large-diameter trees suitable for nesting cavities could impact the species locally.

Table 4-24. Summary of BBS on VCNP: 2008 – 2012

	2008	2009	2010	2011	2012	Cumulative
Birds per net hours	0.41	0.34	0.26	0.29	0.41	0.33
Total net hours	329.50	347.12	989.51	581.86	814.23	3062.22
Total species banded	22	18	26	23	31	38
Total new birds banded	134	117	260	168	331	1010

Table 4-25. Detail of BBS on the VCNP: 2008 – 2012

Species	2008	2009	2010	2011	2012	Cumulative (2008-2012)	Cumulative Relative Abundance
Sharp-shinned Hawk			1			1	0.10%
American Kestrel	1					1	0.10%
Williamson's Sapsucker	6	6	14	17	19	62	6.14%
Red-naped Sapsucker				3	1	4	0.40%
Downy Woodpecker			2		1	3	0.30%
Hairy Woodpecker	2	1	2		3	8	0.79%
Northern Flicker Intergrade					2	2	0.20%
Red-shafted Flicker	3	2	2	3	5	15	1.49%
Western Wood-Pewee	2	2	16	5	11	36	3.56%
Hammond's Flycatcher		1	8	5	7	21	2.08%
Cordilleran Flycatcher					4	4	0.40%
Plumbeous Vireo	1				1	2	0.20%
Warbling Vireo	1		8	2	7	18	1.78%
Steller's Jay					3	3	0.30%
Violet-green Swallow			5			5	0.50%
Mountain Chickadee		1		1	5	7	0.69%
White-breasted Nuthatch	3	3	4	3	9	22	2.18%
Pygmy Nuthatch		8		5	14	27	2.67%
Brown Creeper	6	8	1		15	30	2.97%
House Wren	1	5	34	12	24	76	7.52%
Ruby-crowned Kinglet	2		4	3	6	15	1.49%
Western Bluebird	9	14	15	18	12	68	6.73%
Townsend's Solitaire				3	2	5	0.50%
Hermit Thrush	1		5	2	6	14	1.39%
American Robin	10	7	14	3	19	53	5.25%
Orange-crowned Warbler			2		1	3	0.30%
Virginia's Warbler			1		3	4	0.40%
Audubon's Warbler	51	41	47	30	13	182	18.02%
Grace's Warbler		1				1	0.10%
Green-tailed Towhee	2	2	8	3	13	28	2.77%
Chipping Sparrow	7	4	31	26	30	98	9.70%
Lincoln's Sparrow			1			1	0.10%
Gray-headed Junco	10	10	20	4	88	132	13.07%

Species	2008	2009	2010	2011	2012	Cumulative (2008-2012)	Cumulative Relative Abundance
Western Tanager	8	1	11	11	5	36	3.56%
Black-headed Grosbeak	3		1			4	0.40%
Cassin's Finch	2			1	1	4	0.40%
Red Crossbill				1		1	0.10%
Pine Siskin	3		3	7	1	14	1.39%

4.7 Fisheries and Aquatic Habitat

Aquatic habitats of the preserve comprised of fresh water streams and wetlands contain a variety of native fish as well as introduced rainbow and brown trout. These waters used to contain Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*) (Keller, 2009). Stream and fish surveys of the two major streams/rivers, East Fork Jemez River and San Antonio Creek, of the Valles Caldera have been conducted (2001 and 2002) as well as twice yearly fish sampling at permanent monitoring stations in lower, middle, and upper reaches of each stream (2003-2011). These two streams contain a mixture of the following species:

- **Native**: Rio Grande chub (*Gila pandora*), fathead minnow (*Pimephales promelas*), longnose dace (*Rhinicthys cataractae*), and Rio Grande sucker (*Catostomus plebeius*).
- **Non-native**: rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and white sucker (*Catostomus commersoni*) – one individual found.

4.7.1 Aquatic Habitats

Historically the streams and wetlands of the Valles Caldera sustained a native fish assemblage including Rio Grande cutthroat trout. Stream morphology and pattern was significantly altered in the late 1800's with the advent of commercial ranching, timber development, mineral extraction, and geothermal exploration as well as the road building associated with these activities (Anschuetz and Merlan, 2007). Historical accounts referenced in Anschuetz and Merlan (2007) describe the major valley bottoms as marshlands "teeming with trout". Aerial photos from 1935 show, even at that time, that some portions of San Antonio and Jaramillo Creeks, and East Fork Jemez River valleys remained as wetlands with a network of small, narrow, and very sinuous channels, vegetated completely by herbaceous plants. Cover for fish was probably from deeply undercut banks in loamy material and from water depth itself. The relatively deep and narrow water column, with minimal exposure to the sun, probably tempered the already warm waters from volcanic source. Pool quality was likely relatively poor, developing in the main channel, at pressure points in over-developed bends.

East Fork Jemez River

The East Fork of Jemez River (Figure 4-69) provides 21.43 miles of fish habitat; fish are found from this river's mouth to its headwaters. There are four perennial tributaries to the East Fork Jemez River in the preserve, of which only two have official names: La Jara Creek and Jaramillo Creek (USDA - Forest Service, 2002). La Jara Creek is a shallow, high-gradient, cold water stream originating from a spring

(Viera and Kondratieff, 2004). Jaramillo Creek is a narrow, deep stream with temperatures that can exceed 23°C. Ammonia and aluminum within this creek can be found in levels exceeding state water quality standards (Viera and Kondratieff, 2004). Habitat data is not available for the two other unnamed tributaries. Fisheries data is unavailable for any of these tributaries except for Jaramillo Creek. This tributary was sampled using electrofishing techniques in 2007. Six species were collected: brown trout, Rio Grande chub, longnose dace, fathead minnow, rainbow trout, and Rio Grande sucker (Nelson, 2007). Of the individuals sampled, 46 percent were Rio Grande chub; non-native trout made up 12 percent of the overall catch (ibid).

Riparian conditions along the East Fork Jemez River, and its tributary Jaramillo Creek, are improving in the perennial reaches below the spring to the preserve's southern boundary (McWilliams, 2012) according to repeated Proper Functioning Condition (PFC) Surveys (Table 4-26 and Table 4-27). As shown in the tables, the Las Conchas fire had a measurable impact of the functioning condition of the East Fork but not the Jaramillo. In the intermittent reaches above, riparian conditions had not improved and were classified as "functioning–at-risk" (TEAMS Enterprise Unit, 2007) but now appear to be functioning. The Jaramillo continues to improve and all segments appeared to be in a properly functioning condition in 2012 (McWilliams, 2012).

Water quality in the East Jemez was found to exceed turbidity standards to a high degree. Water temperature exceeded standards to some extent on all streams but particularly, in terms of total duration of record, on East Fork Jemez River (Moser, 2009). Moser (2009) speculates that the warm water temperature of the perennial streams of the caldera may be influenced by bedrock source area. Unusually warm temperatures were recorded during field reconnaissance during summer 2009 for high elevation sites with good forest cover. Further, faulting associated with volcanism largely created the stream valleys; warm and mineralized springs occur throughout the preserve drainages.

The 2001 stream inventory by Forest Service (USDA - Forest Service, 2002) found that pool quantity was properly functioning but lacked quality. In this 2002 report The Forest Service biologist indicated pool volume was reduced from accumulated sediment related to bank erosion and upland runoff. Poor quality for trout from a lack of large woody debris (LWD) was also cited, although the open valley forms and moderately low flows for downstream transport suggest large wood may not have been historically available for pool development.

Table 4-26. PFC survey results for East Fork Jemez River, 2000, 2006 and 2012

Segment	2000 PFC determination	2006 PFC determination	2012 PFC Determinations
1	FARn	FARu	FAR d
2	PFC	FARd	PFC
3	NR	NR	FAR u
4a	FARn	FARn	PFC
4b	FARn	PFC	PFC
5	PFC	PFC	PFC
6	FARu	PFC	PFC
7	NF	FARu	PFC
8	PFC	PFC	PFC

PFC = Proper Functioning, NF = Non Functional, NR = Non Riparian, FAR = Functioning at Risk (n = no trend, u=upward trend, d= downward trend)

Table 4-27. PFC survey results for Jaramillo Creek, 2000, 2006, and 2012

Segment	2000 PFC Determination	2006 PFC Determination	2012 PFC Determinations
1	PFC	PFC	PFC
2a	FARu	PFC	PFC
2b	FARu	FARu	PFC
2c	FARu	PFC	PFC
3	PFC	PFC	PFC

PFC = Proper Functioning, NF = Non Functional, NR = Non Riparian, FAR = Functioning at Risk (n = no trend, u=upward trend, d= downward trend)

During the summer of 2011 the Las Conchas fire burned through the preserve. About 30,000 acres, one-third of the preserve, were burned within the preserve and overland flows moved debris into stream channels across the preserve. Organic debris can be seen along the stream banks of the upper reaches (Figure 4-68) and tributaries. Fish populations declined in the upper reaches of this stream as well as in its tributaries. In the middle and lower reaches of the East Fork of the Jemez River fish habitat wasn't as acutely affected by debris flow and nutrient loading as the upper reach.

Figure 4-68. Tributary to the East Fork Jemez River, post-Las Conchas fire

San Antonio Creek

San Antonio Creek provides 30.5 miles of fish habitat (Figure 4-69); fish are present from its mouth to its headwaters (USDA - Forest Service, 2003). This creek has four perennial tributaries: Sulfur Creek, San Luis Creek, Rito de los Indios, and a fourth, unnamed tributary. Sulfur Creek is a naturally acidic creek (pH 2 to 4) that is characterized by sulfur springs and geothermal activity (Viera and Kondratieff, 2004); it is

unlikely this creek is supporting any fish species. Rito de los Indios Creek is a very shallow, first order stream with largely gravel and some coarse sand (Ibid 2004). A fisheries survey conducted in 2007 found two species of fish: brown trout and Rio Grande chub (Nelson and Manickam, 2007). While the abundance of fish found was high, the species diversity was low. This is likely due to predation by brown trout (ibid). Habitat and fisheries data are not available for San Luis Creek or the unnamed tributary.

The main stem San Antonio Creek was likely altered from excessive runoff prior to the large scale logging in the 1960's. Moser (2009) concludes from comparison of 1935 aerial photographs with those from 1996 that gully forms in the caldera had been initiated in the early 20th century, probably by sheep grazing. Sheep use tends to concentrate on upland slopes. The main stem of San Antonio Creek as well as Jaramillo Creek showed massive accumulation of transportable sand and gravels that had widened and straightened the channels. The larger source of the accumulated sediment was probably the eroded banks of the channels themselves

References from oral history in Anscheultz and Merlan (2007) describe the bottoms of the valleys as marshlands, and the trout occurring in the marshlands or streams emanating from marshes. The 1935 photographs show a broad wet bottom still exists in both Jaramillo and San Antonio valleys, with multiple channel traces indicating a much dispersed flow (Moser, 2009). By 1996 these same valley sections have deeply incised single-thread channels. Moser concludes that though single-threaded channel reaches presently show recovery, the pattern itself may represent a large shift from a wetter, dispersed flow environment. In consulting aerial photos, the channelization seemed to occur prior to the industrial logging of the 1960's.

San Antonio Creek and its tributary Rito de los Indios have shown some improvement in riparian conditions according to PFC surveys until the impacts of the Las Conchas fire (Table 4-28 and Table 4-29) (McWilliams, 2012), although water temperature at several locations in San Antonio Creek exceeds Forest Service and New Mexico Environmental Department (NMED) standards for salmonid development. The Forest standards classified San Antonio Creek as not properly functioning for salmonid development at all sites except station 5 located near the headwaters. The NMED standards classified two of the five sites as not properly functioning for water quality (State of New Mexico, 2002). Other water quality factors that were found to be not properly functioning include the pH of the stream was neutral to basic and often exceeds 8.8 and ammonia and aluminum levels can occasionally exceed water quality standards (USDA - Forest Service, 2003). According to the 2002 survey other physical parameters that were not properly functioning included relative sediment content in riffles, the density of LWD, and pool development, and width-to-depth ratio (USDA - Forest Service, 2003).

Table 4-28. PFC survey results for San Antonio Creek, 2000, 2006 and 2012

Segment	2000 PFC determination	2006 PFC determination	2012 PFC Determination
1	PFC	PFC	FAR u
2	PFC	PFC	NF
3	NR	NR	NR
4	PFC	PFC	PFC
5	PFC	PFC	PFC
6a	FARu	FARu	PFC
6b	FARu	PFC	PFC

PFC = Proper Functioning, NF = Non Functional, NR = Non Riparian, FAR = Functioning at Risk (n = no trend, u=upward trend, d= downward trend)

Table 4-29. PFC survey results for Rito de los Indios, 2000, 2006, and 2012

Segment	2000 PFC determination	2006 PFC determination	2012 PFC Determinations
1	PFC	PFC	PFC
2	FARn	PFC	NF
2b	PFC	PFC	FAR n
3	PFC	PFC	PFC

PFC = Proper Functioning, NF = Non Functional, NR = Non Riparian, FAR = Functioning at Risk (n = no trend, u=upward trend, d= downward trend)

The Las Conchas fire burned through the Valles Caldera during the summer of 2011. This fire burned about 30,000 acres within the preserve; about 1/3 of the total preserve was burned. The fire burned primarily with low severity through the grassland and moderate to high severity through the forests. High severity burning on erosive soils in the forest leads to erosion as described under the previous sections on soils and hydrology. An isolated rain event on July 29, 2011 caused debris flows in San Antonio Creek and Rios de los Indios. These debris flows caused an increase in all measured solid and nutrient components of streamwater (Table 4-30).

Almost all fish in the headwaters of San Antonio Creek were killed during the debris flow; likely by the spike in ammonia (Parmenter pers. comm. 2011). Fish persist in the lower reaches of San Antonio creek. We observed a thick layer of organic debris was observed along the banks of San Antonio Creek during a field visit in October 2011 as well as low water clarity in the upper reaches. However, despite impressive depths of flow indicated by the debris line there was virtually no scour in the main channels, and little silt was retained.

Table 4-30. Stream water components of San Antonio Creek sampled during a normal flow vs. post – Las Conchas fire floodwaters

Streamwater Component	Normal	Floodwater (Post-Las Conchas fire)
Total Suspended Solids (mg/L)	4	10,900
Conductivity (umhos)	72	352
Phosphorus (mg/L)	3	13
Nitrogen (mg/L)	0.3	23
Ammonia (mg/L)	<0.1	1.65

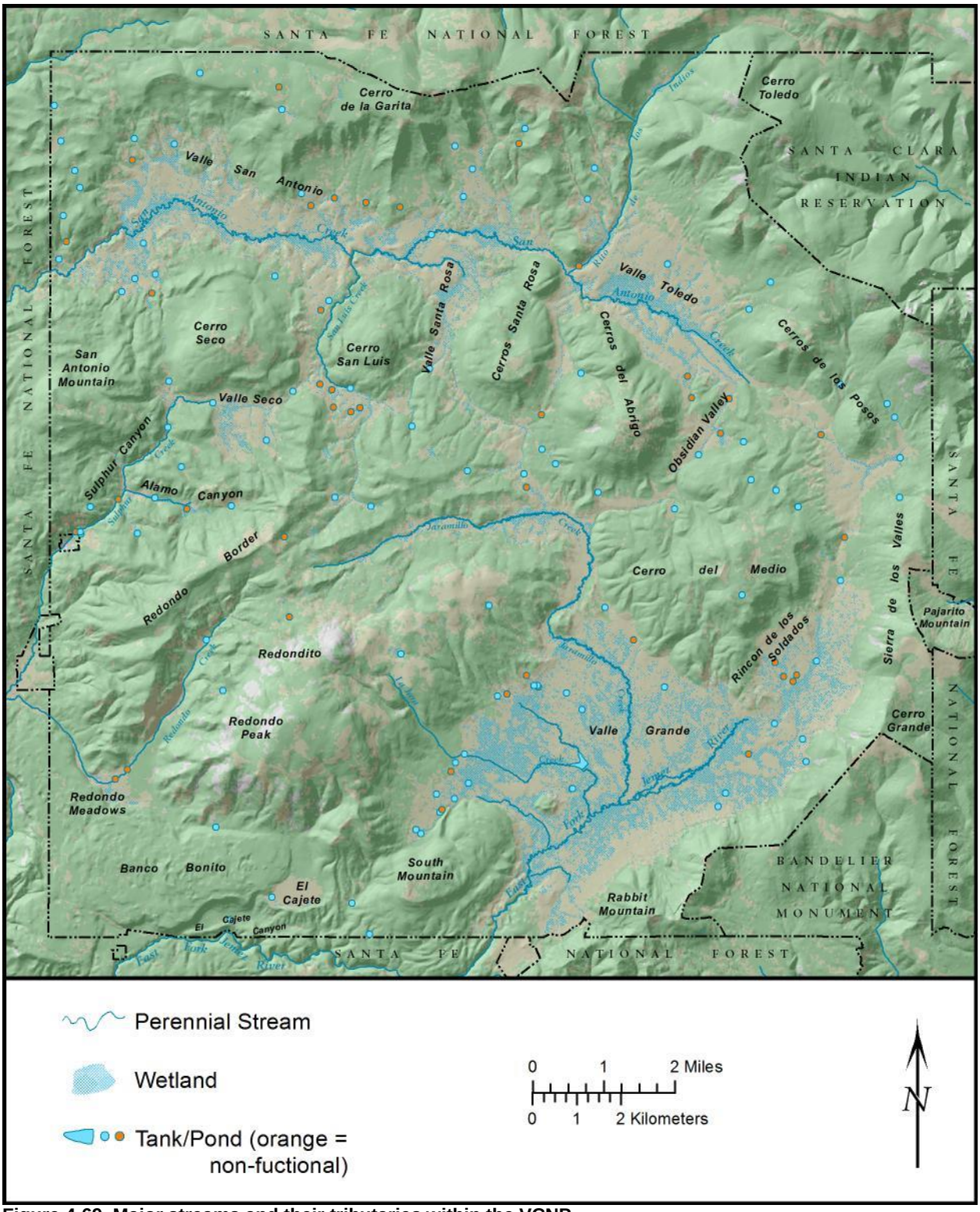


Figure 4-69. Major streams and their tributaries within the VCNP

4.7.2 Special Status Aquatic Species

Threatened, Endangered or Candidate

As shown in Table 4-31 below there are no threatened, endangered or candidate species known to occur on the preserve, however there is potential for the native, Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis),* to occur.

Table 4-31. Threatened, endangered and candidate fish species

Common Name	Scientific Name	Status	Known to Occur?	Potential to Occur?
Rio Grande silvery minnow	*Hybognathus amarus*	Endangered	No	No
Rio Grande cutthroat trout	*Oncorhynchus clarkii virginalis*	Candidate	No	Yes

The Rio Grande silvery minnow with designated critical habitat is listed as "endangered" under the Endangered Species Act (ESA). This species and its critical habitat do not exist within the Valles Caldera. Rio Grande silvery minnow designated critical habitat is found within the Jemez River which the East Fork Jemez River is a tributary of, and this river is found within the preserve but the mainstem of the Jemez River is outside the scope of this existing condition analysis. The Rio Grande cutthroat trout is a candidate species for listing under the ESA. It is also a regional forest sensitive species and is discussed with the other forest sensitive species.

Sensitive Species

The streams within the Valles Caldera contain two species listed on the USDA – Forest Service Forest Service, Southwestern Region list of sensitive species list: Rio Grande sucker and Rio Grande chub. One other species, Rio Grande cutthroat trout has been extirpated from the preserve, but potential habitat is present (Table 4-32).

Table 4-32. USDA – Forest Service, Southwestern Region, sensitive aquatic species of the VCNP

Common Name	Scientific Name	Known to occur?	Potential to Occur?
Rio Grande sucker	*Catostomus plebeius*	Yes	Yes
Rio Grande chub	*Gila pandora*	Yes	Yes
Rio Grande cutthroat trout	*Oncorhynchus clarkii virginalis*	No	Yes

4.7.3 Native Fish

Reductions in predatory trout populations may have actually created an opportunity for native fish. Native fish, adapted to frequent fires, were not killed by post-fire water quality. Without the presence of the predators, their populations actually increased. As shown in the following series of graphs.

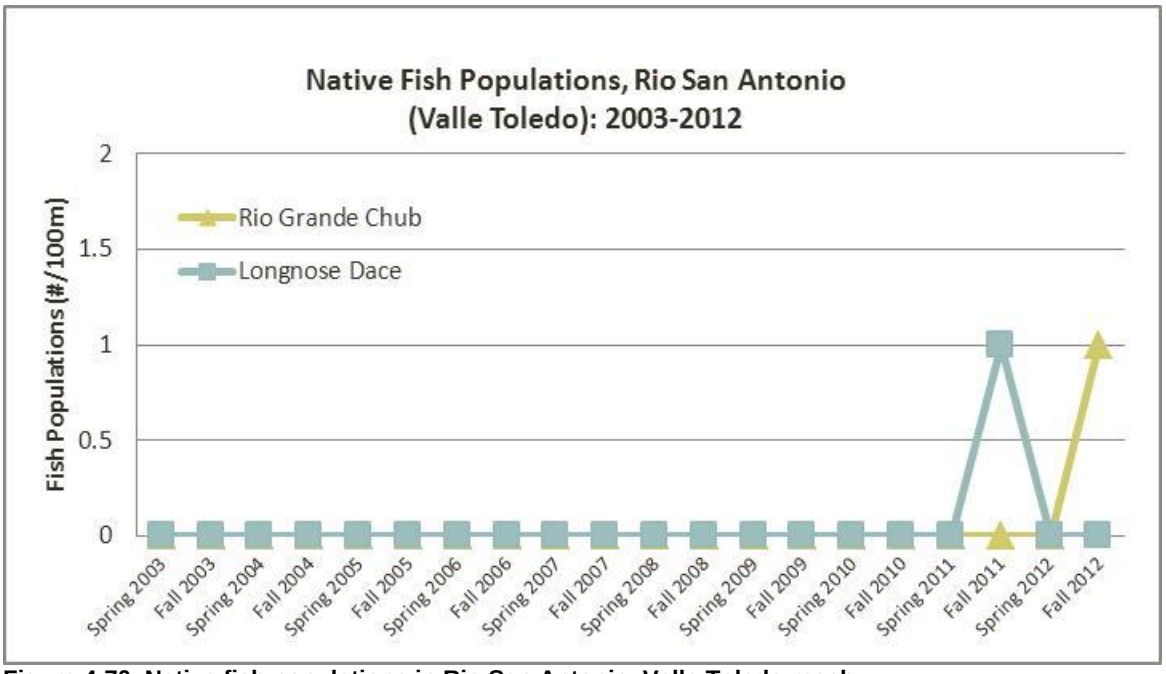


Figure 4-70. Native fish populations in Rio San Antonio, Valle Toledo reach

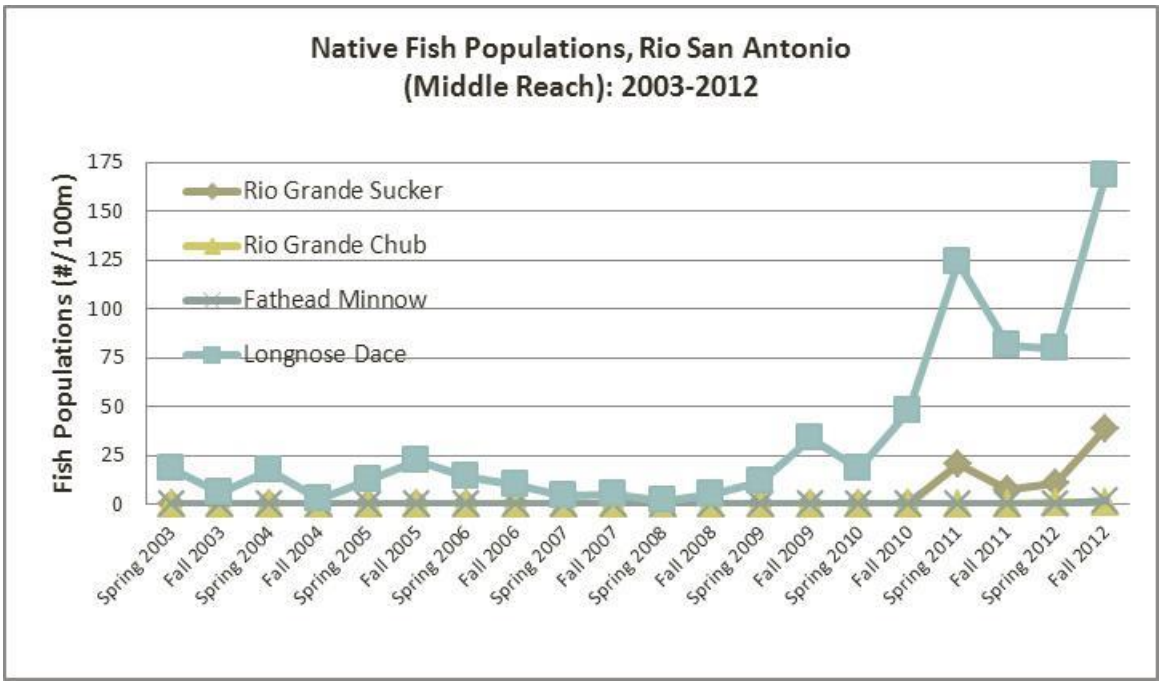


Figure 4-71. Native fish populations in Rio San Antonio, middle reach

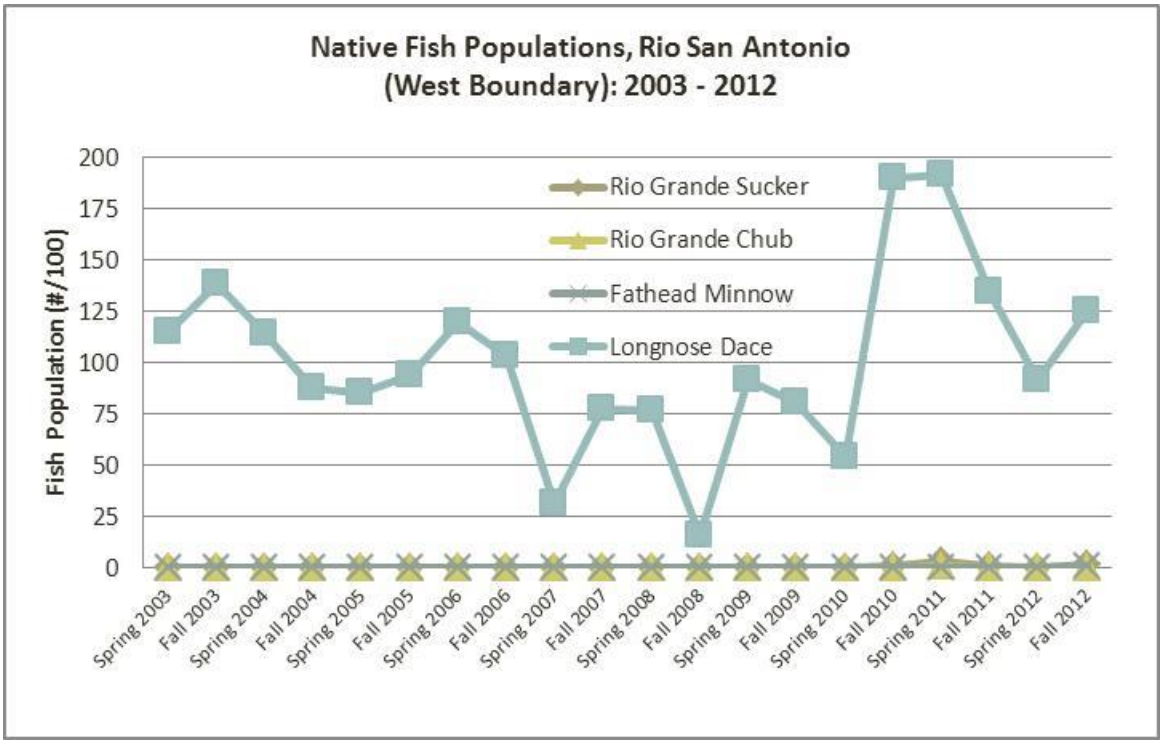


Figure 4-72. Native fish populations in Rio San Antonio, West Boundary reach: 2003 – 2012

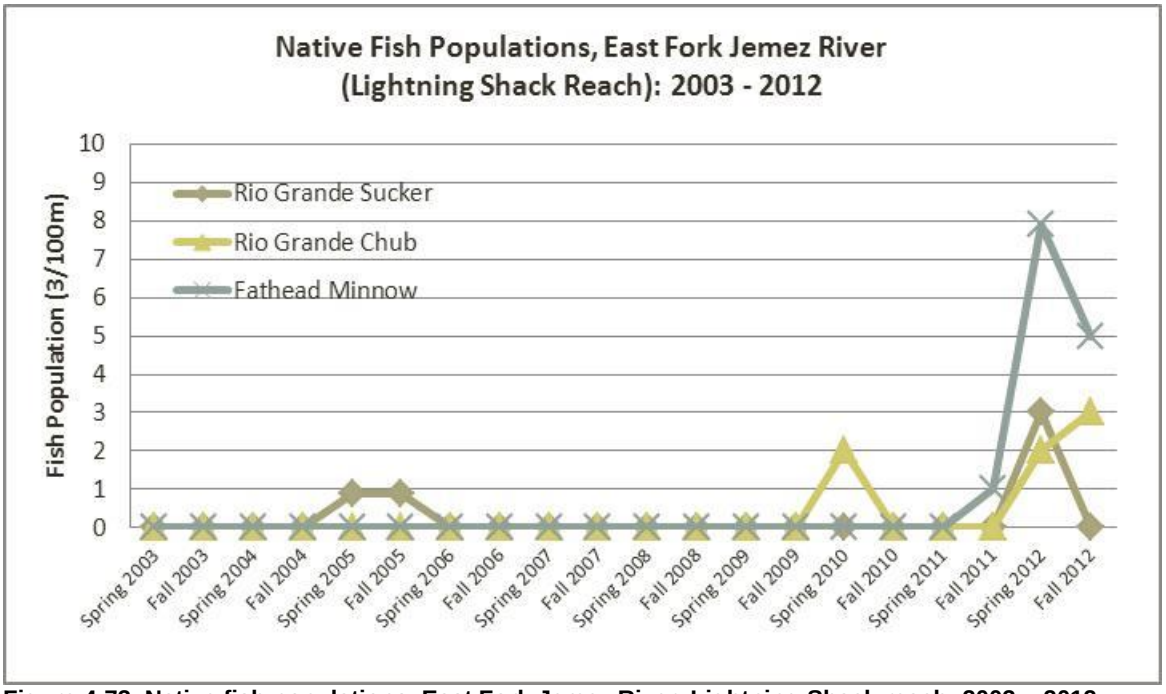


Figure 4-73. Native fish populations, East Fork Jemez River, Lightning Shack reach: 2003 – 2012

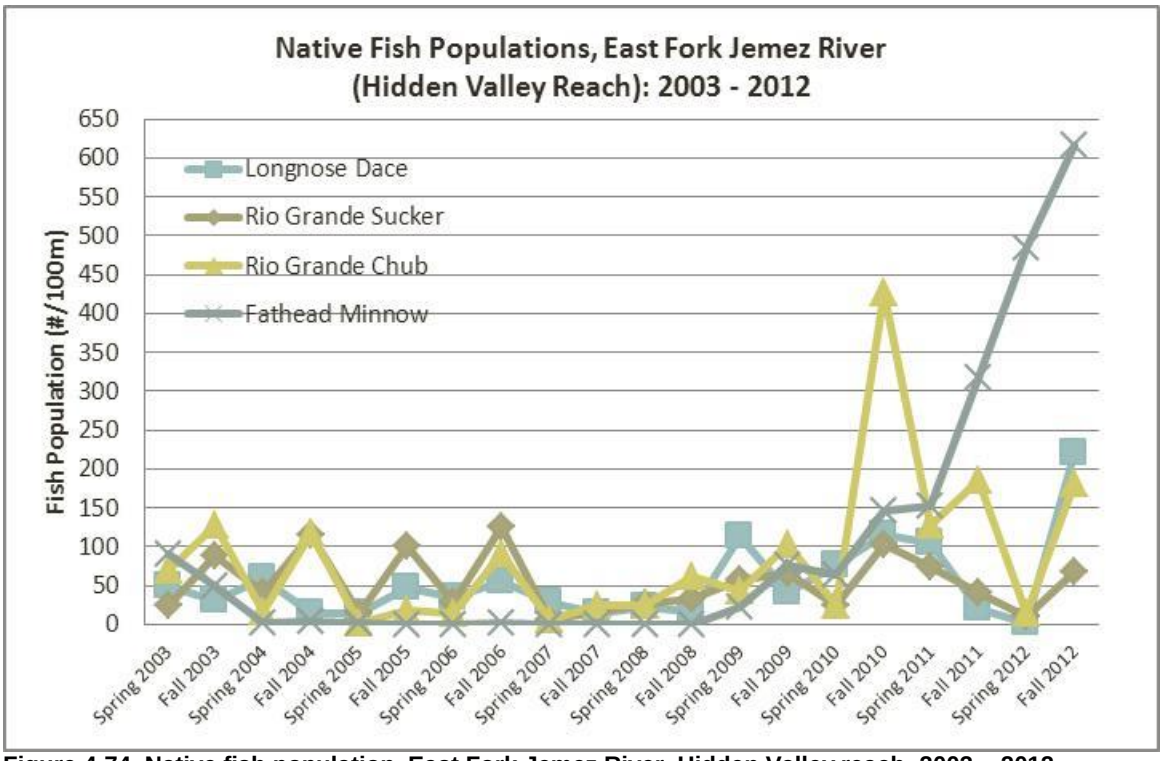


Figure 4-74. Native fish population, East Fork Jemez River, Hidden Valley reach: 2003 – 2012

4.7.4 Trout

The Las Conchas fire inflicted substantial impacts to trout habitats (Figure 4-75 below) on the Valles Caldera. Following the fire in June-July 2011, the beginning of the monsoons in late July 2011 brought flash floods to the upper reaches of the Rio San Antonio (including Indios Creek), Jaramillo Creek and the East Fork Jemez River in the eastern Valle Grande. The water quality during these floods (based on monitoring instrumentation and bulk water samples collected during the floods) was very poor, with high levels of Total Suspended Solids (TSS) and ammonia. The TSS levels from the ash and eroding soils turned the streamwater completely black, and would have stressed the fish, clogging gills and blocking vision.

Figure 4-75. Fish habitat in the Rio San Antonio prior to and following the Las Conchas fire

More importantly, ammonia levels in the streamwater rose from near zero (below detection, <0.01 mg/L) to 1.58 mg/L, which is two- to three-times the lethal level for trout. Ammonia, which is naturally produced in forest and grassland soils through the decomposition of dead plant roots, soil insects, worms, etc., and builds up in post-fire soils until summer monsoon rains leach it into streams, is a toxin to fish, and can kill rapidly by shutting down the kidneys. During the first flash floods in the Rio San Antonio on the preserve, the brown trout population lost approximately 95 percent of the standing crop, or about 35,000 fish (Figure 4-76).

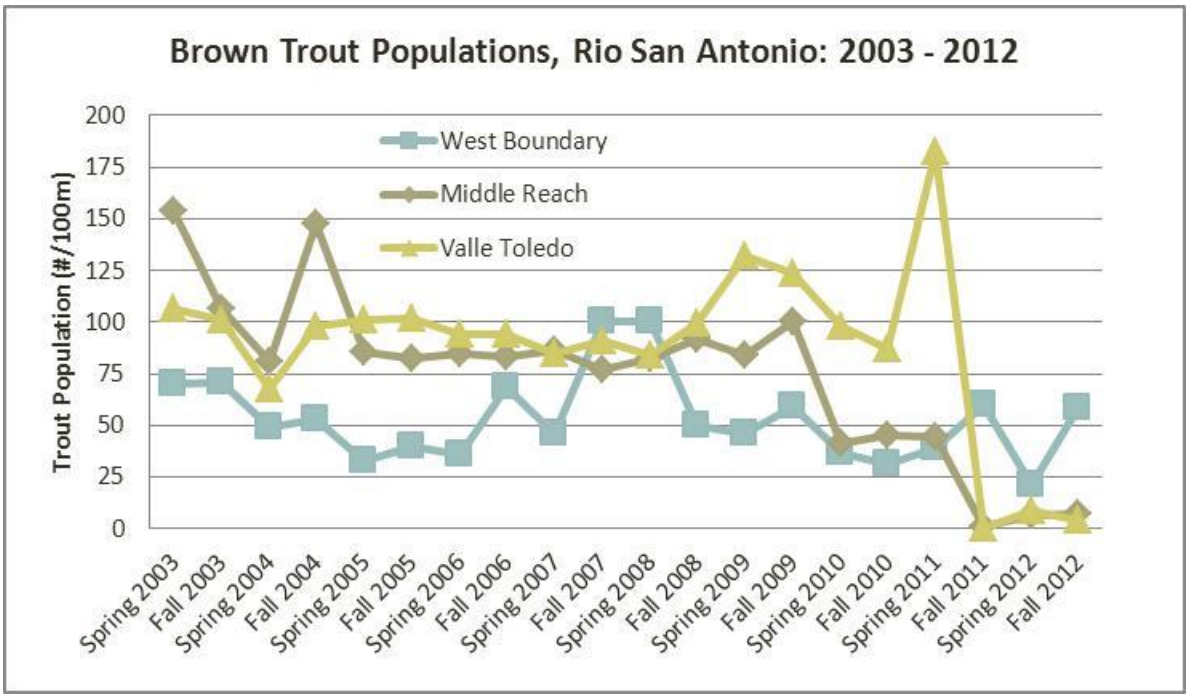


Figure 4-76. Brown trout population, Rio San Antonio: 2003 – 2012

Similar percentage losses of brown trout and rainbow trout occurred in the eastern East Fork Jemez River during summer 2011 (Figure 4-78) however, not all areas of the Rio San Antonio and East Fork Jemez River were affected by the floods; stream reaches on the western edge of the preserve did not

sustain significant losses of trout, and some fishing program activities were able to continue in these areas. Trout populations began to recover in the eastern Valle Grande (Lightning Shack area of the East Fork Jemez River) during 2012 (Figure 4-79), but thick mats of algae growing in the stream (Figure 4-77 precluded good fishing conditions (this algae growth was likely the result of the nutrients, such as phosphate and nitrogen, carried into the stream by the floodwaters).

Figure 4-77. East Fork Jemez River, middle reach (Lightning Shack), post-Las Conchas fire: October 2011

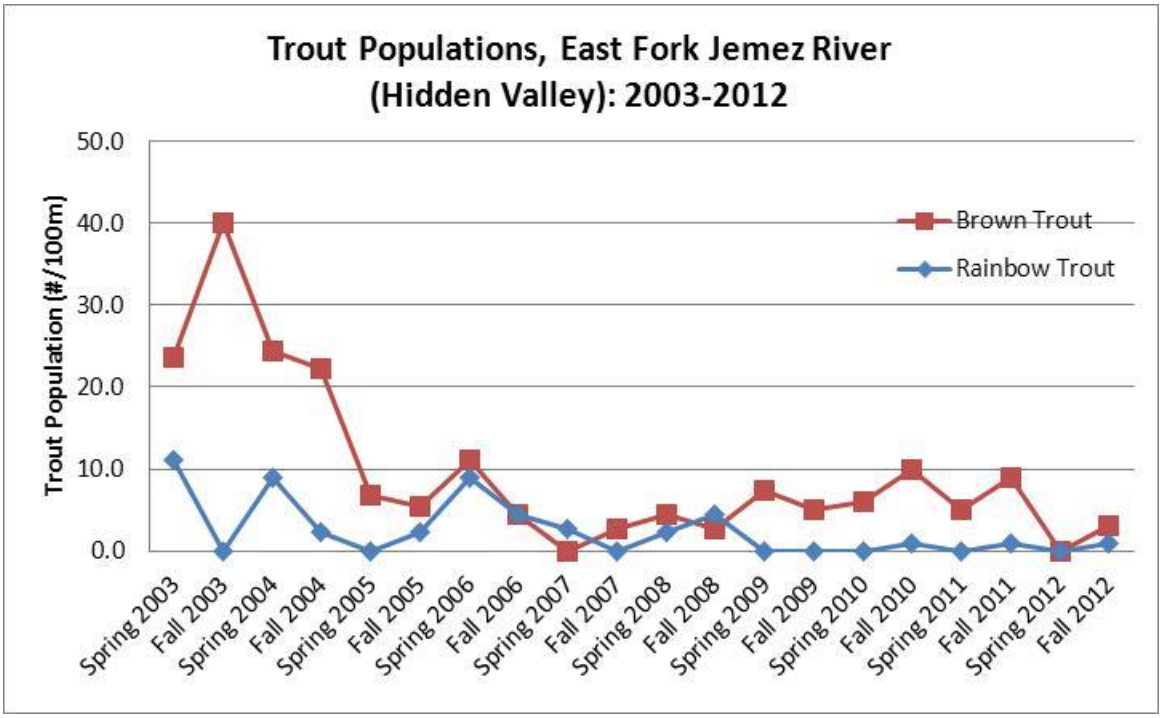


Figure 4-78. Trout populations East Fork Jemez River (Hidden Valley): 2003 – 2012

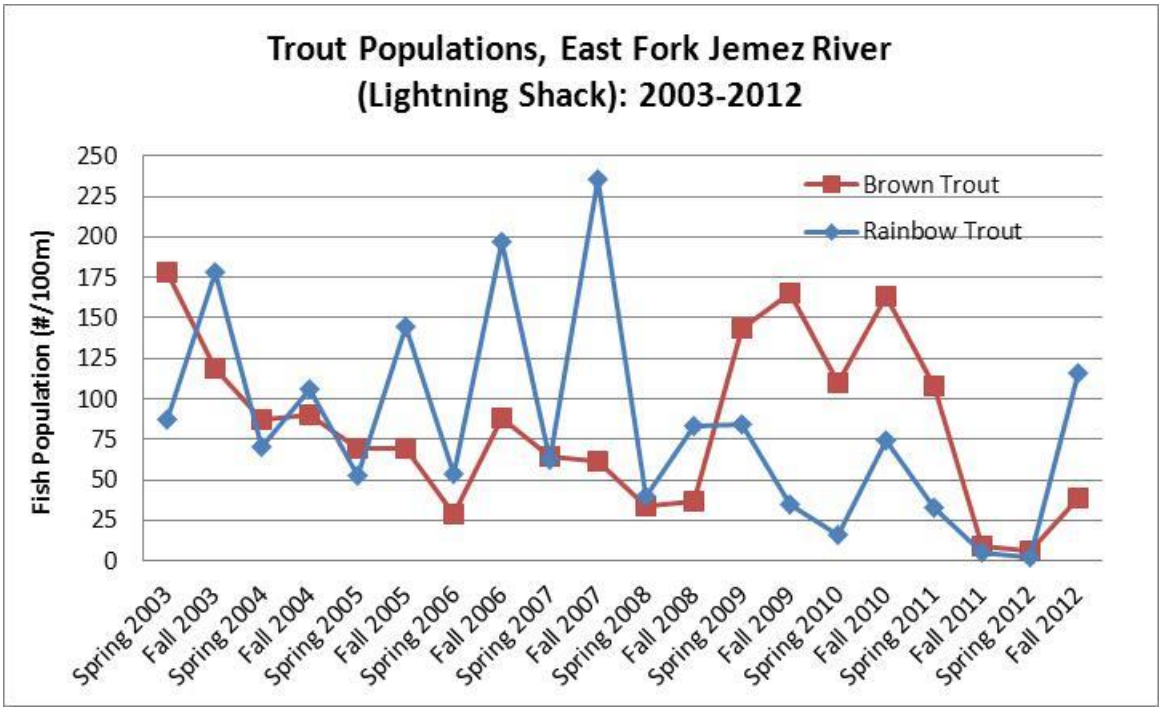


Figure 4-79. Trout populations East Fork Jemez River, middle reach (Lightning Shack): 2003 – 2012

4.8 Cultural Resources

The Trust uses a multidisciplinary landscape approach to cultural resource management that integrates scientific and cultural values and interpretative potential with recreation, resource use, conservation and

public concerns. Through on-the-ground inventories we are developing information on the nature, distribution and quantity of cultural resources. The information gathered is evaluated in conjunction with data from adjoining federal lands, especially with that of our CFLRP collaborators at the Santa Fe National Forest. This landscape approach will support management of cultural resources within the context of historic and ethnographic themes defined at a landscape scale.

4.8.1 Methods

The primary goals of the Valles Caldera Trust, Cultural Resources Program (VCT CR program) are to learn about changing patterns human land-use in the preserve, and to manage and preserve the ubiquitous cultural resources of the preserve in accordance with the Trust's enabling legislation, strategic plans, and federal laws and regulations. Conducting archaeological fieldwork is the primary means to learn about archaeological and historical resources on the preserve. In order to ensure a consistent approach to the acquisition of archaeological data and thus to facilitate the use of that data for preservation and interpretation, standard field procedures are required.

Since 2004, the VCT-CR program has taken a multi-scalar approach to documenting cultural resources on the Preserve, which begins with the artifact at the smallest scale and graduates to the cultural landscape at the most expansive scale. Using GPS and GIS technology facilitates this approach by providing highly precise spatial control and also enables the creation of standardized datasets. The most important advantages of standardized data are: 1) data can be grouped at multi-scales, which improves our ability to characterize, interpret, and evaluate resources, and 2) data is rapidly acquired and accessed by staff, which supports adaptive management.

During survey, the location of a discovered individual artifact, or small groups of artifacts, is recorded rapidly with high precision in the field using GPS technology. Artifacts are recorded, at least initially, without regard to management designations such as "site" or "isolate." Other cultural resource phenomena, such as features, are recorded in a similar manner. This approach allows for a more complete spatial assessment of surface deposits and cultural resources across large areas and allows consideration of archaeological deposits in a more complete way.

The manner in which we collect field observations is specifically designed to maximize the amount and utility of information required for documenting and evaluating the cultural resources of the preserve. Our approach is equally designed to produce multi-year compiled datasets that are easy to use not only for management purposes, but also for building knowledge about this frontier and to understand changing patterns in human land use for the last 10,000 years.

Locating, describing and ultimately protecting and managing cultural resource (including prehistoric archaeological sites as well as historic structures and features) begins with a pedestrian survey conducted by archaeologists. Surveys are conducted at two intensities. Planning level surveys identify the presence of cultural resources and may be suitable for documentation associated with Section 110 of the National Historic Preservation Act (NHPA), but are not sufficient documentation for compliance with NHPA Section 106. Compliance level surveys identify the presence and absence of cultural resources and satisfy the requirements for both Section 106 and 110. In some circumstances compliance level surveys may include 100 percent coverage, 100 percent coverage excluding slopes great than 30 degrees, or

sample survey (less than 100 percent coverage or documentation of only certain classes of resources). The suitability of surveys with less than 100 percent coverage is determined depending on the activities proposed. All documentation standards and survey procedures used at the preserve are subject to consultation with the New Mexico State Historic Preservation Office.

All cultural resources are assessed to determine if they should be considered sites, per trust procedures, and then whether sites meet the criteria to be considered eligible to the National Register of Historic Places (NRHP). Sites that are NRHP eligible are considered "historic properties" (a term that includes prehistoric archaeological sites as well historic structures and features) under the National Historic Preservation Act (NHPA). Sites that are potentially eligible are also treated as historic properties until NRHP eligibility is resolved. Per NHPA Section 106, the trust is committed to considering the potential effects of proposed actions on these historic properties and, in keeping with the goals of NHPA Section 110, the trust also seeks to compile data and learn from other cultural resources that may not be NRHP eligible. Our multi-scalar data recording and GIS system make this efficient and feasible.

Site Data

To-date compliance level cultural resources survey on the preserve stands at 16 percent. Prior to federal acquisition in 2000, 2,585 acres (2.9 percent) had been surveyed at a planning level. Between 2000 and 2012, 14,300 acres have been surveyed at a compliance level, and an additional 2,850 acres were surveyed at the planning level. Adjusting for overlaps and re-surveys, to date 19 percent of the VCNP (Figure 4-80) has been surveyed for cultural resources at all levels. In recent years we have increased our survey acreage to greater than 2,000 acres per year. At this rate, we can expect to reach 30 percent survey coverage (at the compliance level) by 2018 (Figure 4-81).

Our understanding of the human past of the preserve grows as cultural resources inventory increases. Placing our new knowledge within local and regional contexts enhances this understanding. Over the next several years, as we increase our rate of survey to meet the needs of forest and watershed projects. We will continue to synthesize past human uses of the preserve with patterns of resource use and landscape modification, and continue to place the role of the preserve in the historic and prehistoric patterns in the region and North America.

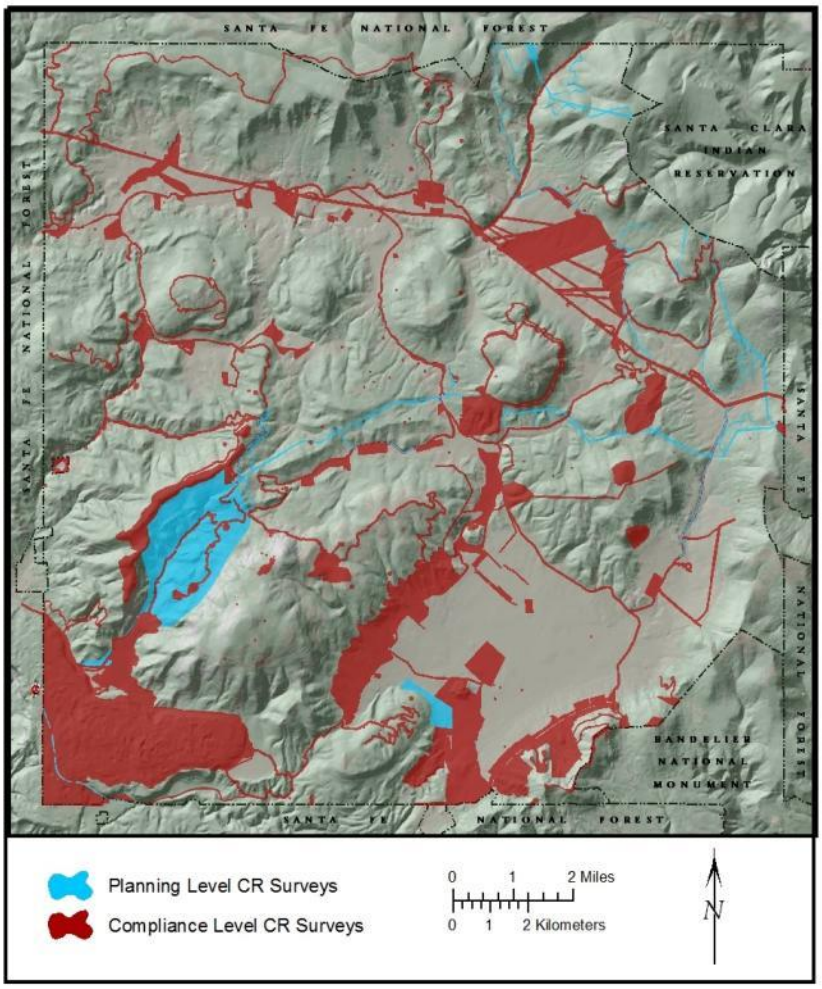


Figure 4-80. Cultural resources surveys completed on the preserve through 2012

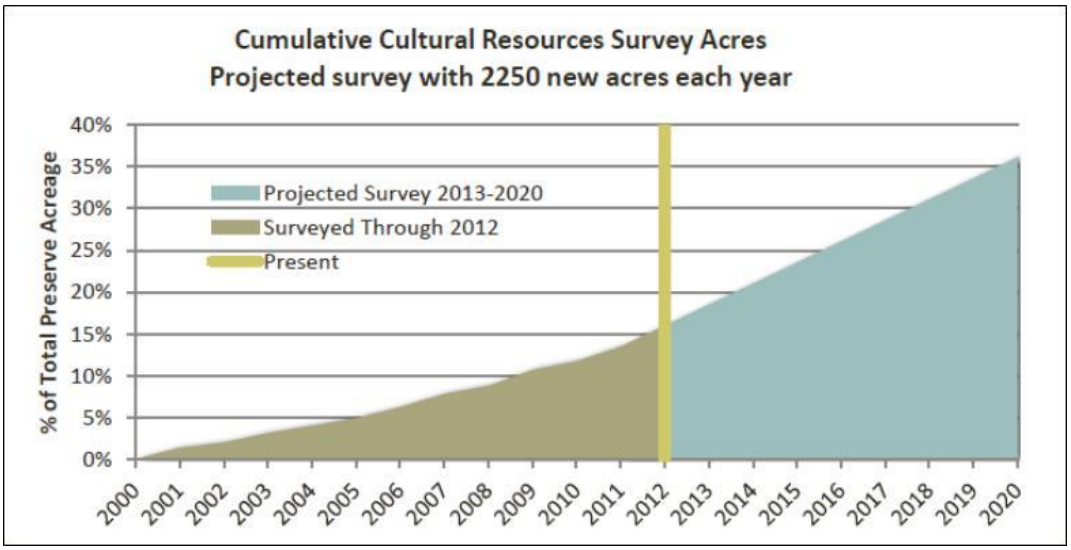


Figure 4-81. Cultural Resources survey acres cumulative since 2000; projected to indicate when 30 percent coverage can be expected assuming a rate of >2,000 acres per year

4.8.2 Prehistoric and Historic Periods

The rich animal, plant and mineral resources of the Valles Caldera have provided materials and food for human use throughout prehistory. The earliest occupation of the Southwest began during the Paleoindian period from over 12,000 to about 7,500 years ago (5500 B.C.). These early sites can be difficult to find because the deposits in which they occur are buried or have eroded over time, or because artifacts from the period are mixed in with those from subsequent human use at the same locations.

Figure 4-82. Deep soils in the Valles Caldera contain valuable information about very early human use of the Southwest

Paleoindian spear points and other flaked stone tools are often are made from high quality lithic materials such as chert and obsidian that have been transported over long distances. The most distinctive of these early diagnostic point types, the finely-made Clovis and Folsom points, have been found as isolated artifacts at a dozen or more locations in and around the Jemez Mountains but not within the preserve. However, a few points known to date to later in the Paleoindian period (e.g., after about 8000 B.C.) have been found in the preserve in recent years confirming use of the preserve by humans in the early Holocene (Steffen, et al., 2009; Pinson, et al., 2009). Paleoindian campsites (as compared to their tools) are even more rare in the Jemez Mountains and none have yet been identified within the preserve. One the most exciting opportunities for archaeological research in the Valles Caldera is locating and documenting the character and distribution of these early sites. Ideal locations for Paleoindian sites are the grasslands and river terraces within broad valles of the caldera, as well as high-elevation saddles and ridges used as prehistoric transportation routes. In contrast to the more arid and eroding landscapes surrounding the preserve, the deep soils within the caldera provide a promising context for the preservation of the earliest archaeological sites (Figure 4-82).

During the Archaic period (5500 B.C. through A.D. 500), the subsistence base for human groups witnessed a shift from hunting of large game animals and gathering of plant resources over wide geographic ranges, toward a focus on harvesting and processing of region-specific plant resources such as seeds and nuts. In essence, Archaic peoples became regional experts in the most sustainable use of available resources, and overall human population throughout the Southwest increased substantially. For the first time, artifact assemblages commonly include ground stone artifacts used in processing of plant resources. Flaked stone artifacts often were made of locally available materials, and dart points become more common than spear points (Figure 4-83). This functional shift from spear points to dart points provides a time-marker for archaeologists, which can be especially useful for dating the pre-ceramic sites of the Paleoindian and Archaic periods. Analysis of diagnostic projectile points at the preserve supports the interpretation of increased human use of the caldera throughout the Archaic Period.

The large number of sites dated to the Middle and Late Archaic is further evidence of increasing human use of the preserve throughout the Archaic. The numerous large and small scatters of stone tools and debris in the caldera represent a range of uses – from locations used briefly to make stone tools or prepare specific resources, such as game or fish; to small, seasonal camps; to expansive sites that were occupied repeatedly over centuries. Excavations in the 1980s and 1990s associated with geothermal and associated power line projects contributed substantially to what is known about the Archaic period in the Jemez Mountains. In all, the caldera is an excellent place to study the Archaic period and Archaic lifeways because even as Ancestral Pueblo populations moved into the Jemez Mountains uplands developing large pueblos in the mesas surrounding the caldera, they continued to use the interior of the caldera in a manner similar to Archaic populations. Even today, human use in the caldera shares many attributes in common with the Archaic period. That is, habitation and use are not year-round due to winter snow-cover, our domestic areas include towns away from this high-altitude environment, outdoor activities are most prevalent, and hunting and fishing are dominant over agricultural activities.

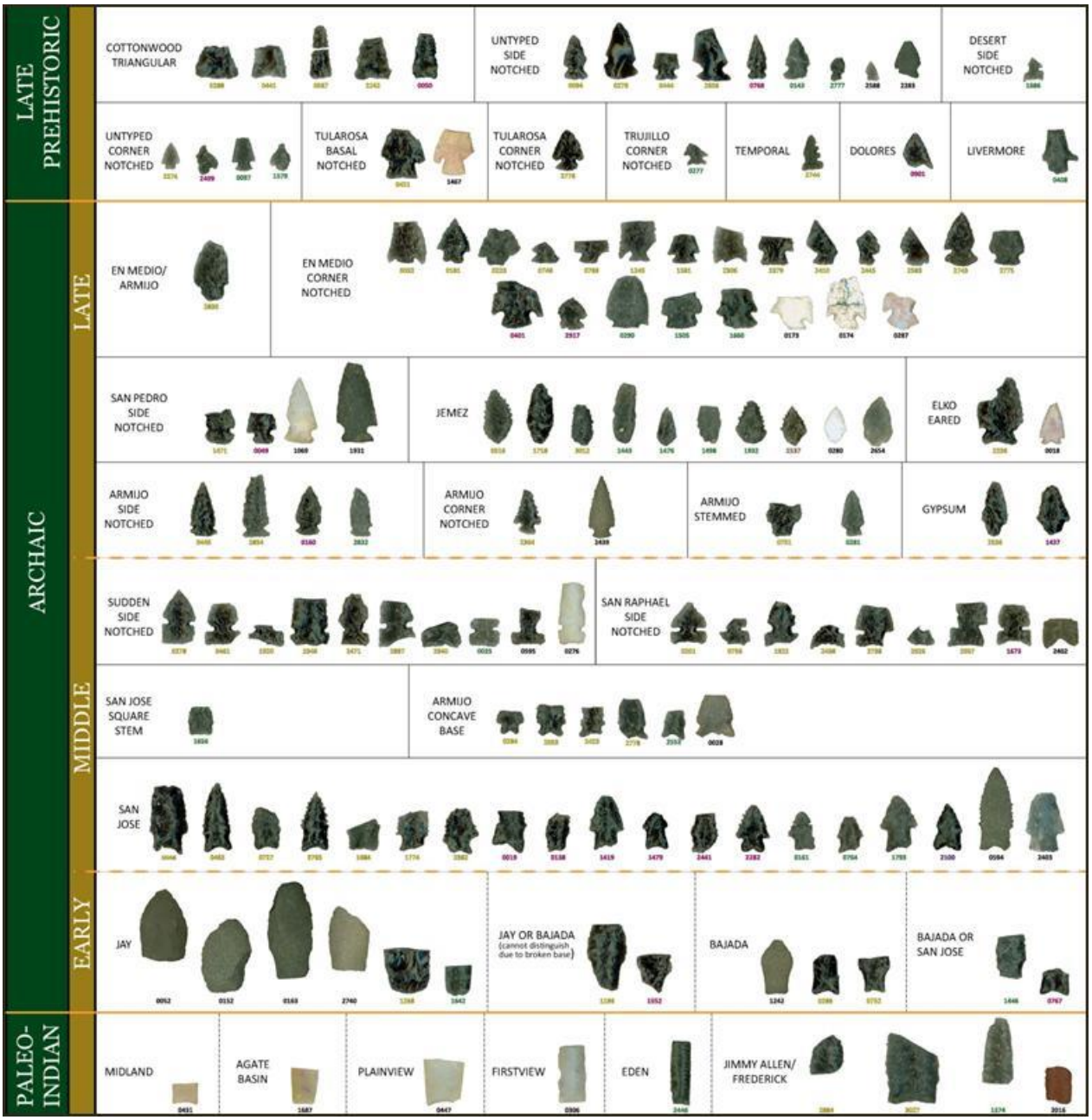


Figure 4-83. Prehistoric spears, darts, and arrows found in the Valles Caldera National Preserve and included in the Diagnostic Projectile Point study. (Decker, et al., 2009)

The most recent prehistoric period is the Ancestral Pueblo period (A.D. 500-1540) which witnessed a shift to a dependence on cultivated plants and horticultural practices that were only beginning to develop toward the end of the Archaic. Pottery first appears after A.D. 500, initially as plain ceramics and then in a diverse range of decorated types, including the black-on-white ceramics common throughout the Jemez Mountains. Small chipped stone points suitable for use on arrows first appear at this time. Ancestral Pueblo peoples also had distinctive house types. After A.D. 1000, a shift to masonry habitation structures appears to coincide with the beginning of agricultural intensification and increased permanence in settlement that continued throughout the period and characterizes the historic pueblos across the Southwest. Small one- and two-room masonry structures known as “fieldhouses,” which are

ubiquitous in the Jemez area and on the Pajarito Plateau, occur on the Banco Bonito in the southwestern part of the preserve (Figure 4-84). The preserve is surrounded by numerous prehistoric, historic, and modern Pueblo communities (i.e., large multi-room settlements, such as at Bandelier National Monument), but there are no known pueblos in the caldera.

Figure 4-84. Fieldhouse on the Banco Bonito

Fieldhouses on Banco Bonito are usually located on ridges or slight rises adjacent to lands suitable for prehistoric farming. Work completed on Banco and the surrounding Jemez Plateau has shown that these fieldhouses most often date to the Paliza Phase of the Classic Period (AD 1325-1425) and most likely represent short durations of seasonal occupation and use. Other agricultural features constructed to maximize farming success such as terraces and grid gardens are also present on the Banco Bonito below 8440 feet (Figure 4-85). Terraces are often constructed with one course of local, unshaped stone and are usually built into the hillslope. Size and shape are variable and scaled to the local topography. These features were likely designed to create microclimates, with moisture and temperature conditions favorable for improving yield. Future investigations will analyze moisture and temperature conditions within features and fields (Stark, et al., 2011) and the sediment, pollen, and phytolith record could be examined to determine exactly which plants were grown and how they were grown.

Figure 4-85. Terrace garden on Banco Bonito

Field house agricultural feature elevations on the Banco within the preserve range from 8000 feet to 8440 feet above mean sea level (Figure 4-86). This is the upper limit for maize agriculture, where the gains in moisture due to orographic uplift outweigh the risk of a shorter growing season. At elevations higher than 8440 feet, the frost-free season is too short to invest energy in growing crops. This is probably why there are no large, multi-room prehistoric pueblo settlements within the caldera like the ones that are common on the Jemez and Pajarito Plateaus (such as in Bandelier National Monument). Certain plant foods may have been cultivated at higher elevations within the caldera, but the types of plants would have been quite different from those that supported Puebloan populations who relied on maize-beans-squash agriculture. Both the fieldhouses and agricultural features on Banco Bonito can help us understand the phenomenon of agricultural intensification by ancestral Pueblo people that occurred during late prehistory, including the adaptation techniques required for farming success within such a marginal, high-altitude environment.

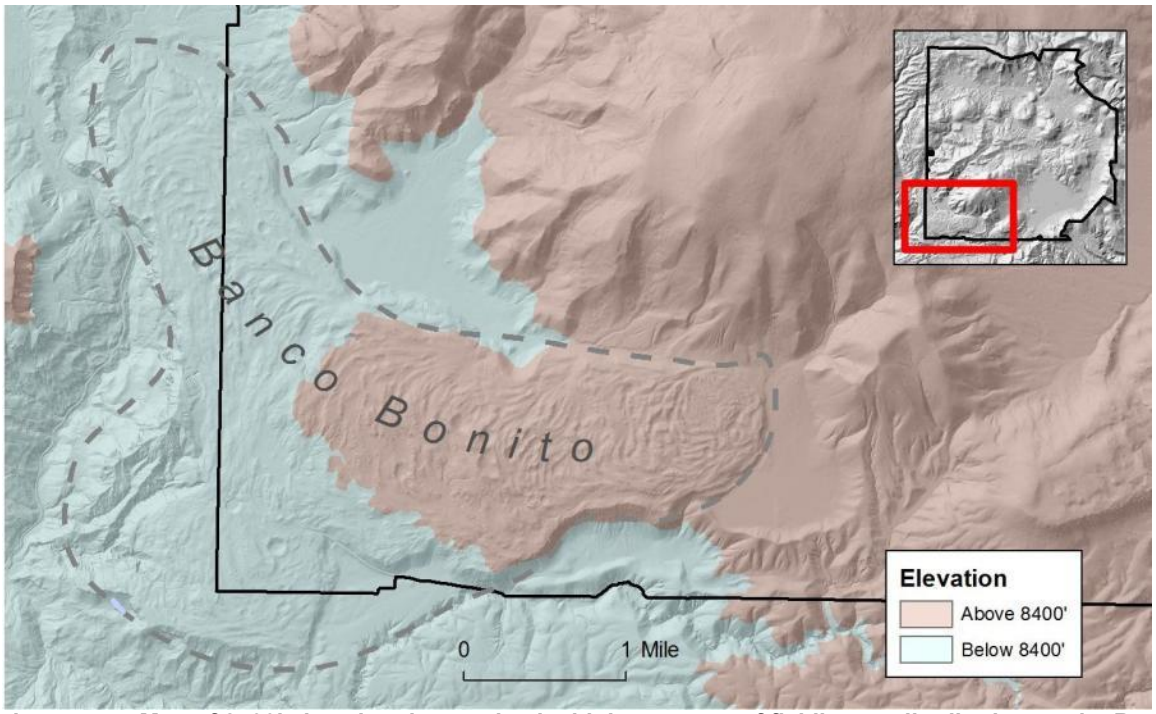


Figure 4-86. Map of 8400' elevation that marks the highest extent of fieldhouse distribution on the Banco Bonito

However, the restricted distribution of fieldhouses and large settlements within the preserve does not mean that ancestral Pueblo people did not use the caldera. Rather, sedentary agricultural people in late prehistory probably used the caldera much as it is used today – an area without large or permanent habitation, but visited or occupied briefly by the people of the region. While ceramic sherds are a small fraction of the total artifacts present on the preserve, the decorated sherds that have been recovered represent distinctive ceramic types characteristic of the numerous cultural groups in the region (Stark, 2010).

The historic period in the region first begins after 1540 when Spaniards first explored the Jemez Mountains. In 1598, Spaniards under the leadership of Juan de Oñate entered several of the pueblos. Hispanic missions were established in the pueblos around New Mexico (including Jemez Pueblo) in the 1600s. After the Pueblo Revolt and re-conquest by De Vargas (1680-1692), missions and settlements started anew in the Jemez region and a land-grant system was set up to encourage settlement. Settlers brought domesticated livestock and horses and, by the late 1700s, Hispanic settlers and Puebloan Indians were herding cattle and sheep in the valles of the caldera. Pastoral use of the land was risky; Apaches, Navajos and Utes who hunted in the Jemez Mountains often raided herds, a practice that continued into the late 1800s.

Anglo-American trappers hunted and trapped in the caldera in the 1800s, but the first detailed record of Anglo-Americans occurred in 1851 when a route between Santa Fe and a camp on the northeast portion of the Valle Grande was created. Hay was cut and sent back to Santa Fe to feed livestock owned by the U.S. Army, which had moved into New Mexico Territory in 1846 at the beginning of the war with Mexico

for control of the territory (the area became a U.S. Territory in 1848). The camp was used seasonally until Navajo raiders attacked it in 1851 forcing its abandonment.

A legal claim to the caldera occurred in 1860 when the heirs of Luis Maria Cabeza de Baca (who died in 1827) gave up their land grant around Las Vegas, New Mexico, in exchange for five tracts of land in New Mexico Territory as part of a land dispute settlement arranged by the U.S. Congress. The first area the family selected was a square of 99,289 acres around the caldera, which subsequently became known as "Baca Location No. 1." The Baca family began using the land in 1876 when the property boundaries were finalized. The numerous heirs divided the land for raising sheep and stock, but most sold their land claims.

By 1881, only a handful of Baca family members still held claims, while other land entrepreneurs who had purchased claims on unclear terms bickered over boundary rights. Legal battles (and occasional violent disputes) continued until 1899 when the New Mexico Supreme Court tried to settle the matter by ordering that Baca Location No. 1 be sold at public auction and the proceeds divided among the claimants. Attorney Frank Clancey purchased the land for $16,548 and immediately sold it again to the "Valles Land Company" run by businessmen Mariano and Fredrico Otero, two of the former claimants.

The Oteros continued cattle ranching and sheep herding, and began mining sulphur at Sulphur Springs on the west side of the property. They opened a hot spring resort that continued until 1977. They also built the first roads and cabins for office and living quarters. In 1909, they sold the Baca Location to the Redondo Development Co. of Pennsylvania, but retained grazing rights on the property. Redondo Development began logging, but completed only small-scale cutting due to transportation difficulties. The company continued leasing land for grazing until two Española businessmen, Frank and George Bond, purchased the land in 1918. Redondo Development Co. retained the timber rights. The Bonds grazed thousands of sheep and built cabins for their families and hired help. They produced millions of tons of wool and dominated the market in New Mexico until World War II when the wool market weakened.

Meanwhile, Redondo Development Co. sold its timber rights in 1935 to Firesteel Lumber, who immediately sold the rights to the New Mexico Land and Timber (later named New Mexico Timber Company). The company began logging operations on the Banco Bonito in 1935, just after the Civilian Conservation Corps constructed a road (now New Mexico Highway 4) that made transportation of logs much easier. They set up a logging camp in Redondo Meadow (Figure 4-87) and later in the north portion of the property. They continued logging until the early 1970s, cutting trees on 50 percent of the property and creating over a thousand miles of logging roads.

Figure 4-87. Cabin remnants from a logging and mill town in Redondo Meadows. The New Mexico Timber Company used the area from 1935-1939.

When Frank Bond died in 1945, his son Franklin began running more cattle than sheep; by 1960, sheep had been replaced by cattle. By this time, the Bond family wanted to sell the property, expressing interest in the federal government as a potential buyer, an idea that conservationists and legislators had hoped for since the late 1800s. That plan was disrupted in 1963 when the property was sold for $2.5 million to the Baca Land and Cattle Company run by wealthy Texas oilman James Patrick Dunigan. Dunigan built the A-frame cabins and a guest lodge at the north edge of Valle Grande and maintained the land as a cattle ranch and location to hunt elk.

In 1964, the Baca Land and Cattle Company filed a lawsuit against New Mexico Timber Company seeking damages for destructive logging practices, which eventually resulted in the transfer of timber rights to Dunigan by 1972. In 1973 he made a deal with Union Geothermal Company to drill several locations on the west side in hopes of harnessing geothermal steam for a power plant – a plan that was never realized because of Native American concerns about impacts to springs and aquifers outside the caldera and disturbance to sacred land around Redondo Peak, and ultimately to the lack of sufficient steam to generate the desired power.

By the late 1970s, Dunigan wanted to preserve the land for the public and began negotiations for sale of the land with the U.S. Forest Service and Park Service. His death in 1980 disrupted the process; his sons (Andrew, Michael and Brian) maintained the property, primarily as a cattle ranch, until 2000 when they sold it to the federal government to become the Valles Caldera National Preserve.

4.8.3 Documented Prehistoric and Historic Resources

Between federal acquisition and the end of the 2012 season, over 633 historic and prehistoric archaeological sites were documented, including one National Register of Historic Places eligible historic district (Baca Ranch Headquarters).

Table 4-33. Prehistoric and historic CR components documented through 2012. Note the total is higher than the number of sites (633) because some sites have multiple components

Cultural Component	Percent	Number
Obsidian quarries	4%	31
Lithic scatters	58%	410
Artifact scatters (w/pottery)	2%	11
Fieldhouses	13%	92
Rockshelters	3%	20
Rock/feature sites	2%	13
Historic sites	18%	129
Total	**100%**	**706**

The Valles Caldera is renowned for obsidian quarries, but the most common sites are “lithic scatters” (Table 4-33). Based on observations to date, obsidian artifacts are ubiquitous across the preserve; in contrast, “fieldhouses” are present in abundance, but only on Banco Bonito. Because so many of the archaeological sites in the preserve are large lithic scatters or obsidian quarries, counting the number of sites does not provide the whole picture of just how expansive and abundant these resources are across the caldera landscape. On the Banco Bonito for example, one archaeological site may consist of a cluster of two fieldhouses comprising only 0.3 acre, while one lithic scatter archaeological site located in the Valle Toledo may extend across 6 acres. These large sites are often difficult to avoid when planning projects and activities, requiring some kind of mitigation measure to address potential impacts.

One of the challenges in understanding the archaeological record of the preserve is interpreting the function and age of the numerous obsidian artifact scatters found throughout the caldera. The abundance, high-quality and large nodule size of the volcanic glass was valued and exploited by people throughout prehistory. The artifact scatters were created while toolmakers knapped obsidian collected at geological deposits on Rabbit Mountain and Cerro del Medio (Figure 4-88), and in the Rio San Antonio and East Fork Jemez River in the Valle Grande. Artifact scatters could represent complex habitation activities, or simpler specialized or brief activities. Obsidian scatter sites can be associated with any and all cultural groups and these scatters often lack artifacts that are distinctive of cultural periods. The obsidian quarries pose additional interpretive challenges because they cover large areas and contain vast quantities of obsidian artifacts accumulated over millennia of use.

Figure 4-88. Obsidian Quarry on Cerro del Medio

Approximately 18 percent of the documented sites on the caldera are historic in age. These sites help confirm and augment knowledge of the historic period gained from archives, documents, and oral history, and broaden our understanding of life in the caldera in the 18th, 19th, and 20th centuries. The historic sites recorded thus far represent diverse uses including sheepherding, ranching, logging, hunting, and geothermal and mineral extraction, as well as the landscape modifications and infrastructure that accompanied each period of development or use on the caldera. Historic site types include, but are not limited to, historic trash dumps, cabins and cabin remains, corrals, stocktanks, lumber mills, roads, sheep pens, and ranching/grazing features.

Historic artifact scatters are the most common historic site type and appear throughout the caldera. On Banco Bonito we have identified numerous small historic scatters with assemblages from the 1930's-1960's, probably associated with Banco logging activity and the close proximity to town locations such as Redondo Camp and Vallecitos de los Indios where more developed occupations were established. Redondo Camp, located in Redondo Meadows, was a 1930s village for loggers and their families working on logging operations within the Baca Location No. 1. In the remainder of the caldera, the historic artifact scatters found thus far are generally located along the margins of the valleys. These historic artifact scatters include small scatters (i.e., less than one hundred artifacts such as cans, bottles, lard buckets, and tobacco tins) that most likely represent limited activity sites related to short-term camping and general use by sheepherders or later by loggers who perhaps lived long-term at Redondo Camp. We have also documented several camps in association the use of portable lumber mills along the northern and western caldera that followed the closing of the main permanent mill in Redondo Meadows in 1940. Larger domestic historic can/trash dumps are concentrated near the logging towns in Redondo Meadows

and near the Ranch Headquarters area where larger group size or longer term occupation resulted on much larger quantities of trash to dispose.

The next most common historic sites are cabins or cabin remains. The great majority of these cabin/structures were constructed to accommodate logging and ranching activities during the Bond era (1917-1962) and Dunigan era (1962-2000). This includes nearly all the structures of the Baca Ranch Headquarters area, which is in the process of being nominated to the National Register of Historic Places as a Historic District. The Toledo cabin (constructed prior to 1908; (Hoard and Martin, 2002)), and Otero cabin (constructed around 1908; (SWCA, 2007)) are the only dwellings known to pre-date the Bond era. As in any natural landscape, the threat of fire to these wooden resources is ever-present. Although the Toledo cabin and the Indios Cabin (built in 1959 by Ethel Bond Huffman) completely escaped burning during the Las Conchas Fire of 2011, the Toledo corral shown in Figure 4-89 (before the Las Conchas fire) was nearly completely consumed with only a few corral posts surviving the fire.

Figure 4-89. Historic corral in the Valle Toledo before the Las Conchas fire

The known corrals associated with twentieth century historic sheep and cattle ranching operations include six wooden corrals and two metal corrals. Best known is the metal corral at the Valle Grande Staging Area, once known as “the black corrals”. Another type of historic site/feature present on the landscape and representative of the early days of sheepherding on the Baca are lambing pens. Although only a few of these small stone enclosures have been located so far, we anticipate that given the continuous and widespread nature of grazing sheep, more of these resources will be discovered as survey expands into new areas of the caldera.

Since 2008, a group of dedicated local citizens have combed the preserve's forests annually for aspen carvings and other historic tree art. They systematically document the carvings with photography, drawings, transcriptions, and GPS locations. The group has logged over 3000 hours dedicated to this task, which has resulted in full documentation of over 900 aspen carvings across the preserve.

4.8.4 Cultural Resources Management

The goals for cultural resource management are "…maintaining constructive consultation with tribes that are culturally affiliated with the preserve…to ensure protection of culturally significant sites and to provide the tribes with appropriate access to them. The VCT will strive to protect the preserve's archaeology in compliance with the National Historic Preservation Act; to launch, in partnership with appropriate research institutions, a vigorous program of archaeological research; and to channel the understandings thus attained into the preserve's interpretive and educational programs. Additional goals…include protective maintenance and, in some cases, the renovation of historic structures and the development of a strong interpretive program in the cultural history of the caldera" (Valles Caldera Trust, n.d.).

In its programs, activities and management actions, the trust seeks to avoid adverse effects to cultural resources in the Valles Caldera. The cumulative effects of road building, logging, geothermal development, infrastructure development and livestock and elk grazing have all impacted archaeological resources but the landscape is in recovery. Because most archaeological resources are soil deposits that contain the remnants of prehistoric cultural activities, the condition of these deposits is correlated with the recovery of vegetation communities, stream health, and reduced soil erosion. Actions by the trust that improve these values will maintain and enhance the condition of intact prehistoric cultural deposits.

Management of cultural resources on federal lands or using federal resources is done in compliance with the National Historic Preservation Act (NHPA). Compliance with NHPA involves consultation with the Advisory Council on Historic Preservation (ACHP), Native American Tribes and Pueblos, and the public.

Much of our consultation with ACHP is achieved through consultation with the New Mexico State Historic Preservation Office (NM SHPO). We are currently working with NM SHPO to reinitiate work on finalizing a procedural Programmatic Agreement (PA) for the trust. This agreement will provide a comprehensive process for management of cultural resources on the preserve and is being developed in collaboration with NM SHPO and the ACHP to streamline NHPA compliance. Work on this overarching PA was first initiated in 2003 and then suspended in 2010 by ACHP and NM SHPO in response to congressional proposals to move the preserve to National Park Service management. Completion of this procedural PA is scheduled for 2013. Other formal NHPA compliance agreements in place include a PA for Public Access and Use planning, which includes planning for a new visitor center and for public access.

The trust is developing a PA for forest and watershed restoration under the Landscape Restoration and Stewardship Plan for Southwest Jemez Collaborative Forest Landscape Restoration Act; this agreement will be completed in 2013. It will specify the details associated with inventory of historic properties in proposed project areas, standards for evaluation of potential effects and measures to avoid effects. It also will provide details on monitoring goals and activities.

Tribal consultation includes government-to-government dialogue with Pueblos and Tribes that have cultural affiliations or historic connections with the Valles caldera and surrounding lands. Tribal consultation with 37 groups elicits comments and collaboration from Pueblos and Tribes for trust planning and projects. Annual meetings with close neighbors, especially Jemez Pueblo and Santa Clara Pueblo, help to inform us of concerns as well as opportunities to collaborate with tribal governments and resource managers. Tribal consultation for LRSP has included informational mailing, invitations to public meetings, and requests to meet on in-person government-to-government basis. To-date, the trust has held one government-to-government in-person meeting with Jemez Pueblo that focused on LRSP, and multiple meetings with Jemez Pueblo, with Santa Clara Pueblo, and with Zia Pueblo in which the discussion of proposed LRSP activities has been a prominent component of the meeting.

Finally, consultation with the public provides the trust with opportunities to learn of the heritage values emphasized by the members of the communities that surround the preserve. As we move forward with large planning endeavors, such as for the Stewardship Plan, we are integrating NEPA and NHPA scoping and consultation goals by creating opportunities for public input concerning heritage values and cultural resources preservation.

4.9 Recreation and Scenery

4.9.1 Methods

As described under “Present Actions”, visitation to the trust has quadrupled to approximately 100,000 visitors. Much of this increase can be attributed to how we count visitors. Up until 2011 we counted we only counted “active” visitors to the preserve or those visitors who participate in an activity or who signed in at one of our two staging areas. However, it was determined that this method undercounts visitors relative to the methods employed on other public lands. Therefore, the trust moved forward in developing and implementing a more rigorous and defensible counting system. Bringing the visitor counting system on par with other public land management agencies will assure a reasonable comparison of visitor counts with other public lands and ultimately allow a better analysis of visitation patterns and assess the potential level of visitation to the preserve.

4.9.2 Visitation

Our new methodology allowed us to count “casual” visitors to the preserve. Casual (spontaneous) visitors are on a restricted schedule and generally are not prepared for extended recreational activities, and rather visit briefly at the Visitor Staging Area or one of the free trails along Highway 4. As shown in Figure 4-90 below, active visitors represent only a small portion of the visitors that are drawn to the preserve and would benefit by the day use opportunities that will be provided by the facilities and infrastructure planned for the future.

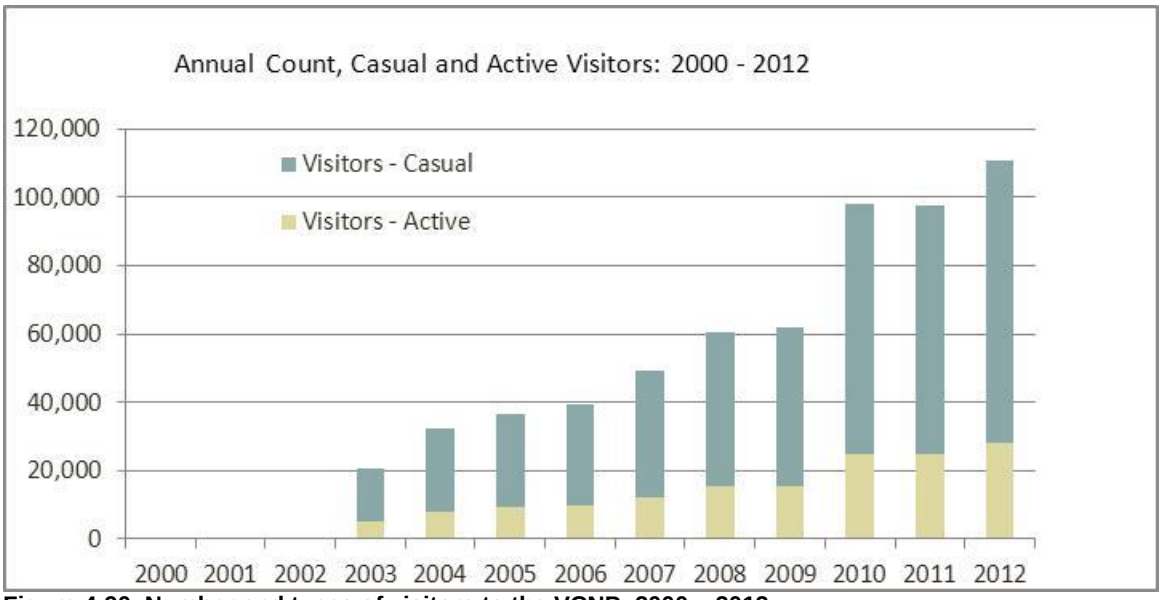


Figure 4-90. Number and types of visitors to the VCNP: 2000 – 2012

In 2010 Matt Gagnon a graduate student at the University of New Mexico administered a survey to over 700 individuals who responded to his outreach. Online surveys were made available through resources that recreationists interested in the preserve would likely encounter. Sources were chosen in a way to both make certain that as many recreation groups as possible had some exposure to the survey, and to negate bias toward one specific recreational group. The main source of responses came from the email directory of the VCNP, a voluntary sign-up list for those that seek to have additional information about the Valles Caldera emailed to them.

This list was likely to represent a broad spectrum of the people that are most interested in recreation on the preserve. Other survey distribution locations included: two running groups that have events in the VCNP, through email and a Facebook post; the New Mexico Wildlife Federation's September newsletter; NMWA's September Newsletter; Albuquerque Wildlife Federation's email list; New Mexico 4-Wheeler and New Mexico Off-Highway Vehicle Alliance (NMOHVA) email lists; the Caldera-Action website email list; a posted link on the vallescaldera.com webpage; and a posted link on the home webpage of the Espanola Sun, a local newspaper.

In total 712 respondents participated in the survey four questions were aimed at simply understanding what types of activities people would (or would not) like to see available on the preserve:

Question 1 [*What recreational activities do you engage in on the Preserve?*],

Question 2 [W*hat recreational activities do you engage in on public lands outside of the Preserve?*],

Question 3 [*What recreational activities would you like to see more widely or frequently allowed on the Preserve?*], and

Question 4 [*Are there any recreational activities that you would not like to see on the Preserve in the future?*]

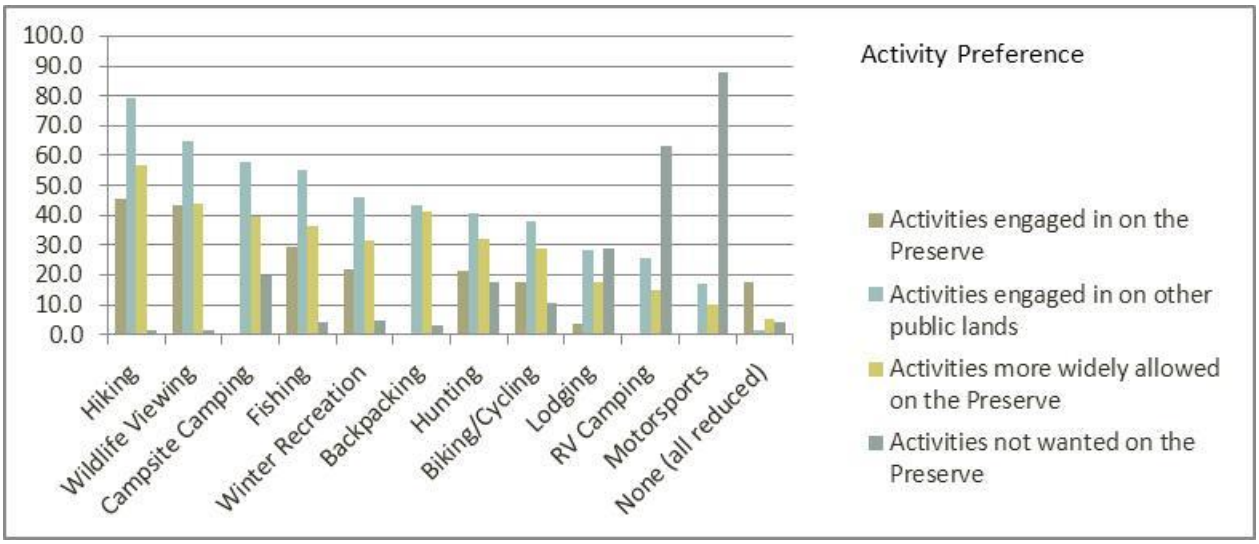


Figure 4-91. Activities visitors currently enjoy on the VCNP, on other public lands and those they would like (or not like) to see offered in the future (Gagnon, 2009).

The types and preferences of activities currently offered on the preserve is consistent with the distribution of activities visitors would like to see, those that that enjoy on other public lands (with the exception of camping, back backing and RV camping) and those they would like to see expanded in the future. While, the types of activities they were enjoying were similar, people were participating in more activities on other public lands than on the preserve. A surprising 17.4 percent of respondents indicated that they had never participated in an outdoor recreation activity on the preserve while only 1.4 percent had not recreated on other public land (Gagnon, 2009). A supplemental question explored what factors prevented individuals from visiting the preserve. The majority cited limited access (77.6 percent) with 40.1 percent citing lack of activities and 26.5 percent citing finances (Gagnon, 2009).

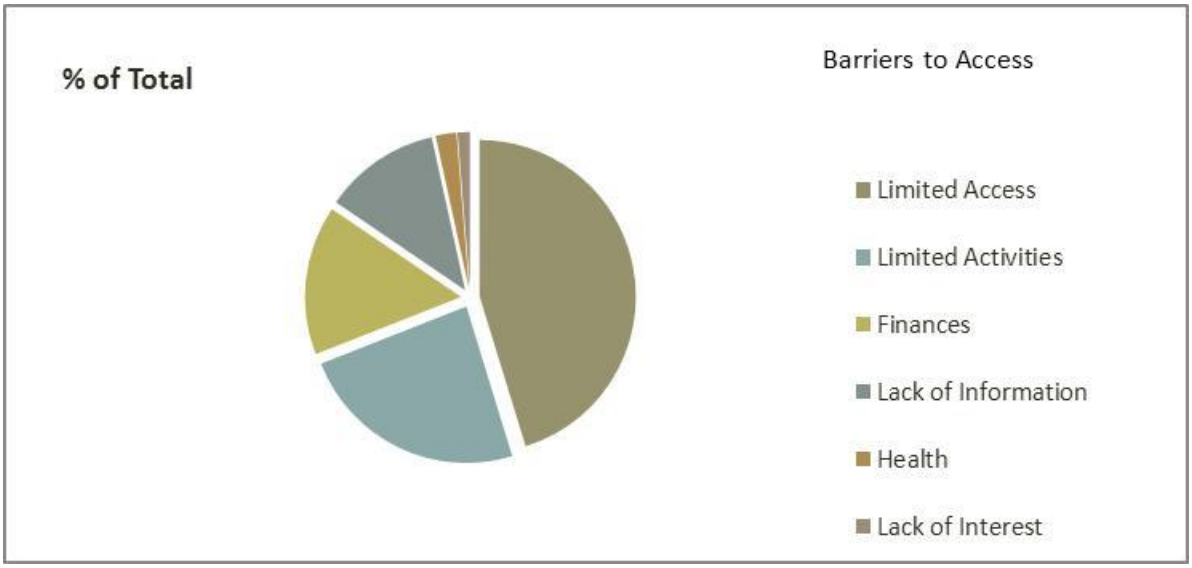


Figure 4-92. Survey respondents citing the reason they had not visited the VCNP (Gagnon, 2009)

Back-packing, camping, and RV camping were all being enjoyed on other public lands but are not broadly available on the preserve. Backpacking is an activity we expect to incorporate in the near future. The

development of campgrounds and/or RV camping facilities has not been determined. There are private and public campgrounds available near the preserve and onsite development may or may not be warranted. Respondents generally wanted broader access to enjoy the activities they currently enjoy and were only strongly opposed to the development of RV camping and motorsports as new activities.

4.9.3 Scenery

Sensory resources include the sights, sounds, smells, and overall sense of place one experiences on a landscape. A view or vista can be somewhat measured and in fact land managers have developed tools to establish and evaluate measurable objectives for visual quality. However, the sight of golden grass moving in the breeze against a backdrop of a deep blue sky is a moment that one experiences with all their senses and is much more difficult to quantify.

The expansive grasslands provide the foundation for the total sensory experience on the preserve. Whether one is standing in the middle of a valle with the grassland extending out in all directions, climbing upward through the forest to turn and view the grasslands from above, or rounding the corner of a forested road when the view of the expansive grasslands appears suddenly, the focal point is the grasslands.

The forests connect to the grasslands in a way that appeal to human nature. Visitors will consistently walk through the remnant old growth forest near the historic headquarters area of the preserve and stop at its edge to view the grassland. Perhaps a forgotten instinct returns to remind them they cannot be easily seen by predators or enemies if they stay within the canopy's shade.

The juxtaposition of golden aspen against blue sky or evergreen forests draws out the camera but the photo does not capture the rustling leaves, the sounds of the raven's wings, or the smell of leaves turning to soil. Our current recreation programs strive to limit the number of people in a place at any one time, protecting the sights, sounds, and sense of place.

"Scenery Management" is a tool incorporated into USDA Forest Service Land and Resource Management Plans (Forest Plans) to determine the relative value and importance of scenery on National Forest System lands. While we are incorporating elements of a scenery management system (classifying landscapes, and setting goals and objectives for maintaining, enhancing, restoring, and monitoring scenic integrity) we also recognize that people experience the preserve with all of their senses. They take in the scenery, the sounds, the smell, and at the same time experience the expanse of the caldera and, in the words of Aristotle, "The whole is greater than the sum of its parts".

Methods

Although the VCT has not conducted visitor surveys directly related to perceptions of scenic views or compiled data specifically addressing existing viewsheds, the USFS addresses the importance of this resource in its 1995 scenery management handbook, titled *Landscape Aesthetics Handbook for Scenery Management*. According to *Landscape Aesthetics*, people need natural-appearing landscapes to serve as psychological and physiological "safety valves," for these reasons:

- The world's urban population pressures are increasing.
- Technology is rapidly advancing.
- Demands for goods and services are increasing.
- People's lives are becoming more complex.
- Urban pressures are demanding more land for development.
- Once plentiful, natural-appearing landscapes are becoming more scarce

Landscape Aesthetics notes that research has shown that high-quality scenery, especially related to natural-appearing forests, enhances people's lives and benefits society. Research has also shown that the scenic quality and naturalness of the landscape directly enhance human well-being, both physically and psychologically, and contribute to other important human benefits. These benefits include people's improved physiological well-being as an important byproduct of viewing interesting and pleasant natural-appearing landscapes with high scenic diversity (USDA - Forest Service, 1995).

Findings from psychological and physiological studies of people under stress, recovering in hospitals, in recreation settings, and in other settings, demonstrate that natural landscape scenes have restorative and other beneficial properties. This is particularly important when contrasted with built urban environments, such as pedestrian malls and commuter traffic routes. Research shows that there is a high degree of public agreement regarding scenic preferences. This research indicates that people value most highly the more visually attractive and natural-appearing landscapes. However, preferences may vary in different regions or cultures (USDA - Forest Service, 1995).

Based on guidance from *Landscape Aesthetics*, the following components of landscape aesthetics were inventoried to describe the existing aesthetic values of the preserve relative to landscape management:

- landscape character: the existing characteristics of the landscape, including its relative scenic attractiveness and historic range
- scenic integrity: the degree of intactness and wholeness of the landscape character
- landscape visibility: the relative importance of various scenes to the public based on distance from an observer

In addition, the visual absorption capability of the preserve's landscapes was identified. Visual absorption capability is a classification system used to indicate the relative ability of a landscape to accept human alteration without the loss of landscape character or scenic integrity. Visual absorption capability is a relative indicator of the potential difficulty, and thus the potential cost, of producing or maintaining acceptable degrees of scenic quality. It can be used to scenic condition levels resulting from management activities in a landscape. (USDA - Forest Service, 1995).

Landscape Character

Landscape character describes an area's visual and cultural image, and consists of the physical, biological, and cultural attributes that make each landscape identifiable or unique. Landscape descriptions provide an overview of an area's landform patterns, water characteristics, vegetation patterns, and cultural elements. Landscape character also includes descriptions of scenic attractiveness, which is the primary indicator of the intrinsic scenic beauty of a landscape and the positive responses it invokes in people. The combination of valued landscape elements, such as landform, water

characteristics, vegetation, and land use and cultural features, determines the measure of scenic attractiveness (USDA - Forest Service, 1995).

- Landform patterns and features: the relative occurrence and distinguishing characteristics of landforms, rock features, and their juxtaposition to each other.
- Surface water characteristics: the relative occurrence and distinguishing characteristics of rivers, streams, lakes, and wetlands vegetation patterns: the relative occurrence and distinguishing characteristics of potential vegetative communities and the patterns formed by them.
- Land use patterns and cultural features: visible elements of historic and present land use that contribute to the image and sense of place.

People regard landscapes having the most positive combinations of variety, unity, vividness, mystery, intactness, coherence, harmony, uniqueness, pattern, and balance as having the greatest potential for high scenic attractiveness (USDA - Forest Service, 1995) as described below.

- Variety creates added interest when present in moderation.
- Unity provides a sense of order that translates into a feeling of well-being.
- Vividness is related to variety and contrast, adding clearly defined visual interest and memorability.
- Mystery arouses curiosity and adds interest to a landscape.
- Intactness is related to unity and also indicates wholeness; there are few or no missing parts in the landscape.
- Coherence describes the ability of a landscape to be seen as intelligible rather than chaotic.
- Harmony is related to unity and exhibits a pleasant arrangement of landscape attributes.
- Uniqueness arouses curiosity and often signifies scarcity, rarity, and greater value.
- Pattern includes pleasing repetitions and configurations of line, form, color, or texture, as well as harmony.
- Balance reflects unity and harmony, and displays a state of equilibrium that creates a sense of well-being and permanence.

Scenery Integrity

Scenic integrity is defined by *Landscape Aesthetics* as the degree to which a landscape is visually perceived to be “complete” (USDA - Forest Service, 1995). It is the current state of the landscape, considering previous human alterations. Scenic integrity indicates the degree of intactness and wholeness of the landscape character. Degrees of scenic integrity are defined as very high to very low. Integrity is limited to the deviations from or alternations to the existing landscape character that is valued for its aesthetic appeal. Scenic integrity spans a range of six levels of integrity, from very high to unacceptably low.

- **Very High** (Unaltered)—Very high scenic integrity refers to landscapes where the valued landscape character is intact with only minute, if any, deviations. The existing landscape character and sense of place is expressed at the highest possible level.

- **High** (Appears Altered)—High scenic integrity refers to landscapes where the valued landscape character appears intact. Deviations may be present but repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident.
- **Moderate** (Slightly Altered)—Moderate scenic integrity refers to landscapes where the valued landscape character appears slightly altered. Noticeable deviations remain visually subordinate to the landscape character being viewed.
- **Low** (Moderately Altered)—Low scenic integrity refers to landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed, but they borrow valued attributes such as size, shape, edge effect, and pattern of natural openings, vegetative type changes, or architectural styles outside the landscape being viewed. They not only appear as valued character outside the landscape being viewed, but are compatible or complimentary to the character within.
- **Very Low** (Heavily Altered)—Very low scenic integrity refers to landscapes where the valued landscape character appears heavily altered. Deviations may strongly dominate the valued landscape character. They may not borrow from valued attributes such as size, shape, edge effect, and pattern of natural openings, vegetation type changes, or architectural styles within or outside the landscape being viewed. However, deviations are shaped and blended with the natural terrain (landforms) so that elements such as unnatural edges, roads, landings, and structures do not dominate the composition.
- **Unacceptably Low**—Unacceptably low scenic integrity refers to landscapes where the valued landscape character being viewed appears extremely altered. Deviations are extremely dominant and borrow little, if any, form, line, color, texture, pattern, or scale from the landscape character. Landscapes at this level of integrity need rehabilitation.

Scenic integrity descriptions were determined for each alternative based on field visits and photographs, aerial photography, and inventories of disturbed areas and other data.

Landscape Visibility

Landscape visibility addresses the relative importance and sensitivity of what is seen and perceived in the landscape. Landscape visibility is a combination of the seen area in relation to the context and types of viewers who see it. Landscape visibility consists of three elements:

- Seen areas (travelways and use areas)
- Distance zones
- Concern levels

In order to determine landscape visibility, specific areas that would be seen from travelways or use areas were determined (known as “seen area mapping”). Landscape areas denoted by specified distances from the observer (known as “distance zones”) were also identified to determine landscape visibility. The importance people place on these travelways and use areas were then determined (known as “concern level assignments”).

David Evans and Associates considered landscape visibility relative to potential areas for visitor staging and the development of a visitor center as part of our environmental analysis for public access and use

planning (Valles Caldera Trust, 2012). Important existing travelways and recreation areas that receive high visitor use were identified and mapped. These include NM-4 and the preserve's Level 3 roads, as well as those sections of the East Fork of the Jemez River and San Antonio Creek that are open to fishing. Level 3 roads were mapped because they provide the transportation routes to hunting, fishing, hiking, and winter activities, and are used by the VCT to conduct tours (see Figure 4-93).

The importance people place on these travelways and use areas was determined to measure the degree of public importance associated with them, divided into three levels:

- **Level 1:** Most sensitive—Applies to travel routes and recreation areas where substantial public use occurs and where the visual quality is of high concern to typical users. Examples of such routes and areas include public highways, local roads, recreational lakes and rivers, and designated recreational trails and areas that provide a high level of scenic quality.
- **Level 2:** Moderately sensitive—Applies to travel routes or recreation areas not included in Level 1, where visual quality is of moderate concern to typical users. Examples of these routes and areas may include public highways and local roads, recreational lakes and rivers, and designated recreational trails that provide moderate to high scenic quality but less significant public use.
- **Level 3:** Less sensitive—Applies to travel routes or recreation areas not included in Levels 1 or 2, where visual quality is of less concern to typical users. Examples may include public highways and low-volume local forest roads, nondesignated trails, and nonrecreational lakes and rivers.

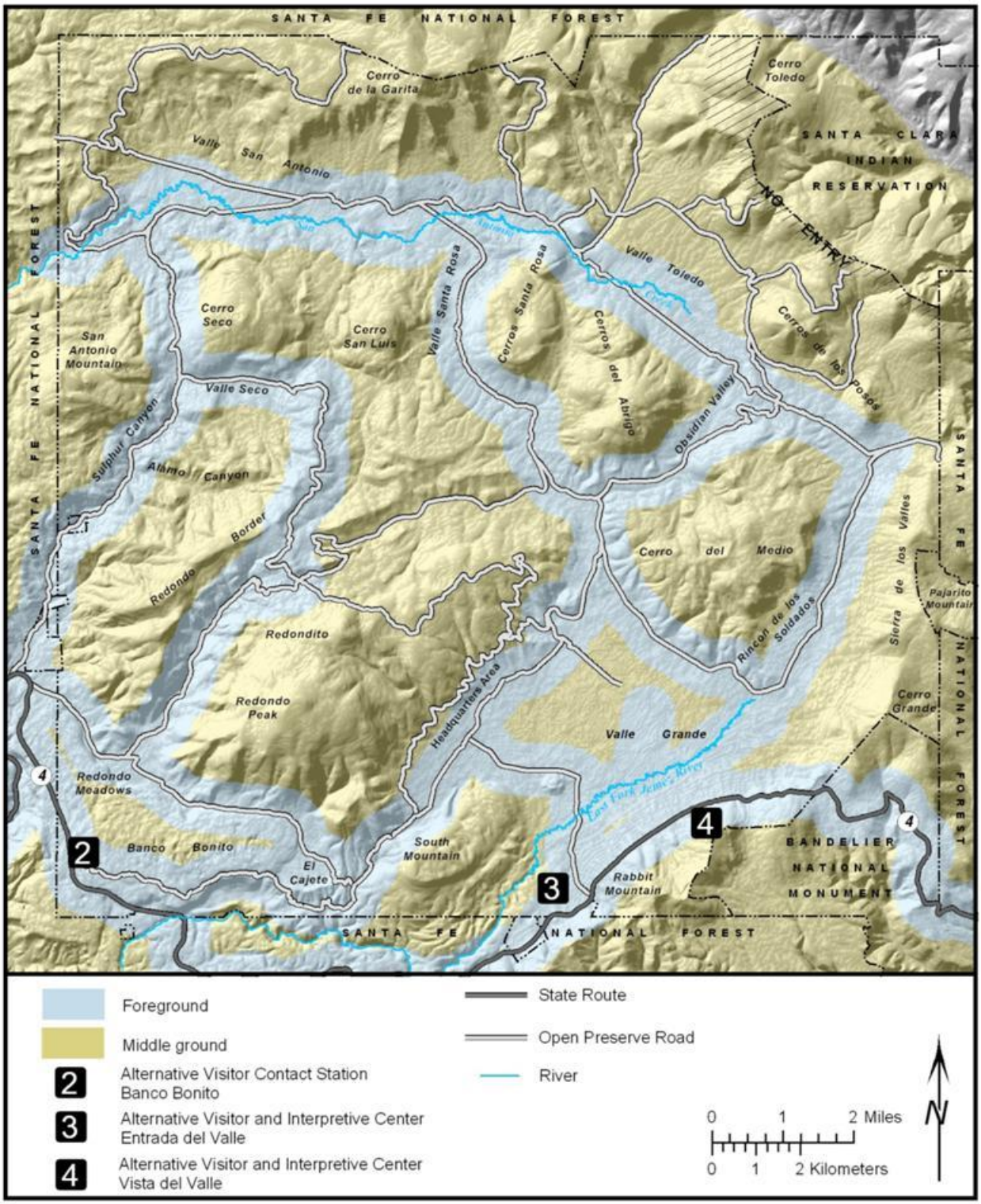


Figure 4-93. Seen area map for the VCNP in context with potential locations for visitor center/staging areas (Valles Caldera Trust, 2012)

As mentioned above, the preserve's grasslands, particularly Valle Grande, are some of its most dramatic features. Foreground and background views of the Valle Grande are provided from several high-use areas. This includes visitors driving on NM-4 and to the Valle Grande Staging Area. Visitors fishing the

East Fork of the Jemez River and anglers driving to San Antonio Creek also experience views of the Valle Grande, as do visitors taking shuttle tours of the preserve and tours of the headquarters area. The Valle Grande is open to cross-country skiers and snowshoers in winter.

Although elk hunters do not hunt in the Valle Grande itself, several designated elk hunting units provide views of the Valle Grande. The same is true for visitors hiking South Mountain, Rabbit Mountain, and Cerros del Abrigo and those hiking past Redondito. These travelways and use areas represent substantial public use and are likely places where visual quality, particularly of Valle Grande, is of high concern to visitors.

San Antonio Creek is very popular with anglers and a hiking shuttle route currently follows part of it. Three hunting units provide views into the Valle San Antonio, grassland, through which the creek flows. This area also represents substantial public use and is likely a place where visual quality is of high concern to visitors. In addition to the roads that provide access to the visitor use locations described below, all Level 3 roads provide background views of higher-elevation peaks and hills. These areas currently receive minimal use, but provide views of distant mountains.

Visual Absorption

Principles of visual absorption capability that could affect the ability of the preserve's existing landscape to accept human alteration without loss of landscape character or scenic integrity are described below.

- The degree of visual screening provided by landform, rockform, or vegetative cover affects visual absorption capability.
- Variety or diversity of landscape pattern, particularly the amount and extent provided by landform, rockform, water, or vegetative cover, affects visual absorption capability.
- Heavily dissected landform and rockform partially screen and break up the visual continuity of landscape alterations, while smooth landform does not.
- Tall vegetation, such as trees, screens and breaks up the visual continuity of landscape alterations. Short vegetation, such as grasses and low shrubs, does not.
- Heavily patterned and diverse, dense vegetative cover, especially if mixed with waterforms, breaks up the perceived continuity of landscape alterations. Homogeneous vegetative cover and lack of waterforms do not.
- Dense vegetation on flatter slopes provides more screening of landscape alterations than the same vegetative cover on steep slopes.
- Vegetation regeneration potential affects visual absorption capability. Where vegetation quickly reproduces, it can screen and blend human alterations into the landscape more quickly.
- A landscape prone to landslide, soil slippage, and erosion exacerbates the visual impact of landscape alterations. A stable landscape does not.

The three most important factors in providing visual absorption capability are slope, vegetation cover, and geology, as described below (USDA - Forest Service, 1995).

Slope: On steep mountainous terrain, slope is the most important visual absorption capability factor. Slope includes factors related to landform screening, vegetation screening, geologic stability, and soil depth and stability. Therefore, it is the best physical factor of relative visual absorption capability. Since it is not likely to change, slope is the most constant factor of visual absorption capability. Slope is not an appropriate factor for flat landscapes.

Vegetation Cover: On gently rolling landscapes, vegetation cover is the most important visual absorption capability factor. It is also a key factor on hilly or mountainous landscapes. Although vegetation cover can produce a certain level of visual absorption capability, it is the least stable factor. Natural disasters, such as the fires that burned in and near the preserve in 2010, and human activities, such as past logging in the preserve, can easily modify vegetation, altering its visual absorption capability. Vegetation screening is primarily a function of the height and physical structure of the leaves, branches, and stems of individual plants, including trees, shrubs, and herbaceous layers.

Soils and Geology: Soil factors such as mass stability, erosion hazard, and soil color contrast provide visual absorption capability. Geologic formations, such as rock outcrops, slides, and cliffs, can affect visual absorption capability by providing natural openings from which to borrow when designing human alterations.

The 2012 Public Access and Use Plan (Valles Caldera Trust, 2012) examined data about slope, existing vegetation, and geologic formations to identify the visual absorption capability of the preserve's landscapes, as shown in figure 3-24. Tightly spaced topographic lines indicate areas of steep slope; broadly spaced lines indicate relatively flat areas. The preserve's vegetation was classified by height into three categories based on its ability to screen views: high, moderate, and low. High indicates tall vegetation, such as evergreen forests, with the greatest potential to screen views. Moderate indicates medium-height vegetation, such as shrublands and wetlands, with a moderate potential to screen views. Low indicates grasslands and meadows, with the least potential to screen views.

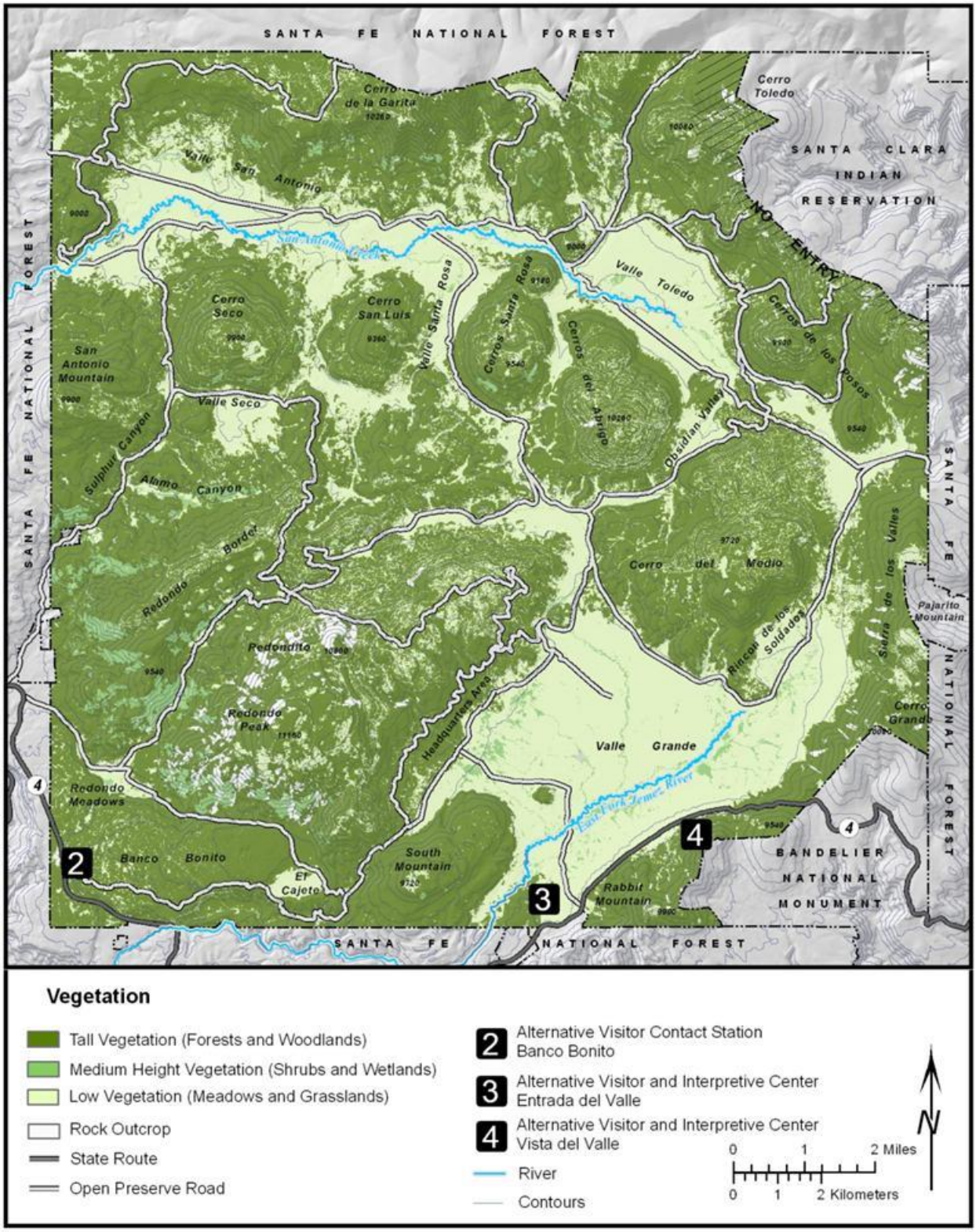


Figure 4-94. Visual absorption factors in context with potential visitor center/staging locations (Valles Caldera Trust, 2012)

4.10 Socioeconomic

The Omnibus Public Land Management Act of 2009 includes Title IV: Forest Landscape Restoration (Title IV). The purpose of this title is to conduct ecosystem restoration that encourages economic and social sustainability, leverages local resources with national and private resources, reduces wildfire management costs, and addresses the utilization of forest restoration byproducts to offset treatment costs and benefit local economies (USDA - Forest Service, n.d.). An emphasis is placed on the "collaborative" development of a restoration strategy. The Collaborative Forest Landscape Restoration Program (CFLRP) involves developing a system where public and private stakeholders work together to reach compatible goals of sustainable forest management and economic development. CFLRP provides funding to cover up to 50 percent of ecological restoration treatments on National Forest System (NFS) lands.

One key element of developing a CFLRP proposal is a socioeconomic assessment of the project area. Such information is needed to identify the social and economic structure under which restoration activities would occur. This section discusses three components of the socioeconomic environment relative to restoration: 1) existing conditions of the socioeconomic environment; 2) supply of woody products resulting from restoration activities; and 3) the demand for those products in the local market place. The existing conditions define the socioeconomic dynamic through a series of demographic and economic variables. Social concerns and economic health are also addressed in this section. The scale of this assessment focuses on Sandoval County and extends beyond the preserve to the SWJML. The discussion of sustainable supply of woody products in this report is in the context of aggregating both entities. Any restoration strategy would be jointly applied to the SFNF and preserve. Woody debris removed from both serve as the basis for a sustainable flow of inputs to production for local niche markets.

Woody products serve as the material production side of the restoration efforts. From an operator standpoint, it is important to know the supply of raw materials available as inputs to production. This section addresses the potential for a sustainable supply of woody products over time. Also, demand for the products is a crucial component of developing a collaborative restoration strategy in which stakeholders on all sides would benefit. Having a marketplace for the woody products removed during restoration efforts would provide for some economic value to be capitalized upon by private enterprises that could partner in the strategy. This section assesses the existing demand for small diameter wood products by identifying local businesses and infrastructure, and also addresses the potential for the development of new markets with the aid of CFLRP funding. Identification of possible partnering entities is included in the assessment of the potential for new markets.

4.10.1 Methods

Several analytical methods are used throughout this report. Methods range from qualitative analysis of social values to quantitative modeling of economic impacts. Application of these methods reflects the use of the best available science. Although other methods can be found in the literature, those used best meet the purposes of this proposal. Qualitative social analysis is a descriptive tool relied upon to illustrate the current state of the socioeconomic environment so that the conditions under which restoration activities would occur are understood. This is used in combination with reporting

quantitative data on a variety of economic and social variables. These methods applied together allow for the determination of whether or not proposed activities contribute towards the Title IV objectives regarding economic and social sustainability.

A collaborative approach is taken to address existing infrastructure and capacity, as well as the potential for additional infrastructure and the identification of new markets. A collaborative workshop was held in Santa Fe, NM in February 2010. Representatives from the wood products industry, interest groups and public land managers met to identify important issues facing the SWJM restoration strategy. One session and a working group were dedicated to wood utilization and economic benefits. This collaborative effort served as the best available method for collecting and analyzing information regarding existing use and potential demand for small diameter wood products.

Economic benefits were estimated by applying regional economic science to the local study area. The volume of jobs and income per million dollars of activity in the forest industry are developed from an economic impact analysis of the production area. Economic modeling was done with IMPLAN version 2.0 and 2007 data. Additionally, the economic effects are paired with a qualitative discussion of non-market benefits. These are benefits that are not directly accounted for in the market place and don't have a quantitative value assigned to them. These values were the topic of many discussions during the collaborative workshop, and therefore warrant further analysis in this proposal.

4.10.2 Socioeconomic Environment

Two different impact areas are defined in this report. The "local area" is defined as Sandoval County and serves as the base area for statistical analysis in the existing conditions. This is the area in close proximity to the SFNF and preserve. The development of new markets and identification of key partners would occur within this area. However, the "production area" consists of Sandoval, Rio Arriba, Santa Fe, Los Alamos and Bernalillo Counties. Identification of existing infrastructure and demand for small diameter woody products occurs within this area because they would be within a reasonable transportation distance and affect the total demand for products removed from the SFNF and preserve.

This section provides a comprehensive evaluation of the existing conditions in the local area, Sandoval County. Variables of concern include basic demographics, employment and personal income. The demographics section includes a variety of human factors affecting the overall state of the local workforce; those factors include population, age and ethnicity. Employment and income are reported by economic sector, which are a set of local businesses by industry, grouped together according to similarities in the goods and services offered. Economic sectors are reported according to 2-digit North American Industry Classification System (NAICS) codes. NAICS is a system developed by the United States government for grouping establishments into industries based on the primary activity with which they are engaged (US Bureau of Labor Statistics, n.d.). Assessing employment and income by sector will aid in the identification of those industries important to the economic sustainability of the region, and those potentially dependent on the activities taking place on NFS lands.

Located in north-central New Mexico, Sandoval County is an economically and culturally diverse region. Its history dates back to long before Don Francisco de Coronado first explored the area. Modern day Sandoval County was one of two districts created in the New Mexico territory, and became part of Santa

Ana County in 1852. Sandoval County was first established as its own entity in 1903, nine years prior to New Mexico's statehood, and was separated from what is currently Los Alamos County in 1949 (Sandoval County, Board of Commissioners, n.d.). With its strong agricultural ties, many county residents rely heavily on ranching operations for both income generation and to maintain historical and cultural activities. Also, like many rural areas across the United States, natural resource based recreation is becoming an increasingly popular source of economic stimulus. Visitors are drawn to the unique landscape and climate of northern New Mexico to participate in a variety of outdoor recreation activities. The recreational and agricultural opportunities supported by NFS lands are likely to generate significant levels of economic stimulus. Sandoval County currently encompasses 3,716 square miles and includes a total of 6 incorporated communities: Bernalillo, Cuba, Corrales, Jemez Springs, Rio Rancho and San Ysidro (Sandoval County, Board of Commissioners, n.d.).

4.10.3 Demographics

Sandoval County has experienced substantial population growth in recent years. Between 2000 and 2008, the population grew by 36 percent; this is much faster than New Mexico and the United States, which grew by 9 percent and 8 percent respectively (Table 4-34). Much of this population growth is result from industrial change. Historically an agricultural region, manufacturing enterprises such as Intel have opened production facilities and drawn workers to the area. This has contributed to making Sandoval County the second highest in weekly wages in the state (Mid-Region Council of Governments, n.d.). The local area is also rich in natural amenities, which make it highly desirable location for many residents. Nearby counties whose primary economic driver is agriculture have not experienced such an increase in population. Agriculture jobs have declined in recent years which has slowed growth in many rural communities. It is therefore the transition from an agricultural to a manufacturing based economy that has stimulated population growth in Sandoval County.

Table 4-34. Population and Growth Rate

	2000	2008	% Change
Sandoval County	89,908	122,298	36%
New Mexico	1,819,046	1,984,356	9%
United States	281,421,906	304,059,724	8%

Source: factfinder.census.gov

The age distribution across Sandoval is dominantly middle aged. Figure 4-95 summarizes the age distribution for the county and state. Most individuals lie within the 25 to 54 year old age group; suggesting the majority of residents in the study area are of working age and likely dependent on their employment status to support themselves. Those areas with an older population typically have a higher percentage of retirees, and are thus less dependent on local employment conditions due to the influence of transfer payments from outside the local region. There are no significant differences in the age distribution between the county and state; the largest difference is that Sandoval County has a slightly higher percentage of individuals in the 35 to 44 year old age group.

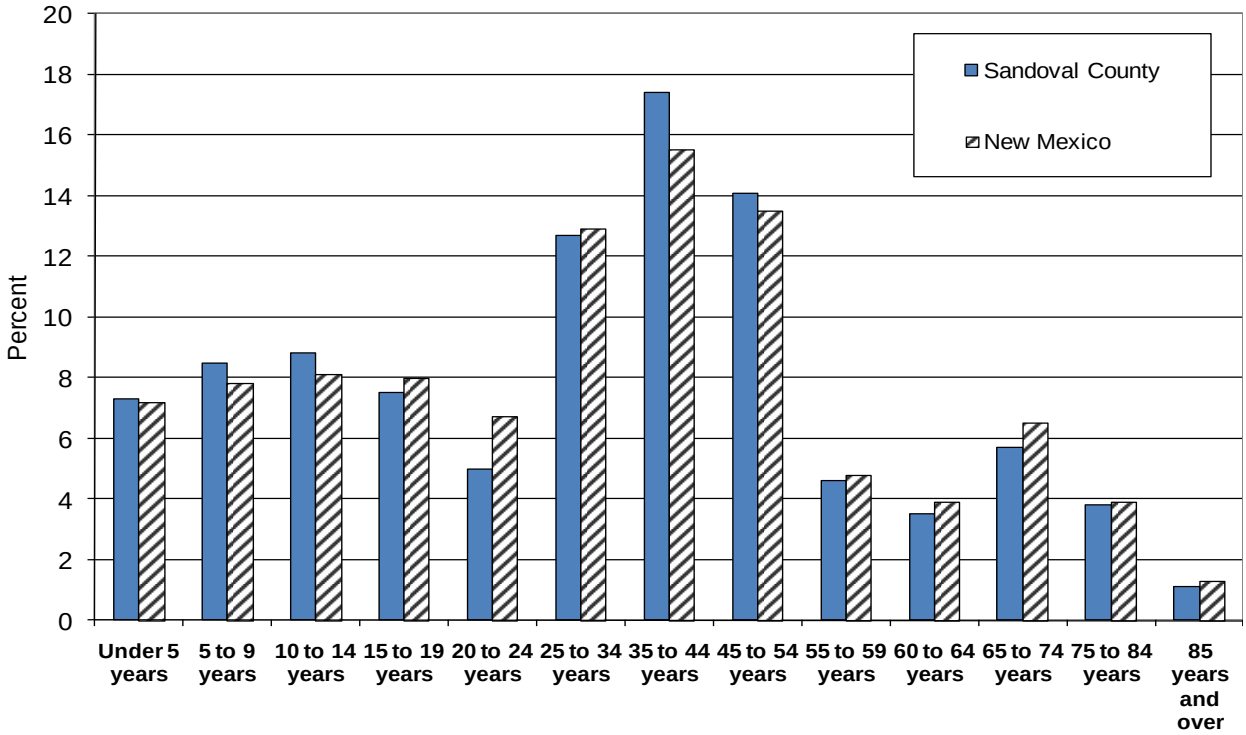


Figure 4-95. Age distributions (Source: factfinder.census.gov)

Table 4-35 reports the ethnic distribution. According to Census definitions, Hispanic or Latino may be of any race. As defined by the U.S. Census Bureau, race and Hispanic origin are two different concepts; thus, people in each racial group may be either Hispanic or not Hispanic (US Census Bureau, n.d.). Individuals are also allowed to report more than one race which further complicates the manifestation of overlapping groups. Because of this, summing the ethnic distribution in an area often results in a sum of greater than 100 percent. The majority of the individuals in the county and state are Caucasian, however, a large percentage of the population is American Indian and Latino. American Indians and Latinos have a strong history in Sandoval County. Many are still actively tied to the agricultural community. The SFNF and preserve are important resources for many minority residents trying to sustain agricultural operations.

Table 4-35. Ethnic Distribution of Sandoval County and New Mexico

Ethnicity	Sandoval County	New Mexico
Caucasian	68.1 %	69.9 %
African American	2.2 %	2.3 %
Latino	29.4 %	42.1 %
American Indian	17.2 %	10.5 %
Asian	1.5 %	1.5 %
Pacific Islander	0.2 %	0.2 %
Other	14.4 %	19.4 %

Source: factfinder.census.gov

4.10.4 Employment

Minnesota IMPLAN Group (MIG) reports annual economic data for all counties in the United States. The most current IMPLAN data available is 2007, which is the data utilized throughout this analysis. MIG utilizes national, state and local data sources to report county level employment, and includes full-time, part-time, seasonal and self-employment. IMPLAN employment data is reported simply as jobs, not full time equivalents (FTEs); thus one person with multiple jobs will show up more than once in the data. This prohibits the comparison to local population data provided by the US Census.

According to the 2007 IMPLAN data, total employment in Sandoval County is 36,109 jobs. Table 4-36 reports total employment by industry at a combination of 2 and 3digit NAICS codes. Manufacturing is the largest employing sector, accounting for 45 percent of total jobs. Jobs in the professional scientific and technical services sector are the second most abundant. The distribution of jobs is largely influenced by the recent introduction of high-tech companies such as Intel. Interestingly, agriculture and forestry account for less than one percent of total employment. This represents a major transition in economic base. Historically, Sandoval County has been dominantly agricultural with livestock production as the primary activity. Forestry services also played a primary role in industrial composition during the pre-high-tech era. However, most small mills and logging enterprises have closed down due to poor timber markets. A total of 82 jobs (0.2 percent of total jobs) remain in Sandoval County. These jobs are still very important to many long-time local residents. Agriculture and forestry still have historical and cultural importance because they represent a traditional way of life. Under different market conditions, it is likely that many workers would return to more traditional enterprises that rely on natural resources as inputs to production.

Table 4-36. Employment by Sector in Sandoval County

Employment Sector	# of Jobs	% of Total
Agriculture, Fishing and Hunting	265	0.7%
Forestry and Logging	42	0.1%
Mining	87	0.2%
Utilities	45	0.1%
Construction	3,128	8.7%
Manufacturing (except wood products)	16,329	45.2%
Wood Products Manufacturing	82	0.2%
Wholesale Trade	1,106	3.1%
Transportation and Warehousing	2,421	6.7%
Retail trade	1,140	3.2%
Information	3,513	9.7%
Finance and Insurance	947	2.6%
Real Estate and Rental	317	0.9%
Professional Scientific and Technical Services	6,687	18.5%
Total	**36,109**	**100%**

Source: IMPLAN

The U.S. Bureau of Labor Statistics reports the unemployment rates for Sandoval County and New Mexico. Sandoval County has experienced trends similar to that of the state in recent years. Currently unemployment is on a rising trend, and Sandoval County is 1.6 percent higher than the state. This is

likely a result from job cuts in high-tech companies that have been adversely impacted by the recent economic downturn. Because of the large influence from manufacturing and professional services, Sandoval County is affected differently by economic cycles than counties that are still dominated by agricultural activities. Those counties are less impacted by market swings in professional services and high-tech industries, but are more dependent on agricultural markets for employment and household income. As jobs are created in a region, labor comes from two primary sources: local unemployment and in-migration of households. With unemployment rates currently elevated, it is likely that any new jobs created would be filled by the local labor supply and not affect household migration patterns.

Table 4-37. Unemployment Rate for Sandoval County and New Mexico, 2005 - 2009

	Sandoval County	New Mexico
September 2005	5.0%	4.8%
September 2006	3.9%	3.8%
September 2007	4.1%	3.2%
September 2008	5.1%	4.2%
September 2009	9.0%	7.4%
November 2011	7.9%	7.0
December 2012	7.4%	6.6

4.10.5 Income

Another indicator of the overall health of the local economy is household income. Figure 4-96 reports the 2007 median household income for Sandoval County, New Mexico and the United States. Sandoval County has a very strong household income compared to the state ($57,651 vs. $44,631) and the nation ($57,651 vs. $52,762). The per capita income in the local area is $26,757 compared with the states per capita income of $23,537 and a per capita income in the United States of $27,915. In Sandoval County census data found that 12.4 percent of the population was living below the poverty level compared with the 19 percent found for the state. (US Census Bureau, n.d.).

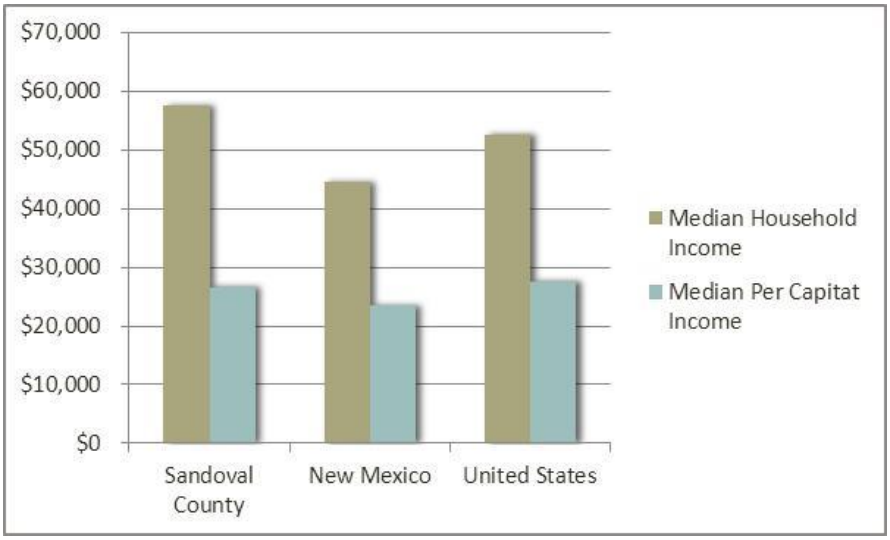


Figure 4-96. Median Household Income; 2007-2011 Source: factfinder.census.gov

Table 4-38 reports the total income by a combination of two and three digit NAICS sectors for Sandoval County. Total income is the sum of employee compensation, proprietors' income and other property income. Similar to the distribution of employment, Sandoval County generates the majority of income from manufacturing. Manufacturing is high paying relative to other sectors because it accounts for 45 percent of total employment and 60 percent of total income. Agriculture and forestry make up on 0.4 percent of total income, thus it is not a major contributor of economic stimulus. But for those families dependent on agricultural and forestry based enterprises as their primary source of income, it is essential that both sectors remain viable in the local area.

Table 4-38. Total income by sector in Sandoval County

Sector	Total Income ($ Millions)	% of Total
Agriculture, Fishing and Hunting	7.568	0.3%
Forestry and Logging	1.185	0.1%
Mining	18.686	0.8%
Utilities	11.769	0.5%
Construction	179.569	8.2%
Manufacturing (except wood products)	1,328.306	60.3%
Wood Products Manufacturing	4.534	0.2%
Wholesale Trade	79.016	3.6%
Transportation and Warehousing	67.212	3.1%
Retail trade	35.709	1.6%
Information	91.427	4.2%
Finance and Insurance	21.745	1.0%
Real Estate and Rental	23.621	1.1%
Professional Scientific and Technical Services	331.064	15.0%
Total	**2,201.411**	**100%**

Source: IMPLAN 2007

4.10.6 Small Diameter Wood Products

Demand

Demand for wood products in the United States in influenced by several factors. Demand occurs at multiple levels: demand for raw materials by processors affects the rate which timber is harvested from federal lands, and demand for wood products by consumers affects the price at which processors sell their finished products. Ultimately, it is the demand by consumers that drives the demand for timber by processors. The price they receive for finished products must at least cover their production costs, which includes the cost of harvesting timber. Transportation costs greatly affect the bottom line for processors. Therefore producers selling to local markets have a better chance of being economically viable and remaining in operation for the long term.

There is an abundance of small diameter timber in the SWJM which, conflicts with many ecological goals. Part of this landscape restoration strategy is determining the role of commercial removal of timber during restoration efforts. The underlying question of this topic is: does sufficient demand exist for small diameter timber to offset the management cost of meeting environmental objectives. Essentially, if commercial processors demand small diameter wood products, there may be a restoration strategy that

utilizes this demand to remove unwanted timber from forested areas. In this case processors and land managers would be working together to improve ecological health while benefiting local economies through increased activity in wood products industries. This section assesses demand for small diameter timber on the SWJM in two ways: 1.) Determining existing infrastructure and capacity in the market place; and 2.) Assessing the development potential of new markets that could utilize small diameter wood products. New markets would be considered any manufactured good using products removed from the SWJM. Examples include: wood pellets, latillas, vigas, wood flooring, and energy from biomass.

Existing Infrastructure and Capacity

Existing infrastructure and capacity affect the current demand for wood products from the SFNF and the preserve. Although this proposal is geared toward the communities in Sandoval County, a broader scale must be defined for demand from existing operations because transportation of raw materials as inputs to production is possible if the marketplace permits. This broader geographical region is referred to as the production area and consists of Sandoval, Rio Arriba, Santa Fe, Los Alamos and Bernalillo Counties. It is assumed the existing operators within these counties have some current level of demand for wood products that could be supplied in part by the SWJM restoration strategy.

Several proprietor-owned businesses exist in the production area. These businesses produce a variety of wood products. Current wood products in the study area include rough-cut airdried building materials (including latillas, vigas and beams), other specialty carvings for homes, wood chips, wood pellets, small furniture, and fuel wood. Existing infrastructure in closest proximity to the Valles Caldera is the Walatowa Timber Industries (WTI). Products currently being produced by WTI are shown in Figure 4-96. WTI is a joint venture between Jemez [Pueblo] Community Development Corporation and TC Company, a local forest restoration and small sawmill operator. The WTI expanded an existing forestry and small wood enterprise in Jemez Pueblo (Walatowa Woodlands, Inc.). The enterprise was funded in part through a Collaborative Forest Restoration Program Grant. Its purpose is to develop jobs and economic opportunity in the Jemez Valley, particularly Jemez Pueblo and to protect and preserve Jemez Ancestral lands in the Jemez Mountains. The grant includes a monitoring program that will provide helpful information in quantifying potential socioeconomic contributions that could be derived from restoration and small wood enterprises. The first quarterly report showed five full time employees hired (one administrative and four in operations).

Table 4-39. Small wood products produced at Walatowa Timber Industries. Clockwise from top, left: vigas, rough-cut lumber, posts, firewood, animal bedding, and mulch

Given that business typically respond to the level of woody materials available to them, not all operate at full capacity, or remain functional full time. Because of this it is difficult to gauge the full capacity of the wood products industry. The New Mexico Forest Industry Association (NMFIA) provided any available data regarding current operational capacity of businesses in the production area. The data is limited throughout the region, however, there is evidence that considerable infrastructure and capacity exist, and there is interest for further investments if a reliable flow of material is offered. The potential for additional infrastructure and capacity, as well as volume for viable industries is addressed in subsequent sections of this document.

NMFIA contacted 3 active processors in the production area; combined they demand a total of 6,000 mbf and 9,000 tons of material annually. There are other commercial processors, however their annual capacity unknown. In 2009 it was likely that current capacity is not sufficient to meet the total volume that would be removed from the SWJM restoration plan (Valles Caldera Trust, Santa Fe National Forest, 2010). But new enterprises such as WTI are promising have already increased the local capacity. Additional investment in infrastructure is likely still needed to ramp up production levels so that capacity meets the supply that will be made available.

Both commercial and household fuel wood is an important use of woody material in the production area. According to the US Census 2000, 36 percent of houses in the Jemez Pueblo geographic area are heated from wood. Therefore the subsistence implications of fuel wood are very important to local communities. It provides cost savings to many households in the form of reduced heating expenses, and also provides an economic opportunity for entrepreneurs harvesting and selling fuel wood on the open market. On the Jemez District of the SFNF, permits sold for 5 cords of fuel wood typically range from 800 to 1,000 per year. This represents considerable current demand for wood products.

Processing the material is just one part of industry's role; there also needs to be sufficient capacity to harvest and transport the material to processing facilities. The New Mexico Forest Workers Safety Certification (FWSC) Training Program provides some data regarding the number workers that are able to participate in harvest activities. This program was initially developed to help employers reduce insurance

premiums for workers' compensation (Forest Guild, n.d.). Only a fraction of total workers are certified, therefore this data serves as a baseline proxy for the existing capacity for removal. To date over 400 workers has been certified in the state, with 113 of those in the production area. Industry will respond to supply, so if additional capacity is needed for wood products removal, additional employees will be hired.

Potential for Additional Infrastructure and Capacity

According to industry representatives present at the collaborative workshop in Santa Fe, NM there is a lot of potential for investment in additional infrastructure and new markets for value added products. However, in order for this investment to take place a reliable supply must be offered. The potential supply of wood products is reported in the next section. Industry repeatedly expressed that once supply is made available to them, they will develop utilization strategies accordingly. Additional infrastructure and capacity is likely to be generated in two forms: expansion by current operators and creation of new value added products. Existing operators would be willing to ramp up production and make investments to do so when they know exactly what volume is available to them and during what timeframe. This provides one means of extracting and processing the additional wood products that would be removed under this restoration strategy.

There has also been a lot of interest in developing new markets in the production area when a reliable supply is determined. The most interest is in using wood products is for creating biomass energy. This would involve considerable investment because current infrastructure is very limited. A small college in Santa Fe and some public schools in Jemez have the infrastructure to heat their facilities with wood, but these operations are very small scale. There is interest in developing a large-scale biomass facility in the production area that would at a minimum be able to power local communities. Depending on location of the plant there is potential to supply this power to the grid and supplement the demand for energy in other regions of the state. Other ideas include the development of a rough-cut green mill that would use byproducts for biomass material, fuel wood, wood stove pellets, agricultural shavings, posts and poles, and other building materials which is currently being realized at the WTI enterprise. A lot of current demand is satisfied in the form of fuel wood permits. There is potential to expand this program. Making wood products easily accessible would greatly increase the demand for both commercial and household use of fuel wood. One idea to increase fuel wood demand is to haul by products from restoration efforts to roadsides so that they are easily accessible.

In 2008 the Los Alamos National Laboratory released a "Renewable Energy Feasibility Study" which included the use of biomass. Three options were evaluated, requiring 30,000, 50,000 and 130,000 tons of biomass per year. A study of forest materials looked at the potential supply within 50- and 100-mile radiuses. According to their estimates the first two options could be supplied with materials from within 50 miles of the site, and the 130,000-ton option couldn't be met with supply from within 100 miles (Jones and Arrowsmith, 2008). If the laboratory decides to pursue biomass technology they could become key contributors to the SWJM restoration strategy.

In response to NMFIA requests for capacity and infrastructure information, an existing operator expressed interest in building additional facilities. They would need 400,000 tons per year to operate at full capacity, and are looking to the Forest Service to provide at least 200,000 tons per year under a 10-

year contract. This is further evidence that substantial willingness and ability of industry to expand infrastructure and capacity exists within the production area.

Much of the investment may come from existing businesses in an attempt to become more vertically integrated. Vertical integration refers to the "explicit arrangements for coordinating production of agricultural commodities with particular value-added marketing activities" (Schrimper, 2001). Essentially, this means that businesses will become involved in more stages of production as well as market products using their own resources. For example, this may involve current processors investing in equipment and manpower to harvest materials during the restoration stage. This could also involve processing multiple goods from the same material. Constructing building materials from larger diameter trees while using byproducts and smaller diameter trees for biomass or wood pellets is one possibility for businesses becoming more vertically integrated. Vertical integration allows for supply chain events to be consolidated, which broadens the margins for producers to be more economically viable.

For any actual investment to take place there must be a reliable supply offered. If that occurs through this restoration effort, entrepreneurs will respond by developing utilization strategies accordingly. Biomass is the most likely market for processing large-scale volumes of material. Once development of such infrastructure begins, industry will increase its marketing efforts. Providing heat to public buildings is a likely application of biomass energy used locally. Other marketing tools available to industry are green certification and a local point of origin brand. These efforts will increase awareness of wood product markets among local residents as well as potential buyers outside the production area. Therefore, it is safe to assume that there exists a lot of potential for investment in additional infrastructure and capacity that would stimulate economic activity in the local area. Once the restoration strategy is funded and on-the-ground applications commence, the true development potential will emerge through industry engagement. Industry engagement is an important element in this strategy, and once restoration activities begin industry will become more active with investment because they will be provided with supply information during the contracting process. By awarding contracts for wood products removal in conjunction with restoration efforts, not only is industry made more viable by having a reliable supply of inputs to production, it is helping to reduce the cost of restoration efforts by purchasing the byproducts.

Supply of Small Diameter Wood Products

At this stage of the restoration strategy total supply of small diameter wood products is a bit of a moving target. This proposal doesn't make any decisions for on the ground activity, because if that were the case it would be subject to NEPA. Instead, NEPA is to be conducted for individual projects that will occur under the broader restoration strategy. Specific acres and treatments will be identified at that time. Therefore the exact supply may not be presented at the proposal level. This section reports the acres and potential volume currently identified as treatable on NFS lands in the area; this includes the SWJM landscape assessment area as well as other National Forests in north-central New Mexico. This data is assumed to be a baseline because it is likely that additional areas will be identified as needing treatment in the future. Also, this section addressed the supply that would be needed to support viable industries in the production area. Data regarding this issue is limited, and the analysis is based on discussions with industry representatives and processor surveys.

Estimated Acres of Treatment and Volume of Wood Products

Reporting the estimated supply of wood products is important for industry to engage in restoration efforts and begin developing utilization strategies. The volumes reported in this section are estimates, and are not guarantees of the supply of wood products from restoration efforts. Although this proposal focuses on the landscape within the SWJM assessment area, the wood products industry may also harvest material from surrounding landscapes in order to be more economically viable. Therefore the potential volume for the greater SWJM area is reported. Only that data available from NFS lands is in this section. It is likely that additional volume may be removed from other NFS land in the area, as well as state and private forests.

Table 4-40 reports the potential product removal from the SWJM landscape assessment area (including both the SFNF and the preserve), as well as the remainder of the SFNF and the Cibola National Forest. The data reported for the SWJM landscape assessment area represents volume that would be removed from the restoration efforts that would occur as a result of this proposal. A total of 62,000 acres is set to be treated, yielding a total volume of 527,000 ccf. Of these acres and volume, the SFNF would produce 53,030 acres and 520,000 ccf, and the preserve would produce 8,880 acres and 75,480 ccf. Averaged over the life of the restoration strategy, the SWJM landscape assessment area would yield 6,200 acres of harvests each year. A separate assessment was done for the SFNF in its entirety and an additional 7,000 were identified as needing treatment. Although those acres are not included in the SWJM landscape assessment area, they would yield an additional 59,500 ccf of volume to be harvested and processed by the wood products industry. There is no timeframe identified with this data, and it is likely that treatment of these acres will extend beyond the 10-year restoration strategy.

Nearby National Forests also have timber removal programs associated with their restoration efforts. This increases the potential volume for wood utilization. The Carson, Gila and Cibola National Forests are located within the broader geographical region surrounding the SWJM landscape assessment area, and are assumed to be within a reasonable transportation distance for wood products industry. Currently there is no data available for the Carson and Gila National Forests. The Cibola National Forest, however, has developed a strategy for wood products removal. Table 4-40 reports the estimated volume to be removed from all Ranger Districts on that Forest. A total of 32,800 acres would be harvested, yielding 190,000 ccf of material.

Table 4-40. Total 10-year harvest acreage and volume available in SWJM Area and adjacent national forest land on the Santa Fe and Cibola National Forests

NFS Forest	Acres	Volume (ccf)[a]
SWJM Landscape Area- NFS land	62,000	527,000
Santa Fe National Forest	53,030	450,755
Valles Caldera National Preserve	8,880	75,480
Other Santa Fe National Forest areas	7,000	59,500
Cibola National Forest – all Districts	32,800	190,000
Total over 10 years	**102,800**	**776,500**

Assuming an average of 8.5 ccf per acre for utilizing all 5-inch and larger diameter material from SFNF and the preserve.

The data reported in this section identifies the need for restoration in north-central New Mexico. This area has a large volume of wood products that need to be removed while performing ecosystems restoration activities. This volume should contribute to the viability of the wood products industry. The

more volume removed from the area, the more economically viable local businesses should be; assuming that contracts are awarded to them. Although the total supply estimated is not a guarantee for local operators, it provides a basis for predicting activity in the area, and may serve as a framework for developing utilization strategies.

Volumes Needed for Viable Industries

A common theme among industry representatives at the February 2010 workshop in Santa Fe, NM was that they will respond to whatever volume becomes available to them. The notion is that they should not be reporting what they need to be viable, but rather that they need to know what supply will become available. At that point industry will respond in various manners to develop utilization strategies that are economically viable. Viability depends on the ability of businesses to remain in operation into the long run. Businesses currently in operation are considered economically viable given the current supply of wood products in north-central New Mexico. However, given additional volume, current businesses could ramp up production and new businesses may emerge that will contribute to the overall viability of the local wood products industry. Potential new markets are identified in the "Potential for Additional Infrastructure and Capacity" section above. That section also addresses vertical integration which may improve the economic viability of existing processors in the production area. These markets would be developed if sufficient value added to wood products could be developed to yield profits needed to make them viable.

According to the 4FRI Landscape Restoration Project Strategy, "there is currently no standardized quantification of volumes needed for viable industries due to the fact that various utilization schemes have been advanced that vary greatly in the volumes required and in the precision with which such volumes are estimated." Such is the case for the SWJM restoration strategy. Once supply hits the marketplace, industry will develop appropriate utilization schemes so that they are considered viable. Estimating specific volumes needed for viable industries is not a reliable exercise at the proposal stage. Rather, it is important to note that industry will respond to the supply that is made available to them.

The USDA has rural economic development programs that may help with the facilitation of industry expansion once a reliable supply of material is developed. Several grant and low interest loan programs are available to assist small businesses with investment in infrastructure and technology. However, industry will scale their investment to the level of supply coming from restoration activities. Examples of programs to help industry achieve rural economic development goals are the Rural Business Opportunity Grant, Value Added Producer Grant, and the Rural Economic Development Loan and Grant Program. Such programs are traditionally geared to food-crop agricultural producers, but opportunities may exist for timber industries if conditions meet the objectives of the programs. Additionally, the USDA has the Biomass Crop Assistance Program, which provides "financial assistance to producers or entities that deliver eligible biomass material to designated biomass conversion facilities for use as heat, power, biobased products or biofuels. Initial assistance will be for the Collection, Harvest, Storage and Transportation (CHST) costs associated with the delivery of eligible materials" (USDA - Forest Service, 2010). These types of programs may be used to make industry more economically viable in association with the restoration treatments that would occur under the SWJM strategy. Once a reliable flow of supply is calculated, and then industry may use these types of programs to be more competitive in the wood products market place.

Chapter 5. Environmental Consequences

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

"When we try to pick out anything by itself, we find it hitched to everything else in the universe."

-John Muir

5.1 Introduction

Even though the proposed action is designed to protect and preserve natural and cultural resources and values, activities designed to restore and rehabilitate the natural systems also initiate impacts of their own. What are the direct, indirect and cumulative effects of the proposed activities? How significant will these impacts be? Will they be beneficial or adverse? These are some of the questions that will be answered in this chapter.

The actions and activities being proposed are all common activities employed in public land management; many can be categorically excluded from documentation in an EIS when employed at the project level (limited in time or space). To avoid an encyclopedic presentation of all that is known about the direct effects of common land management activities, we have focused our analysis on the indirect and cumulative effects of the actions at the landscape scale.

This chapter is organized similar to chapter 4 and begins with Vegetation and Ecological Condition, followed by Wildland Fire Environment, Noxious Weeds, Watershed, Carbon, Air, Wildlife and Terrestrial Habitats, Fisheries and Aquatic Habitats, Cultural Resources, Sensory Resources, Public Access and Use, and Socioeconomics. Additional Sections include: Cumulative Effects, Unavoidable Adverse Impacts, and Short Term Benefits vs. Impacts to Long-term Productivity.

The organization of the environmental consequences may vary in each section. Rather than selecting a single, ridged format for presenting the information, we have customized each section to focus on the issues pertinent to a particular resource and combining sections as practical to avoid redundancies. Each section will include the direct, indirect and cumulative effects of the proposed actions. Cumulative impacts are presented in several ways:

1. The present condition of the resources including the cumulative effects of past actions was detailed in chapter 4 – Affected Environment; this information will not be repeated in this chapter.
2. Each resource section will include the cumulative effects all actions and activities being proposed under the stewardship plan.
3. The cumulative effects of the proposed plan and past present and reasonable foreseeable future actions beyond the activities put forward in the proposal are presented in a separate section.

Each section summarizes the objectives the goals and objectives from chapter 2 that relate to the topic and describes the methods (key concepts, terms and data) used to predict the environmental effects.

5.1.1 Methods

This chapter details the anticipated environmental consequences that are expect to occur as the result of any action or of taking no action at all. Environmental consequences may be:

- **Direct** - Effects that are a direct result of the action or activity.

- **Indirect** - Effects that are initiated by the action or activities but occur at a later time or different location.
- **Cumulative** - Effects are cause by the combination of all the proposed actions or by any of the action(s) combined with any past, present or reasonably foreseeable future actions.

Both beneficial (🡅) and adverse (🡇) effects are discussed; the significance of the effect is described in terms of context and intensity. Context is defined by the extent of the impact in both time and space and intensity is defined by the degree of impact. Context can affect intensity.

Table 5-1. Context and intensity

Context	Intensity
Short-term – Effects are evident for 5 years or less	None – No effect or impact
Mid-term – Effects are evident for 5-10 years into the future	Negligible – Impact cannot be detected
Long-term – Effects will remain evident for 10 years or more into the future	Minor – No measureable change to structure, composition or function
Localized – Effects are discrete to isolated areas with an area physically treated	Moderate – Change to structure, or composition, is measurable, but the resource remains within natural or existing state and function.
Project level – Effects would occur through the area physical treated	Major – A transition in structure, composition, and function is anticipated
Landscape level – Effects would occur throughout the planning area (in this case, the preserve-wide)	
Regional – Effects would extend beyond the planning area	

The presentation of the environmental consequences is organized to minimize redundancy. For example the wildlife and fisheries sections are in order following vegetation and ecological condition, wildland fire and watershed so that we can refer to those analysis when discussing impacts to wildlife habitats. The order is not a reflection of importance of impacts to one resource over another. As the analysis progresses, each section becomes shorter as we can refer to previous sections. Again, the abbreviated narrative is does not reflect any less consideration of one resource over another.

5.2 Forest Vegetation and Ecological Condition

This section will describe the direct, indirect and cumulative impacts of no action or the proposed restoration activities on the forest, woodland, grassland, and riparian vegetation and ecosystems measured at the landscape scale. We have focused on the potential effects of the alternatives on ecological condition at the landscape level.

5.2.1 Goals and Objectives

Chapter 2 included goals, objectives, and monitored outcomes for the Stewardship Plan including: "…move the structure, composition, and function of the preserve's natural systems towards the

reference condition". The distribution of various successional classes (s-classes) is the outcome identified for monitoring and the target accomplishment was to move 35 percent of the forests in s-class B (mid-age, closed) to s-class C (mid-age open).

5.2.2 Methods

The structural, compositional, and functional components of the preserve's natural systems are driven by biotic and abiotic factors, which vary both spatially and temporally. These components are interdependent and must be considered together to understand the effects of alternative courses of management. Understanding of historical landscape dynamics can provide a baseline, or reference condition, for evaluating current and future management decisions ((Landres, et al., 1999; Keane, et al., 2009). Reference conditions are assumed to represent natural systems where the vegetation structure, composition, and associated function provide ecological integrity and resiliency to future stressors (e.g., insect and disease, wildfire, climate change).

We have analyzed the impacts and changes to forest vegetation and ecological condition at two scales. To assess the direct and indirect effects we applied the Vegetative Condition Class (VCC) using the methodologies (described in chapter 4) at the stand level, isolating the VCC analysis to the area not burned in the Las Conchas fire. To assess the cumulative impacts we applied the VCC mapping tool version 2.2.0 (FRCCmt 2008[36]) at the watershed or regional area consistent with published FRCC methodology. Both approaches compare the current distribution of vegetation structure and composition to an estimate of that which may have existed under the historical fire regime.

Two VCC metrics are presented: *S-class Relative Amount (RA)* and *Strata VCC*. S-class RA assesses the current proportion of each *individual* s-class relative to its reference proportion. This is the most robust metric produced by the VCC mapping tool as it not only provides information about whether an individual s-class is departed from the reference condition but also in which direction (i.e., too much or too little) and by how much. The s-class RA metric consists of five classes as shown in Table 5-2.

Table 5-2. S-class RA class description

S-class RA Class	Range of Departure
Trace	< -66%
Under-represented	≥ -66% and < -33%
Similar	≥ -33% and ≤ 33%
Over-represented	> 33% and ≤ 66%
Abundant	> 66%

At the strata level departure is assessed across all s-classes within a particular forest type and assessment landscape (i.e., stratum). Strata level metrics assess the condition of the forest type as a whole and allow comparison across landscapes and between different forest types. Table 5-3 below presents the range of departure for each VCC designation.

[36] The reference Vegetative Condition Class replaces the term Fire Regime Condition Class (The LANDFIRE Project 2011)

Table 5-3. Strata VCC metric

Strata VCC Class	Range of Departure
Strata VCC 1	≤ +/- 33%
Strata VCC 2	> +/- 33% and ≤ +/- 66%
Strata VCC 3	> +/- 66%

Understory response potential, resulting from treatment, was analyzed for suites of vegetation organized by fire regime class. Soil map units (sourced from the terrestrial ecosystem unit inventory) were intersected with vegetation suites for each alternative. Soil map units were analyzed for their potential ability to support certain types of vegetation, exceptions were identified based on site-specific information, and soils were then lumped into general groups of shared vegetation potential (e.g. forest, grassland, shrubland). The relative proportion of soil/vegetation potential within each vegetation suite was calculated as an approximate percentage of the landscape. The discussion begins with forest vegetation suites in which fire frequency is fairly high, moves to forest vegetation suites in which fires are relatively less frequent or often result in stand replacing events and ends with non-forest vegetation suites (montane grasslands and mixed montane shrublands.

5.2.3 Environmental Consequences – No Action

Chapter 4 – Affected Environment details the existing condition and trend of the forest, grassland, and shrubland vegetation as a current state and cumulative result of past and present actions and events. The condition and trend as described in chapter 4 would persist, if no action is taken, leading to indirect and cumulative minor to moderate adverse impacts preserve wide and extending to the region. These impacts would persist long-term, into the foreseeable future as a result of either taking no action or as the result of severe fire or other uncharacteristic disturbance.

Table 5-4. Environmental consequences summary table: no action, vegetation and ecological condition

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor -moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential

Direct Effects

Forest Vegetation, Ecological Condition

Table 5-5 below summarizes the current condition rating (VCC) information from chapter 4.

Table 5-5. Summary of current VCC for forest systems on the VCNP

Southern Rocky Mountain Ponderosa Pine Savanna								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	73	27	0	0	0	0	100
FRCC Rating								2 (65)
Southern Rocky Mountain Ponderosa Pine Forest and Woodland								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	89	10	1	0	0	0	100
FRCC Rating	0	10	10	1	0	0	0	3 (79)
Southern Rocky Mountain Dry-mesic Mixed Conifer								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	15	15	10	50	10	0	0	100
Existing Condition	0	97	3	0	0	0	0	100
FRCC Rating								3 (82)
Southern Rocky Mountain Wet-mesic Mixed Conifer								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	10	40	25	10	15	0	0	100
Existing Condition	0	96	0	4	0	0	0	100
FRCC Rating	0	40	0	4	0	0	0	2 (56)
Intermountain Basin Aspen/Mixed Conifer								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	25	40	5	30	0	0	0	100
Existing Condition	0	98	2	0	0	0	0	100
FRCC Rating								2 (58)
Rocky Mountain Subalpine Dry-mesic Spruce-fir								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	15	20	15	20	30	0	0	100
Existing Condition	0	94	6	0	0	0	0	100
FRCC Rating	0	20	6	0	0	0	0	3 (74)
Rocky Mountain Subalpine Wet-mesic Spruce-fir								
Class	A	B	C	D	E	UE	UN	Total
Reference Condition	15	20	15	20	30	0	0	100
Existing Condition	0	76	24	0	0	0	0	100
FRCC Rating								2 (65)

Indirect and Cumulative Effects

Forest Thinning and Wildland Fire Management

> "The paradox of fire management in conifer forests is that, if in the short term we are effective at reducing fire occurrence below a certain level, then sooner or later catastrophically destructive wildfires will occur. Even the most efficient and technologically advanced fire fighting efforts can only forestall this inevitable result."
>
> - (*Swetnam and Baisan 1996*)

Without management action the condition and trends identified in chapter 4 would continue. This would equate to a continued decline in the forest condition that could lead to impacts to ecological composition, structure and function. Depending on the intensity and severity of disturbances that may occur on a site, there can be many successional and developmental pathways along with many vegetative and structural mixes possible for a given site and species mix (Graham and Jain, 2005). Therefore it is difficult to predict with certainty the precise succession of the forests without treatment beyond the increased potential for uncharacteristic disturbance (insects, disease and especially fire). We also cannot predict with any certainty exactly when and where such a fire might occur. We can, however, predict that such a fire is likely (and perhaps inevitable) (Swetnam and Baisan, 1996). The intensity of the potential impacts could be major within the preserve in the event that a high severity fire burned through the untreated forests. The degree of impact would relate to the natural fire regime and existing condition and likely be similar to the observed severity and impacts from the Las Conchas fire as presented in chapter 4.

As described in chapter 4, the ponderosa pine and xeric mixed conifer ecotypes on the preserve evolved under a regime of frequent, low severity fire and conversely did not evolve adaptations to respond to severe burning. In these forests localized major impacts in the form of a departure from any characteristic state of succession are likely to follow severe burning (Allen, 1996; Allen, 1989). In 1977, a high severity fire (La Mesa fire) burned 15,444 acres just east of the preserve on the adjoining lands of Bandelier National Monument, Santa Fe National Forest and Los Alamos National Laboratory. Following this event several fire effects studies were initiated. One of these was a study of post fire succession in ponderosa pine stands. In some severely burned stands it took nearly 20 years for pine seedlings to naturally re-establsih. Although the area was seeded with native and non-native grasses the study found that the grass did not markedly inhibit tree production (Foxx, 1996).

Mesic mixed conifer, aspen mixed conifer and mixed montane shrublands on the preserve as noted in chapter 4, are adapted to a mixed severity fire regime. Prior to European settlement and the ultimate exclusion of fire from the Jemez Mountains, fires often covered large areas. The uneven burning pattern in mixed fire regimes was probably enhanced by mosaic patterns of stand structure and fuels resulting from previous mixed burning. Thus, past burn mosaics tended to increase the probability that subsequent fires would also burn in a mixed pattern. Complex mountainous topography also contributed to variable fuels and burning conditions, which favored non-uniform burn severity (Arno, 2000). As described in chapter 4, the mixed conifer forests on the preserve were largely clear-cut in the 1960's. Therefore these forests lack a mosaic that would contribute to a mosaic fire pattern. Instead, they are largely homogenous and would with more extensive high severity than what was likely during the pre-settlement era. Generally more extensive areas of high severity fire take longer to return to a forest due

to the greater distance from seed sources (Allen, 1996; Allen, 1989). More severe and extensive damage to watershed conditions could impact productivity and delay recovery.

Revegetation in the burned area would be most robust in the areas that burned with low to moderate severity. Impacts resulting from the Las Conchas fire were moderate to major within severely burned forests. These areas could be dominated by grasses or shrubs with the return of ponderosa pine or Douglas-fir absent or significantly delayed.

Understory Vegetation

As described in chapter 4, compared to other high elevation sites in the southern Rocky Mountains and Colorado Plateau, the vegetative communities of the preserve are quite diverse and harbor many plant communities that are unique to the landscape of the Valles Caldera (Valles Caldera Trust, 2005). The highly localized occurrence of distinct plant associations, remnant patches of old growth forests, and individual species found on the VCNP makes it one the most diverse sites in the Southern Rocky Mountains Eco-region (Muldavin and Tonne, 2003) representing an uncommon nexus of western North American biomes.

The majority of understory sampling plots within forested areas appeared in high ecological health (TEAMS Enterprise Unit, 2007). Moderate ecological health appeared the next most common state followed by relatively few locations exhibiting low ecological health (Ibid). Where ecological health was low it was primarily because of ongoing concerns with understory plant composition, likely the result of disturbance from past logging or grazing management. Moderate ecological health ratings reflected less than optimum native species composition and/or soil cover levels. Where condition was high, native species dominated the plant community and soil cover had a stabilizing effect.

Abiotic factors, such as soils and climate, as well as historic man-made disturbance appear to exert a large influence on current vegetation conditions. As climate and management objectives have changed, so has vegetation. While the majority of existing conditions may be satisfactory, conditions across forested environments of the preserve could experience downward trends over the long term unless changing ecosystem dynamics (resulting from climate change, fire suppression, etc.) can be addressed. Even sites currently exhibiting a high level of ecological health may be on a threshold because they could be affected by shifting vegetation composition and off-site conditions or disturbance in neighboring stands. Although some level of limited vegetation management is likely to occur in the future, alternative 1 could slow efforts to maintain or restore forested areas, and put the preserve's unique species and diverse plant communities at increased risk.

Grasslands and meadows will almost certainly continue to be affected by forest encroachment if vegetation management and forest restoration efforts are not implemented on a larger scale. Plant communities like the Engelmann Spruce/Parry's Oatgrass plant association will likely expand into montane grasslands as they transition to spruce-fir forest. Blue spruce and ponderosa pine will continue to occupy and expand into grassland sites around the edges of the valles as well. Just as dense blue spruce stands have sparse understories, the development of "dog hair" thickets of ponderosa pine will likely suppress understory plant cover, especially Arizona fescue and Gambel oak. Ponderosa pine itself may even be limited upslope of the valles where it abuts mixed conifer stands, as in-filling of blue spruce and Douglas-fir result in type conversion. And elk browsing coupled with a lack of wetland and riparian

restoration could perpetuate the scarcity and decline of and important montane riparian forests, aspen woodlands, and shrublands.

Altered fire regimes would likely have a significant effect on the species composition and stand structure of plant communities not only in terms of forest encroachment, but also in terms of increased fuels hazards, elevated risk of stand replacing events and possible reduction of long-term site productivity. Grassy understories adjacent to the valles and meadows may benefit from wildfire as they appeared to have done after the Las Conchas burn, but the full effects of wildfire on other forest systems are as yet unknown. Understory response in forb, sub-shrub and shrub dominated understories has been much slower. Forb, sub-shrub, and shrub communities were almost entirely consumed by the fire, leaving vast acreages of exposed bare-soil (see Figure 5-1) —even where aspen and Gambel oak regeneration was relatively strong. The Las Conchas fire, produced extreme heating and post-fire erosion, affecting soil productivity but the long-term consequences remain to be seen.

Figure 5-1. Woodland area severely burned in the Las Conchas wildfire

Riparian and Wetland Restoration

Without management action the condition and trends identified in chapter 4 would continue. Based on a review of monitored outcomes key measures such as diversity have stabilized. The current extent of riparian and wetland vegetation also appears to be stable although no specific measures have been taken to measure if any trend (loss) is occurring.

Road Management and Burned Area Rehabilitation

Indirectly lack of management and erosion control actions would have continued long-term, albeit localized, impacts on vegetation.

Noxious Weed Control and Eradication

Noxious weeds pose a potential threat to understory plant communities as well. Although efforts to eradicate exotic thistles are ongoing, alternative 1 would prevent expanded options for control and eradication of these invaders. Treatment of other invasive species on the preserve such as cheatgrass would not occur, and provisions would not be in place to begin treating any new weeds that may be introduced in the future. As a result, native understory species diversity and composition would be at risk both from direct competition with weed species and indirect effects such as altered fire regimes that can accompany species like cheatgrass (Jackson 2012).

5.2.4 Environmental Consequences - Action Alternatives

As indicated in Table 5-6 below and the following narrative, minor localized adverse impacts could occur as a result of disturbance, however, the impacts overall are anticipated to be beneficial. The benefits of treating a portion of an ecotype would extend to the landscape scale as the ecological condition of the forest type is measured by the distribution of s-class across the landscape. The benefits extend past any single ecotype to all ecotypes present in the landscape. The benefits extend beyond simply an improvement to ecological condition reducing threats such as wildland fire and erosion. The benefits extend in time as we initiate a trend towards developing large and old forest structure.

Table 5-6. Environmental consequences summary table: forest vegetation and ecological condition; action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Certain
	↑Indirect	Project level, Landscape level - region	Minor - moderate	Potential
	↑Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	↓Direct	Project level	Minor	Certain
	↑Indirect	Project level, Landscape level	Minor - moderate	Potential
	↑Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	↓Direct	Localized	Minor	None
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Riparian Restoration	↓Direct	Localized	Minor	Certain
	↑Indirect	Landscape level	Minor - moderate	Potential
	↑Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	↓Direct	Localized	Negligible	Certain
	↑Indirect	Landscape level	Minor - moderate	Potential
	↑Cumulative	Landscape level	Minor - moderate	Potential
Burn Area Rehabilitation	↑Direct	Localized	Minor	Certain
	↑Indirect	Landscape level	Minor -moderate	Potential
	↑Cumulative	Landscape level	Minor - moderate	Potential

Table 5-7 below summarizes the proposed mechanical treatment areas by forest type and prescription for each action alternative from chapter 2. Alternative 2 prioritizes 21,495 acres for mechanical treatment outside the Las Conchas fire area; alternative 3 prioritizes mechanical treatments on 23,498 acres. Management prescriptions include aspen restoration (ASRE), forest health (FOHE), hazardous fuels reduction (HFRE), and restoration treatments (REST). In most cases, mechanical treatments would be followed with prescribed fire. Both alternatives include prescribed burning within mechanically treated areas and as a stand-alone treatment and both alternatives include the option to manage lightning caused fires to achieve resource benefits.

The action alternatives are *intended* to affect forest vegetation and ecology. Directly, indirectly and cumulatively, we intend to change the structure and composition of each forest type found on the

preserve at the landscape level. The intent is to improve the ecological condition; to create a condition (at the landscape level) that is more resilient and sustainable in the event of disturbances such as fire and insects as well as climate events (drought) and even shifts in climate (warming and drying). Both alternatives would create a trend towards the reference condition by moving thinned areas from s-class B (mid-aged, closed) to s-class C (mid-aged open). The overall improvement in VCC (ecological condition rating) is limited, as thinning alone will not move forests into more mature s-classes – only time can accomplish that.

Alternatives 2 and 3 would create the same beneficial outcomes in both montane grasslands, and forest meadows. Outcomes in ponderosa pine savannas and woodlands, dry-mesic mixed conifer, blue spruce vegetation as well as Gambel oak dominated montane shrublands would also be the same. Alternative 2 would benefit more acres of wet-mesic mixed conifer, aspen-mixed conifer, and spruce-fir vegetation than alternative 3. However, alternative 3 by prescribing more acres of mechanical aspen restoration treatments (8,726 acres) than alternative 2 (2,333 acres) has the potential to benefit aspen to a greater degree. Stimulation from mechanical treatment and prescribed fire has been demonstrated to initiate aspen regeneration. However, there is uncertainty as to whether the young aspen will persist beyond the seedling stage due to effects from browsing and climate.

Table 5-7. Mechanical treatment prescription acres by alternative

	Alt 2					Alt 3			
Activity	ASRE	FOHE	HFRE	REST	Total	ASRE	HFRE	REST	Total
Mechanical	2,020	5,480	2,900	11,095	21,495	9,677	522	11,095	23,498

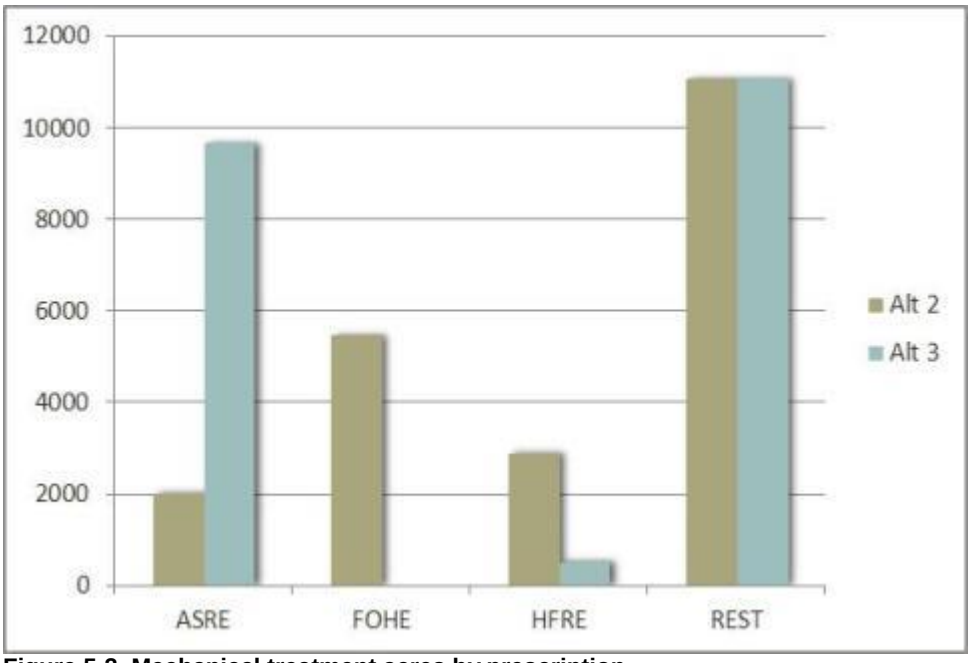


Figure 5-2. Mechanical treatment acres by prescription

5.2.5 Direct Effects - Forest Thinning and Wildland Fire Management

Forest thinning directly improves the health and vigor of the residual forest and understory. Thinning changes the environment of the forest. The penetration of light, the temperature of mineral soil, and the availability of moisture and nutrients are all increased. Understory vegetation quickly responds to these changes, producing a more favorable habitat for wildlife. A relationship between forage increase and reduced basal area has been demonstrated. The diminished canopy that results from thinning allows greater amounts of rain to reach the forest floor, which increases the quantity of water from the watershed by reducing competition for moisture, nutrients and sunlight and increasing the amount of sunlight and moisture available (USDA - Forest Service 1985). Good forest management including thinning has long been recognized as a means of maintaining healthy forest stands, promoting resistance to insects such as pine beetle, and promoting genetic improvements (USDA - Forest Service 1985).

Although there are a variety of methods and models available to develop and model effects to forest health and vigor, all show a positive outcome in various measures. An example using the multi-aged stocking assessment model (MASAM) of a stand in four age classes showed an inverse relationship between the number of trees in each age class and the leaf area index and measures of tree vigor (O'hara, 2009).

As the Las Conchas fire has shown, grass response after burning is likely to be rapid and vigorous. Forb, sub-shrub, and shrub re-growth would likely be slower, perhaps taking a season or more to establish. Species like aspen and Gambel oak may sprout shortly after treatments, but after severe fire significant amounts of bare soil may persist at least until the following growing season. While mixed severity fire can induce desirable changes in understory vegetation, burning under these management alternatives is largely expected to maintain existing vegetation communities and provide a maintenance tool in the follow-up to mechanical treatments.

The understory response to prescribed burning was carefully measured following the Valle Toledo prescribed burn. All measures (cover, vigor, nutrient content, diversity) showed a direct benefit from fire (Parmenter, et al. 2007).

Minor and localized impacts to vegetation can result from equipment damage and disturbance. Localized effects at the project level are known to result from forest thinning. The trust has found the context and intensity of such effects is insignificant at the project level barring the presents of extraordinary circumstances such as potential impacts to cultural resources, sensitive soils, or habitat for threatened or endangered species (Federal Register 2003). Performance requirements listed in chapter 2 are designed to eliminate or mitigate potential adverse effects at the project level.

5.2.6 Indirect Effects – Forest Thinning and Wildland Fire Management

As individual stands were treated over the next 10-years, there would be a measureable change in ecological condition at the landscape scale as measured by VCC methodology.

Recall from chapter 2, alternatives 2 and 3 propose to treat a similar number of acres during the 10-year planning period (21,495 acres and 21,295 acres, respectively). Both alternatives would prioritize treatment in ponderosa pine and xeric mixed conifer forest types. Alternative 2 also prioritizes forests with the greatest fire behavior potential while alternative 3 prioritizes forests with the greatest potential to regenerate aspen.

Indirect Effects Summarized by Thinning Prescription

Thinning prescriptions vary within vegetation types but all thinning prescriptions would move the treated forest to an open s-class. Generally this means a forest currently identified as an s-class B (mid-age, closed) would move to an s-class C (mid-age, open) with the initial mechanical treatment. The thinning prescriptions would be classified silviculturally, as *variable density thinning*, where cut trees are selected primarily from the lower crown classes with other characteristics (species, form, vigor) also given consideration(Hunter, et al. 2007). This strategy is intended to create a trend towards uneven aged forests with all size classes well represented. It is also known to be an effective strategy for reducing wildfire hazard (Hunter, et al. 2007). Silvicultural prescriptions that select trees from the higher crown classes (*crown* or *selection thinning*) or thin forests to a prescribed spacing (*geometric thinning)* are not as effective at reducing crown fire as they do not inherently raise crown base height (Hunter, et al. 2007). Prescription guidelines from chapter 2 were modeled in the Forest Vegetation Simulator (FVS) (Dixon 2002) to determine the effect of each on vegetation composition and structure. These general effects are summarized below by prescription guidelines.

Restoration

The restoration prescription reduces canopy cover and basal area within the ponderosa pine woodland, dry-mesic montane mixed conifer, and ponderosa pine savanna forest types. This prescription results in a direct effect on vegetation structure, primarily in converting mid-closed forests to mid-open conditions leaving clumps of trees and openings.

Aspen Regeneration

The aspen regeneration prescription targets conifer species growing in and adjacent to aspen trees within the aspen-mixed conifer, mesic montane mixed conifer, and xeric spruce-fir forest types. This prescription has a direct effect on vegetation structure and vegetation composition by opening closed canopies and promoting aspen dominated stands.

Forest Health

The forest health prescription reduces tree densities, targeting suppressed, damaged, and diseased trees within the mesic montane mixed conifer forest types. This prescription has a direct effect on vegetation structure, primarily in converting closed to open conditions, however to a lesser degree than the restoration prescription. These forests will move from mid-closed to mid open but feature move of a two-story forest structure rather than clumps and openings.

Hazardous Fuels Reduction

The hazardous fuels reduction prescription removes subordinate trees and reduces canopy continuity within the subalpine dry-mesic spruce-fir forest types and on slopes greater than 25 percent within the mesic montane mixed conifer and aspen-mixed conifer forest types. This prescription has a direct effect on vegetation structure.

Indirectly, the forests within the treated area would benefit by the reduced potential for fire to burn with uncharacteristic severity or extent. This benefit would be equally realized in the ponderosa pine and xeric mixed conifer forests under either alternative. Within the mesic mixed conifer, aspen/mixed conifer and spruce fir forests alternative 2 would treat 14 percent more of the forests with the greatest fire behavior potential (FIS class 5) than would be treated under alternative 3. However, both alternatives 2 and 3 would meet the objective level of hazard reduction, reducing the forests likely to burn as a crown fire (FIS class 4 and 5) by similar amounts (51 and 48 percent respectively).

The VCC methodology inherently includes these basic ecologic concepts in rating conditions over the landscape. As presented below the different approaches to selecting stands for treatment result in slightly different VCC measures at the landscape scale.

Indirect Effects Summarized by Fire Regime

FVS was used to predict the conversion of s-class and ultimately changes in condition class at the landscape scale; this analysis is organized by fire regime. The indirect effects of forest vegetation and ecological condition are followed by a description of the direct and indirect effects to understory plant communities.

Fire Regime I

Forest Vegetation, Ecological Condition

As noted both action alternatives prioritize the treatment of these forests. Overall both alternatives would restore the forests adapted to frequent fire from a high departure VCC 3 rating to a moderate departure VCC 2 rating at this level of analysis.

The VCC rating of the pure ponderosa pine grassland savanna would not be changed by the proposed action. This forest type was less departed as the fringes that ring the valles were well represented by mid-age open forests. Thinning and follow up burning would improve the conditions in the southwest corner and would maintain the existing open forests as they develop into late-open forests.

A marked improvement would be measured in the ponderosa pine and xeric mixed-conifer forests moving them from VCC ratings of *High* to *Moderate* (79 and 82 to 64 and 65 respectively). The over-representation of mid-age open vegetation sets a proportion of these forests on a trajectory to transition into the much needed late-seral open stage which would improve the ecological condition and associated VCC rating further.

Table 5-8. Predicted condition rating (VCC) in fire regime I forest types under alternatives 2 and 3

Class	A	B	C	D	E	UE	UN	Total
Southern Rocky Mountain Ponderosa Pine Savanna								
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	73	27	0	0	0	0	100
Current VCC Rating								2 (65)
Alternative 2 and 3	0	13	87	0	0	0	0	100
Predicted VCC Rating								2 (65)
Southern Rocky Mountain Ponderosa Pine Forest and Woodland								
Reference Condition	10	10	25	40	15	0	0	100
Existing Condition	0	89	10	1	0	0	0	100
Current VCC Rating								3 (79)
Alternative 2 and 3	0	21	78	1	0	0	0	100
Predicted VCC Rating	0	10	10	1	0	0	0	2 (64)
Southern Rocky Mountain Dry-mesic Mixed Conifer								
Reference Condition	15	15	10	50	10	0	0	100
Existing Condition	0	97	3	0	0	0	0	100
Current VCC Rating								3 (82)
Alternative 2 and3	0	56	44	0	0	0	0	100
Predicted VCC Rating								2 (65)

Understory Vegetation

Approximately 8,624 acres of ponderosa pine woodland and savanna, blue spruce and dry mixed conifer forest would be mechanically treated under both alternatives using restoration prescriptions. Treatments would leave the largest diameter trees and reduce overstory canopy closure by more than 40 percent in most areas. Thinning of the overstory would likely have the greatest benefit on grass growth over approximately 11 percent of the proposed treatment area, which is composed primarily of grassland soils (mollisols) that support grassland and ponderosa savanna vegetation (Figure 5-3). Treatment of ponderosa pine would restore and maintain herbaceous understory components like Arizona fescue, Parry's oatgrass and an assortment of grassland forbs. Heavy thinning in ponderosa pine types is also likely to promote important browse species like Gambel oak on another 5 percent of the proposed treatment area where conifer encroachment and fire suppression has or may inhibit growth on droughty, rocky, shallow, or otherwise poorly developed soils such as inceptisols. Aspen inclusions, mapped on forest soils that cover approximately 11 percent of the prescription area, would also benefit from higher levels of ponderosa and mixed conifer canopy reduction. Maintenance or stimulation of the aspen component could lead to type conversion to true aspen forest over time, encouraging understories consisting of Thurber fescue, junegrass, dryspike sedge, vetch, pea, and bluebell bellflower on those sites.

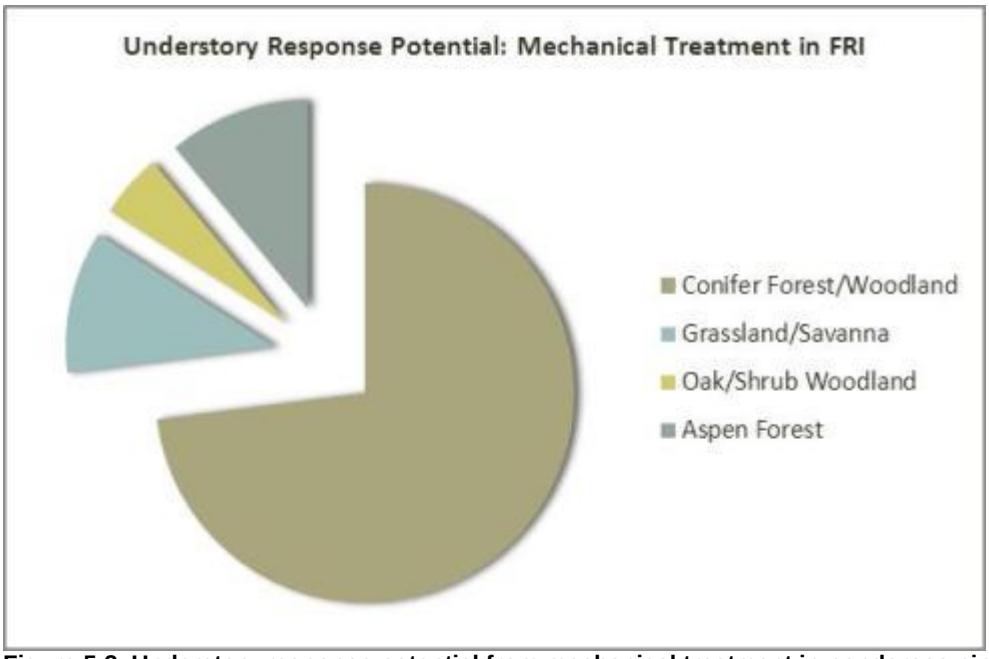


Figure 5-3. Understory response potential from mechanical treatment in ponderosa pine forest and savanna and xeric mixed conifer forest

Approximately 73 percent of soils within the prescription area are mapped as forest soils and support conifer forest and woodland climax vegetation. More intensive thinning is likely to have its greatest effect on understory vegetation along the edges of forest soils like alfisols. For instance, heavier thinning of mixed conifer may help maintain upslope ponderosa pine woodlands and savannas, and ponderosa pine/common juniper plant associations that might otherwise be lost to vegetation succession (Muldavin and Tonne 2003). Although herbaceous species may increase along the ecotone between forest and savanna or grassland, intensive thinning in the middle of dry-mesic mixed conifer stands is not likely to convert these forest sites to herbaceous vegetation communities over the long-term. Rather, most treatments would likely encourage species like whortleberry, mountain ninebark, myrtle boxleaf and creeping barberry, and are therefore well suited to lighter levels of thinning. Lighter treatments of blue spruce on forest soil types may benefit species like dryspike sedge and forest fleabane, and are not expected to result in type conversion to grassland. Lighter thinning operations or group selection would protect sites from erosion and wind-throw, and preserve a woodland character. Heavier thinning of blue spruce would have its greatest effect, in terms of stimulating herbaceous plant growth, where it has spread out onto mollic soils in the valles.

6,395 acres of ponderosa pine woodland and savanna, blue spruce and dry mixed conifer forest are proposed for burning under alternatives 2 and 3 (in addition to prescribed fire in association with mechanical treatment). Treatments are anticipated to maintain woodland species composition common to mixed conifer forests on about one-third of proposed burn acres. Burning in blue spruce would likely stimulate herbaceous grassland plant growth because prescriptions would be applied to stands on grassland soils (encroachment) and blue spruce is especially susceptible to fire mortality. However, grassland restoration is expected to be small-scale due to the limited amount of area proposed for treatment. The majority of grassland maintenance and restoration opportunity exists on mollic soils in the ponderosa pine types, where fire may be used to reverse recent encroachment. The biggest

potential opportunities to increase desirable vegetation (in terms of acreage) are with aspen and Gambel oak/montane shrub communities (Figure 5-4). Aspen regeneration proved to be prolific after the Las Conchas fire and is expected to benefit under each action alternative (with alternative 3 having a slightly higher potential). Potential response is likely to be greatest in cooler (generally north-facing) microsites. But aspen may represent an earlier seral stage in some areas, reverting to conifer-dominated forest in a short timeframe. The amount of type conversion to aspen woodland would depend upon site-specific objectives, fire return interval, burn severity, and potential combination with mechanical treatments that may reduce coniferous overstory canopy over the long-term. Gambel oak regeneration after the Las Conchas fire was also prolific, sprouting in areas where it had not been previously mapped. Little of the area targeted for burning currently has Gambel oak in the species composition. However, slightly less than one-third of the proposed wildland fire treatment area indicates potential for Gambel oak and associated shrub species. Although Gambel oak has been documented on north facing slopes in Valle Seco, burning is expected to be especially beneficial to montane shrublands on south facing slopes where soils are shallower, rocky, droughty, and generally display poor development (the northern rim of the caldera, for instance).

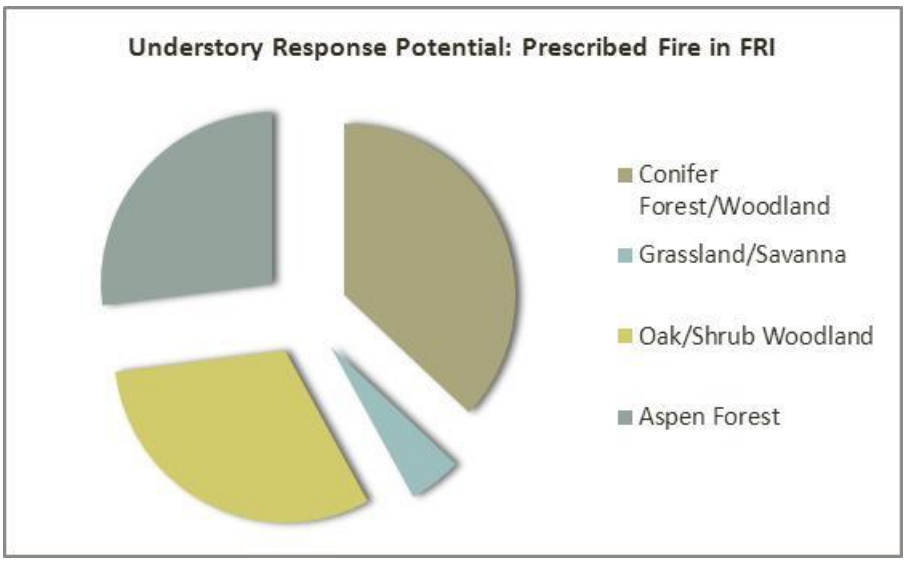


Figure 5-4. Understory response potential from prescribed burning in FR I

Fire Regime III

Forest Vegetation, Ecological Condition

Within the cooler, moist mesic mixed conifer forests, both alternatives are predicted to move this forest type within the treatment area to within the historic range of variability of the reference period. Moving the amount of mid-aged closed forests from *abundant* to *similar* and setting a trajectory for future forests to develop to late development seral stages.

Compositionally, alternative 3 is intended to increase aspen composition. The stands selected for thinning under alternative 2 (those with the greatest fire behavior potential) would not be expected to increase the presence of aspen in the overall composition of the landscape to the same degree.

Within the aspen/mixed conifer forests, the aggressive treatment of the existing aspen forest would actually create a greater degree of departure than presently exists as forests in the mid-age open class became *over represented* relative to the reference condition. The intent would be to aggressively move these forests into a trajectory to the late, open seral stage.

As previously noted, aspen on the preserve may have actually benefitted by historic logging (TEAMS Enterprise Unit, 2007), which likely increased its distribution on the preserve even under a century of fire exclusion. However, at the regional scale and within the intermountain west, aspen is declining (O'Brien, et al. 2010). There are complex, intertwining causes for the decline including climate, the exclusion of fire, and grazing by domestic and wild ungulates. Because the direct impact of forest thinning i.e. creating more open forest structure, also modifies soil moisture the effects to aspen are uncertain. While more open stands increase the capture and storage of precipitation in the watershed, increased drying, localized in time and space, may also result.

There is a risk of indirect adverse effects from aggressive aspen restoration. Monitoring and adaptive management would identify such outcomes but perhaps not in a timely enough manner to adjust the actions or prescriptions. Alternative 2 does not prioritize the restoration of aspen. And would result in further delay of recruitment of aspen into the later development seral stages. However, monitored outcomes could be evaluated and contribute to more effective treatments in the future. Performance requirements in chapter 2 include guidelines for restoration and monitoring made by the Utah Forest Restoration Working Group (O'Brien, et al. 2010). These performance requirements are intended to minimize the risk of unintended, indirect effects to the composition, function, and structure of aspen at the landscape scale.

Table 5-9. Predicted condition rating (VCC) in fire regime III forest types under alternatives 2 and 3

Class	A	B	C	D	E	UE	UN	Total
Southern Rocky Mountain Wet-mesic Mixed Conifer								
Reference Condition	10	40	25	10	15	0	0	**100**
Existing Condition	0	96	0	4	0	0	0	**100**
Current VCC Rating								**2 (56)**
Alternative 2	0	47	49	4	0	0	0	**100**
Predicted VCC Rating								**1 (31)**
Alternative 3	0	51	45	4	0	0	0	**100**
Predicted VCC Rating								**1 (31)**
Intermountain Basin Aspen/Mixed Conifer								
Reference Condition	25	40	5	30	0	0	0	**100**
Existing Condition	0	98	2	0	0	0	0	**100**
Current VCC Rating								**2 (58)**
Alternative 2	5	47	48	0	0	0	0	**100**
Predicted VCC Rating								**2 (55)**
Alternative 3	10	21	69	0	0	0	0	**100**
Predicted VCC Rating								**3 (64)**

Understory Vegetation

Approximately 8,991 acres of aspen-mixed conifer and wet-mesic mixed conifer have been proposed for mechanical treatments under alternative 2. Approximately 9,571 acres of aspen-mixed conifer and wet-mesic mixed conifer have been proposed for mechanical treatments under alternative 3. Alternative 3 proposes 7,657 more acres of the more intensive, aspen restoration prescription than alternative 2. The majority of treatments would reduce overstory canopy cover by 20-40 percent under both alternatives. Prescriptions would include restoration, aspen restoration and hazardous fuels reduction emphasizing the removal of ladder fuels, trees impacted by insects, trees with visible signs of damage or disease, and fire intolerant species such as white fir, blue spruce, and Engelmann spruce. The largest, most vigorous aspen, Douglas-fir, and ponderosa pine, would be favored for retention along with limber pine while other overstory conifers that shade aspen may be targeted for removal.

Alternatives 2 and 3 would likely maintain mixed conifer forest and woodland vegetation on fifty one percent of their respective acres (Figure 5-5 and Figure 5-6). Treatments would likely promote forbs like forest fleabane, woodland strawberry, and Canadian white violet. Grasses like Thurber fescue, Parry's oatgrass, Arizona fescue, and pine dropseed (near montane grasslands), and Rocky Mountain Trisetum, fringed brome, and Ross' sedge (on high exposed ridges) are likely to respond to treatments on the edges of mixed conifer stands and on grassland soils that occupy approximately eight percent of the acres proposed in alternative 2 and three percent of the acres proposed in alternative 3. Understory response would likely be greater in areas with the most overstory canopy reduction, especially amongst the grass species. Understory species in forest stands that are further from forest edges may benefit more from lighter thinning treatments.

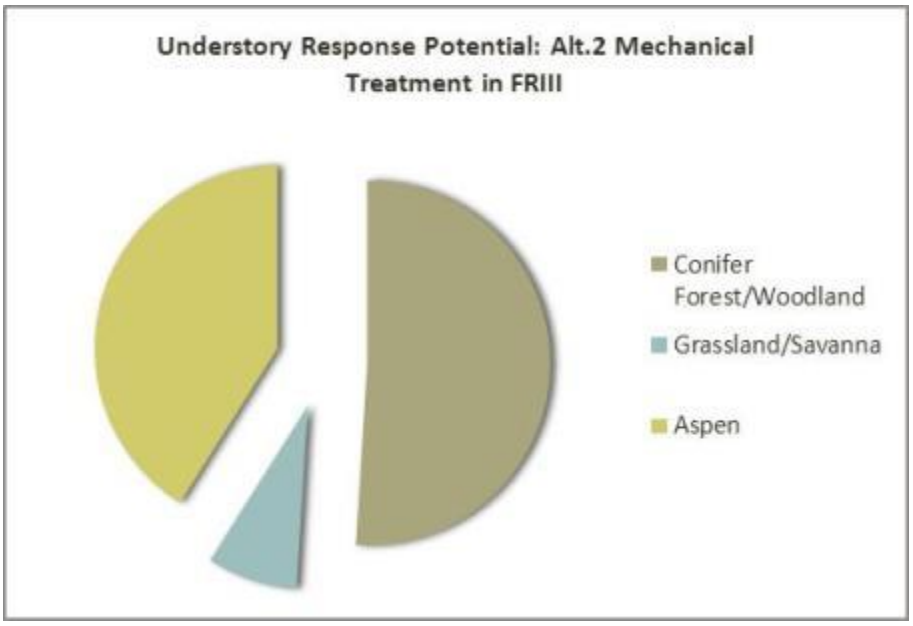


Figure 5-5. Alternative 2 understory response potential from mechanical treatments in FR III

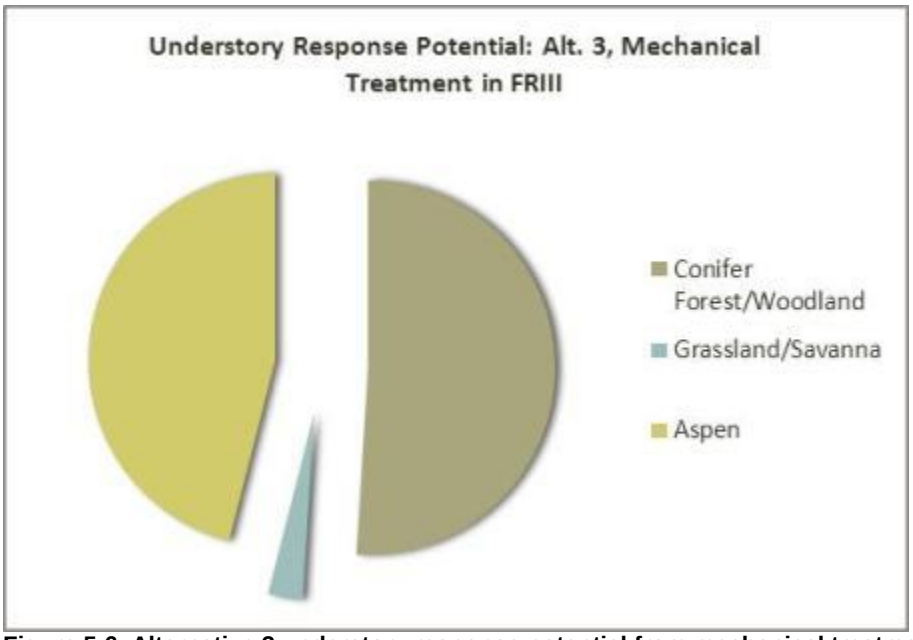


Figure 5-6. Alternative 3 understory response potential from mechanical treatments in FR III

Aspen regeneration alternative 3 potential was mapped on approximately 41 percent of acres proposed in alternative 2 and on 46 percent of acres proposed in alternative 3. However, as previously noted, alternative 2 is more judicious in its application of the more intensive, ASRE prescription. Aspen will likely respond favorably to thinning removal treatments under both alternatives. Where aspen expands, or is currently a common component, understory plants like Rocky Mountain maple, five-petal cliffbush, rock spirea, gooseberry, snowberry, and Fendler's brickellbush are expected to increase along with aspen. Conversion to true quaking aspen forest over time may also result in more understory species such as meadow rue, stickwilly bedstraw and geranium. Kentucky bluegrass may also increase where thinning treatments are located adjacent to disturbed areas such as old clear-cuts.

Approximately 3,863 acres of mesic mixed conifer and aspen-mixed conifer are proposed for burning treatments under alternative 2 and 7,169 acres are proposed for burning under alternative 3. Wildland fire prescriptions would promote low to mixed severity and intensity fire with patchy continuity across the landscape to reduce hazardous fuels, restore structure and composition, and dispose of biomass resulting from mechanical treatments. For alternative 2, nearly 50 percent of burn acres would likely maintain the character and species composition of mesic mixed conifer forests (Figure 5-7). Aspen maintenance and recruitment potential exists on 47 percent of the proposed acreage. For alternative 3, potential aspen maintenance and recruitment acres exist on 46 percent of the proposed area (Figure 5-8).

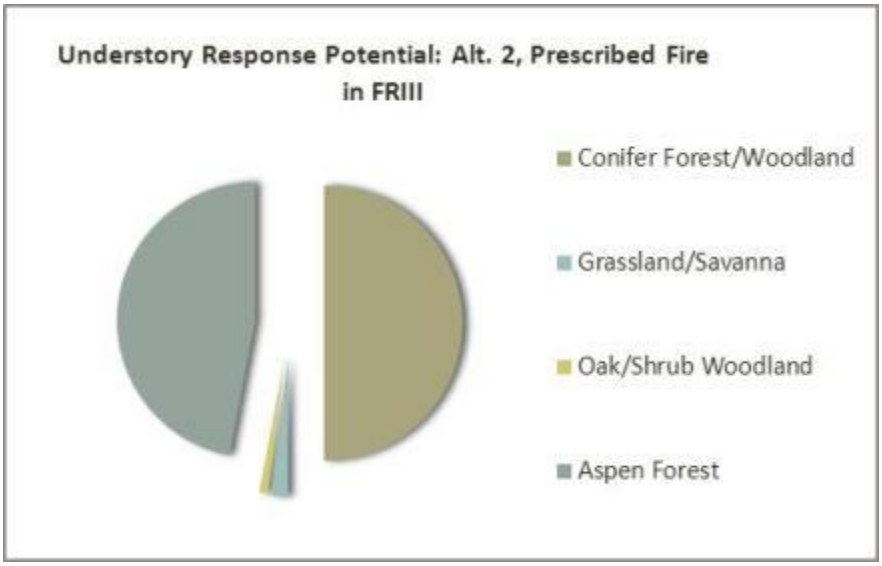


Figure 5-7. Alternative 2 understory response potential from prescribed burning in FR III

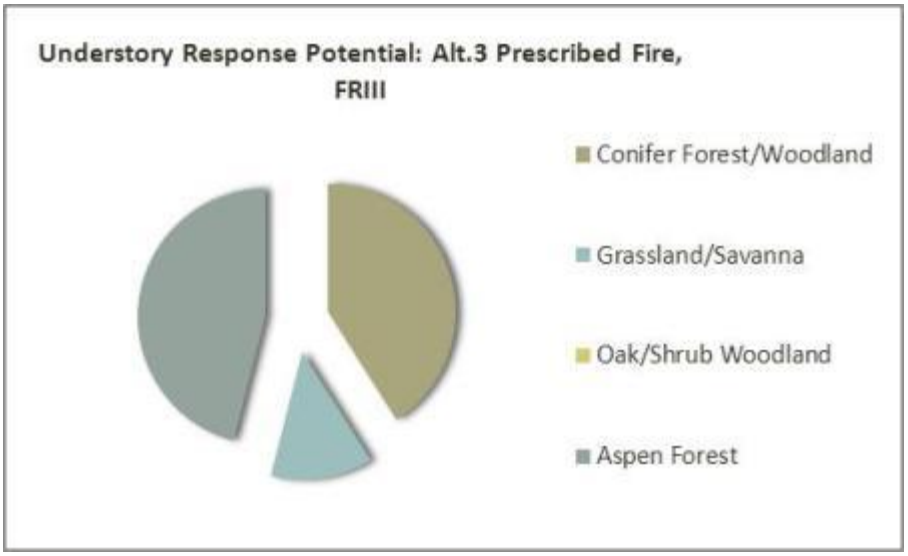


Figure 5-8. Alternative 3 understory response potential from prescribed burning in FR III

Fire Regime IV

Forest Vegetation, Ecological Condition

These high elevation forests are adapted to long periods between disturbances and are less sensitive to over-representation of forests in the mid-age seral stages. Alternative 2 would move more of this forest type to a trajectory to the later development classes, which were largely obliterated by past logging. However, as shown in Table 5-10 below, the effects to the landscape measure of ecological condition are not distinguishable.

Table 5-10. Predicted condition rating (VCC) in fire regime IV forest types under alternatives 2 and 3

Class	A	B	C	D	E	UE	UN	Total
Rocky Mountain Subalpine Dry-mesic Spruce-fir								
Reference Condition	15	20	15	20	30	0	0	**100**
Existing Condition	0	94	6	0	0	0	0	**100**
Current VCC Rating	0	20	6	0	0	0	0	**3 (74)**
Alternative 2	0	70	30	0	0	0	0	**100**
Predicted VCC Rating	0	20	6	0	0	0	0	**2 (65)**
Alternative 3	0	81	19	0	0	0	0	**100**
Predicted VCC Rating	0	20	6	0	0	0	0	**2 (65)**
Southern Rocky Mountain Wet-mesic Spruce-fir								
Class	A	B	C	D	E	UE	UN	**Total**
Reference Condition	15	20	15	20	30	0	0	**100**
Existing Condition	0	76	24	0	0	0	0	**100**
Current VCC Rating								**2 (65)**
Alternative 2	0	41	59	0	0	0	0	**100**
Predicted VCC Rating								**2 (65)**
Alternative 3	0	76	24	0	0	0	0	**100**
Predicted VCC Rating								**2 (65)**

Understory Vegetation

Alternative 2 proposes to mechanically treat approximately 1,209 acres of wet and dry mesic spruce-fir forest versus 429 acres under alternative 3. Hazardous fuels reduction prescriptions would be used to reduce the potential intensity and severity of wildland fire across the landscape, selecting small, diseased or damaged trees for removal—mostly white fir, subalpine fir, and small diameter Engelmann spruce. Healthy and larger Engelmann spruce, Douglas-fir, and aspen would be favored for retention. Wildland fire prescriptions would promote low to mixed severity and intensity fire with patchy continuity to reduce hazardous fuels, restore structure and composition, and dispose of biomass resulting from mechanical treatment. Canopy cover would be reduced by more than 40 percent over most areas under each alternative; followed by twenty to 40 percent reductions and less than twenty canopy reductions. Alternative 2 would encourage spruce-fir understory vegetation on the majority of proposed treatment areas (Figure 5-9). Dry mesic sites will tend to encourage growth of whortleberry along with a few scattered forbs and grasses whereas operations on moist mesic sites will tend to encourage plants like forest fleabane, strawberry, Canadian violet, fringed brome and northern bedstraw. Parry's oatgrass will tend to respond where forest and woodland vegetation lies on exposed northerly ridges and slopes, and adjacent to montane grasslands. Dryspike sedge may decline somewhat where closed forest canopies are opened. Aspen response is expected on 36 percent of proposed acres under alternative 2 and represents the largest potential aspen increase between the two alternatives. Where aspen is currently a common understory component, regeneration is expected to be prolific and possibly result in a transition from spruce-fir to aspen woodland. Understory species in new aspen woodlands are expected to resemble those described for aspen associations in mixed conifer forests, and would benefit from heavier thinning treatments. Alternative 3 will also maintain a significant spruce-fir understory component, but aspen and montane shrub regeneration potential exists on a significant portion of the treatment area as well (Figure 5-10). These latter two vegetation types would also benefit from greater

amounts of conifer thinning and are expected to occur in similar microsites as described for previous vegetation types.

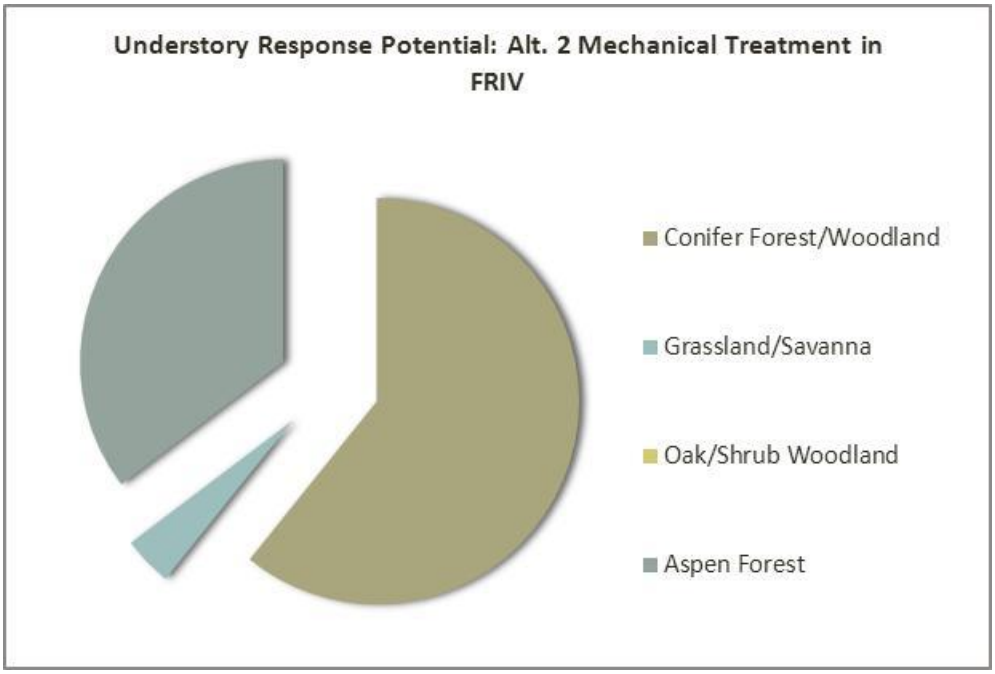


Figure 5-9. Alternative 2 understory response potential from mechanical treatment in FR IV

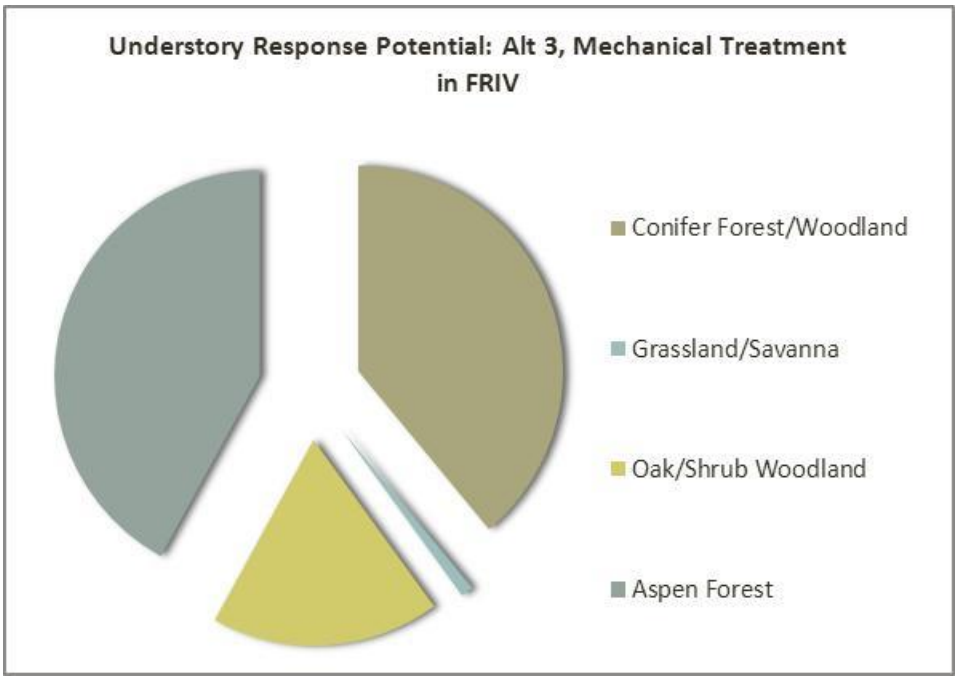


Figure 5-10. Alternative 3 understory response potential from mechanical treatment in FR IV

In addition to prescribed burning in association with thinning, burning alone is also proposed on 2,273 acres of spruce-fir forest under alternative 2, and on 4,464 acres under alternative 3. Spruce-fir vegetation would likely be maintained on a majority of the acreage within each alternative (Figure 5-11

and Figure 5-12). However, aspen maintenance and regeneration opportunities exist on a large number of acres as well. Alternative 3 would potentially result in the most benefit to aspen vegetation.

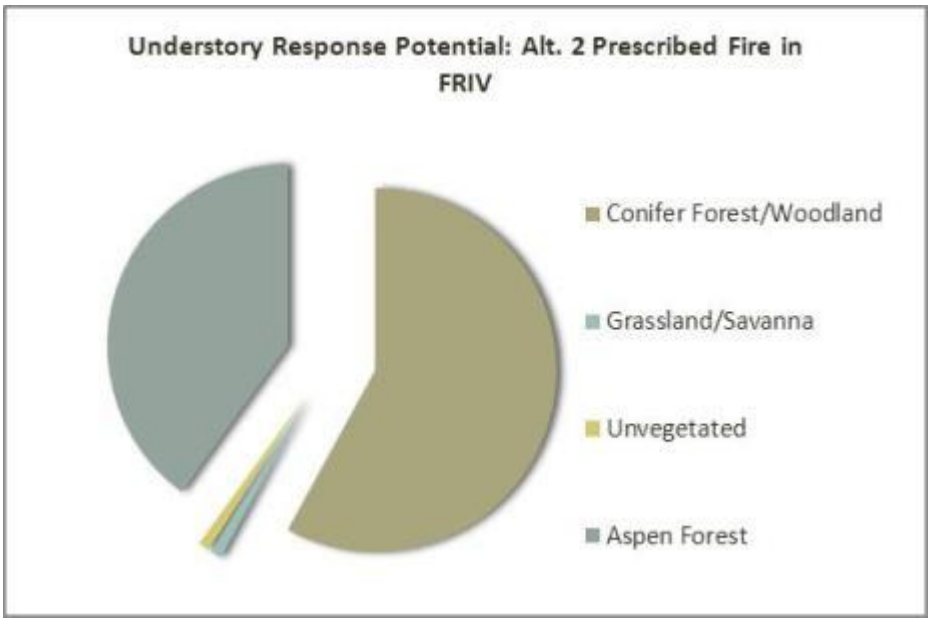


Figure 5-11. Alternative 2 understory response potential from prescribed burning in FR IV

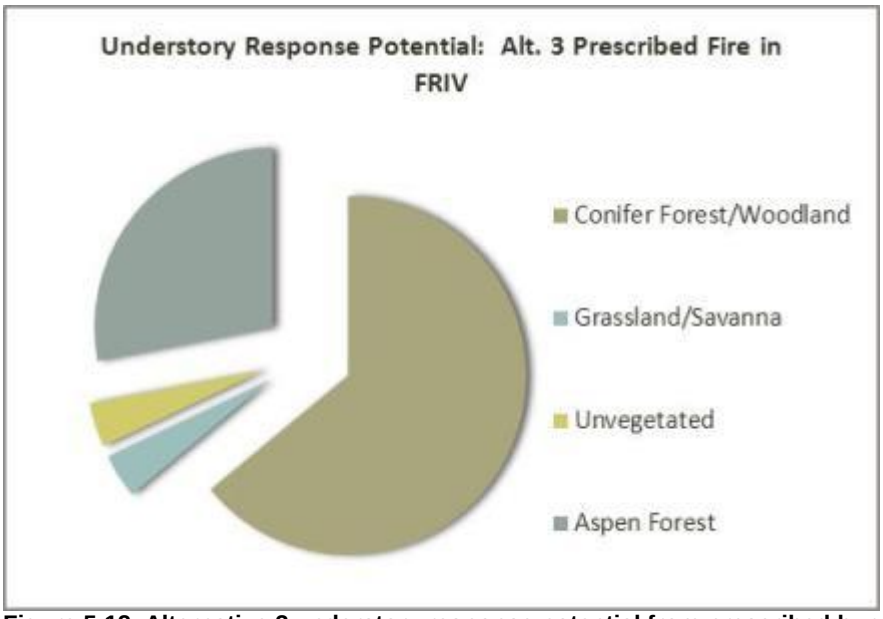


Figure 5-12. Alternative 3 understory response potential from prescribed burning in FRIV IV

Montane Grasslands

Approximately 3,386 acres of grasslands and forest meadows are proposed for mechanical treatment under both alternatives. The proposed treatments would remove greater than 40 percent of the overstory canopy in order to reverse forest and woodland encroachment. Where ponderosa pine trees have encroached into the grasslands, prescriptions would call for retaining small well-spaced groups of

the healthiest trees. Where blue spruce trees are encroaching, the blue spruce would be lightly thinned in an irregular pattern to reduce the susceptibility to wind throw and protect soils, while enhancing watershed function. Wildland fire would be used in these forest types to reduce hazardous fuels, restore composition and structure, or dispose of biomass resulting from mechanical treatment. Roughly 47 percent of the total treatment acres are mapped on grassland soils (mollisols) or are otherwise expected to support climax vegetation communities where grassland species dominate (Figure 5-13). About one-third of those acres currently support grasslands and may not require extensive treatment. The other two-thirds of those acres support ponderosa pine savanna and other plant communities where treatments may have a significant effect on grassland restoration. Higher levels of canopy reduction would have the greatest effect on these sites and encourage species like Parry's oatgrass, Thurber fescue, Arizona fescue, and pine dropseed in and around ponderosa pine stands and on the fringes of blue spruce stands. Roughly 53 percent of the total proposed acres are mapped on forest soils or otherwise have site potentials that favor forest and woodland climax vegetation. Nearly one-third of that area has an aspen component that may also respond favorably to heavier canopy reduction. Treatment of these sites would likely result in woodland vegetation with forb dominated understories rather than grassland restoration. Forest/woodland sites not containing aspen would likely remain forested over the long-term as well. Light thinning on forest soils may preserve understory species like dryspike sedge and forest fleabane. Less overstory removal would acknowledge site potential while limiting vulnerability to wind-throw or erosion where understory response may be somewhat slower and less vigorous due to species composition.

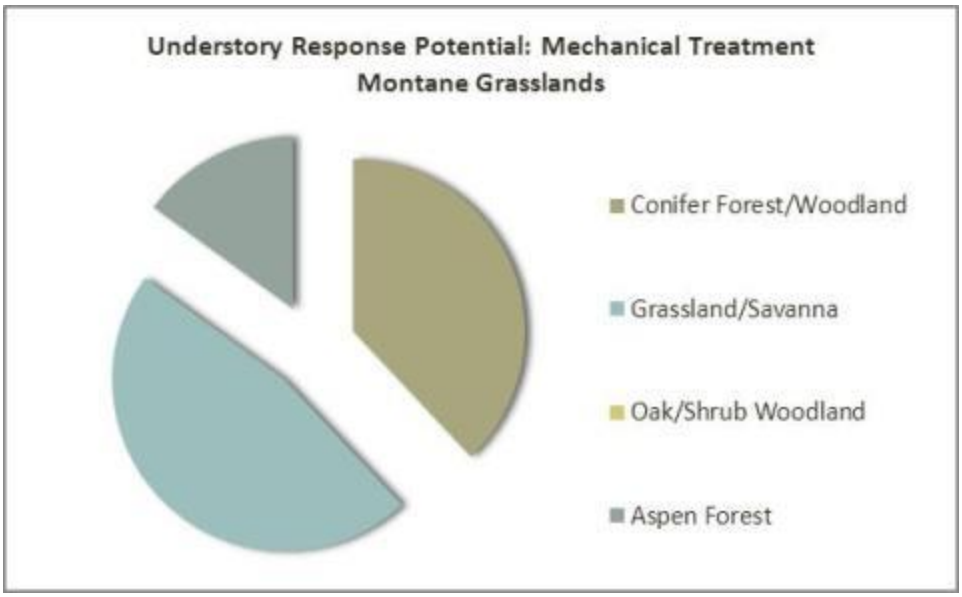


Figure 5-13. Action alternatives understory response potential from mechanical treatment in montane grassland

Mixed Montane Shrublands

Approximately 1,229 acres of montane shrubland (primarily Gambel oak) would be treated under the action alternatives. Mechanical treatments (or other methods such as controlled browsing by goats) would apply hazard reduction and restoration prescriptions to create patches and corridors of various size classes, emphasizing the retention of mature shrubs and trees. Prescribed fire would be applied with

low severity and intensity, patchy and discontinuous burning (<50 percent) across the landscape in order to restore structure and composition as well as dispose of biomass resulting from mechanical treatment.

It is expected that shrub species will respond favorably to heavy forest thinning treatments on 75 percent of the proposed acres (Figure 5-14). These acres occur on soils that tend to be less developed, shallow, rocky, or droughty. Sprouting would diversify age class and structure within aging and encroached stands. Treatments on lower southern exposures, especially, will tend to form dense canopies of Gambel oak, New Mexico locust, chokecherry, and currant with little understory composition. On upper southern exposures and ridgelines shrublands would likely tend to be more open and incorporate other shrubs like mountain mahogany, cliff-bush, and rock spiraea. Treatments in those locations will likely stimulate herbaceous species like sun sedge, mountain muhly, blue grama, slender wheatgrass, kingcup cactus, pineywoods geranium, Fendler's meadow rue, and false spring parsley. These herbaceous species would also respond well on the one percent of the proposed area that consists of grassland soils. Roughly 16 percent of the area, occurring on forest soils and under climax forest vegetation, would likely retain woodland characteristics described for other forested vegetation types, and are potentially best suited for lighter thinning operations. A minority of acres within the proposed area - likely in cooler microsites - exhibit aspen regeneration and recruitment potential. These areas may also favor heavier conifer thinning.

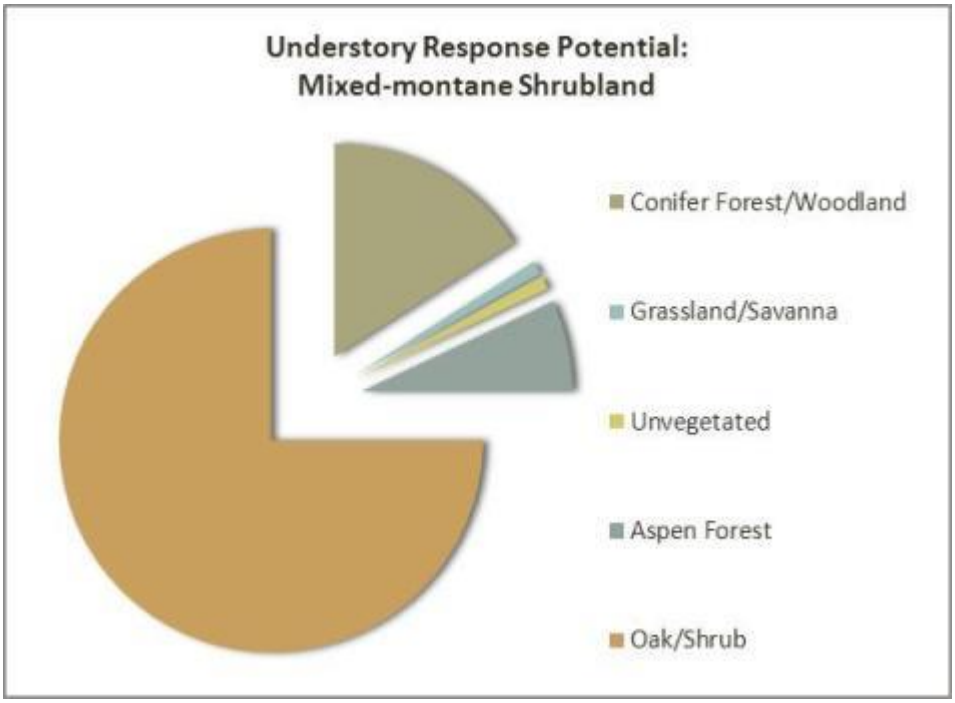


Figure 5-14. Action alternatives understory response potential from mechanical treatment in mixed montane shrublands

5.2.7 Direct and Indirect Effects - Other Proposed Management Actions

Road Management and Burned Area Rehabilitation

Decommissioned roads would initially re-vegetate with herbaceous or woody understory species, with specific composition depending upon surrounding vegetation types and moisture regimes. Over time, many of these areas would likely revert to forest vegetation, again depending upon adjacent vegetation types. Erosion control efforts would help preserve the productive potential of these sites over the long-term.

Riparian and Wetland Restoration

In combination with road management actions the preserve is also proposing to restore wetland and riparian areas. The objectives of this restoration work are to optimize interflow, minimize overland flow, increase base flow, reduce sediments, dissolved oxygen and other water quality impairments; and reduce stream temperatures. Restoration activities would include: stream bank and channel restoration to address site-specific erosion, planting trees and shrubs, placement of log and fabric dams, or Zuni bowl techniques to protect and restore wetlands and improve aquatic habitats. These efforts would directly and indirectly improve and expand montane riparian forests and shrublands through planting and habitat restoration.

Constructing exclosures and planting native assemblages of vegetation are expected to restore this vegetative type on the preserve where it likely existed historically but appears to be impacted by decades of grazing by livestock and browsing by elk (Allen, Oertel, et al. 2005).

Noxious Weed Prevention, Control and Eradication

Implementation of a comprehensive weed management strategy would also positively affect desirable understory species. Mechanisms for the control and treatment of noxious weeds would be in place to address current and future threats. Performance criteria would also ensure that desirable plants would not be adversely affected by invasive species management (see noxious weed section of this chapter).

Research, Inventory and Monitoring

Research, inventory, and monitoring activities would include inventory of floral and faunal habitats using non-destructive as well as destructive methods, measurement of ecosystem processes using temporary and permanent exclosures and instrumentation, and long term monitoring of various ecosystems and various scales using temporary and permanent plots and instruments. While some localized disturbance would occur, the effects of such actions are expected to be short-term and not detrimental. Rather, these activities would likely be beneficial over the long term because they would directly and indirectly contribute to the adaptive management and goal attainment.

5.2.8 Cumulative Effects

In this section we assess the impacts of the proposed action beyond the boundaries of the preserve using the VCC mapping tool. The VCC mapping tool requires raster-format data layers representing the biophysical settings[37] (BpS) and successional classes (s-class) of the preserve. These layers were acquired from the LANDIFRE program (LANDFIRE) and updated for recent disturbance within the preserve and surrounding Jemez Mountains. These data are coarse scale, national data sets and therefore produce different, but not contradictory results.

This section also looks at the cumulative effects to understory composition, structure and function.

As previously mentioned we performed the analysis of VCC and s-class RA at two levels. At the project landscape level all forest types were assess at the same scale – relative to the existing condition within the proposed treatment area. However, the analysis performed using the VCC mapping tool was performed at various scales consistent with published VCC mapping tool methodologies. It is necessary to assess individual BpSs at scales broad enough to include the inherent variability of vegetation structure and composition that may have existed under the historical disturbance regime but not so broad that changes to vegetation structure and composition characteristic under the regime would be indiscernible or "washed out" of the analysis (Barrett, et al. 2012).

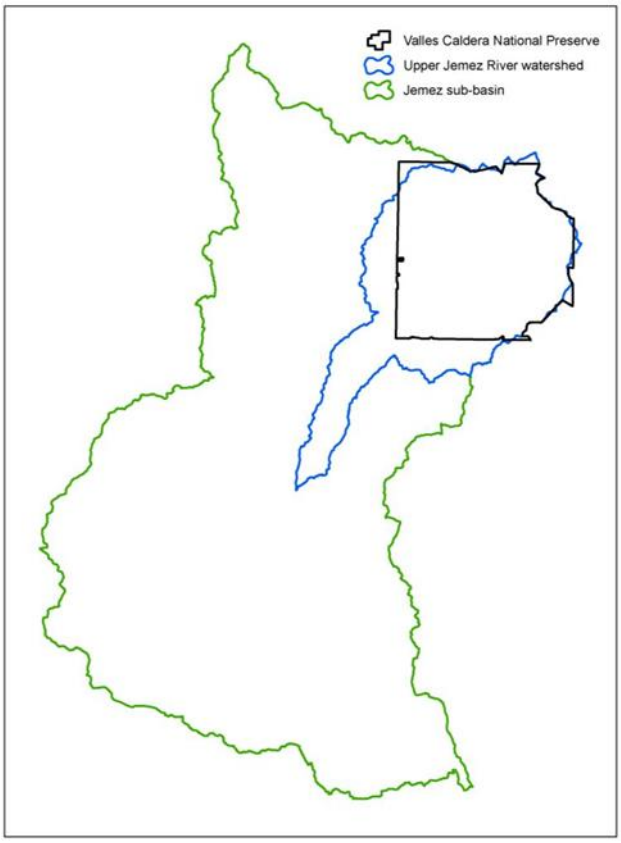


Figure 5-15. FRCC landscape scales for assessment

Determination of the appropriate assessment landscape is therefore not only based on the distribution and extent of the individual BpS but also its historical disturbance regime. Consequently, some BpSs were assessed at a spatial extent larger than the VCNP. Figure 5-15 shows the spatial extent of each assessment landscape.

Table 5-11 summarizes information on the extent, historical fire regime, and assessment landscape used for each of the forested BpS[38] models (forest types) assessed in the cumulative impact analysis. Notable differences LANDFIRE data include the complete absence of the mesic spruce-fir forest type from, the

[37] Biophysical settings are modeled forest types that may or may not align with the forest types determined at the stand level.

[38] Non-forested and riparian BpSs are not discussed in this report. See the Understory Vegetation Report available in the project record for more information on those systems.

attribute of the xeric spruce-fir as "late closed" seral, and the delineation of a small amount of *Rocky Aspen Forest and Woodland* BpS model. Again, differences in the amount and distribution of forest types are due to the method and course scale of the data.

Table 5-11. Summary of extent, fire regime, and assessment landscape for the major forested biophysical settings within the VCNP

BpS Name	BpS Model	Fire Regime Group[a]	VCNP Acres	Percent of VCNP	Assessment Landscape
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	2810610	I	32,833	38%	VCNP
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland	2810520	III	22,169	25%	Upper Jemez River Watershed (5th level HUC)
Southern Rocky Mountain Ponderosa Pine Woodland	2810540	I	9,133	10%	VCNP
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	2810510	I	3,669	4%	VCNP
Southern Rocky Mountain Ponderosa Pine Savanna	2811170	I	3,041	3%	VCNP
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	2810550	IV	2,543	3%	Jemez Sub-basin (4th level HUC)
Rocky Mountain Aspen Forest and Woodland	2810110	IV	1,051	1%	Jemez Sub-basin (4th level HUC)

a - Fire Regime Groups are: I: 0-35 year frequency, surface severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity (LANDFIRE 2007).

Similar to the analysis at the stand level, the prescription parameters Prescription guidelines from chapter 2 were modeled in the Forest Vegetation Simulator (FVS) (Dixon 2002) to determine the effect of each on vegetation composition and structure.

Cumulative Effects – Summarized By Fire Regime

Fire Regime I

Ponderosa Pine Savanna

At the scale of the regional landscape, neither of the alternatives would affect the overall degree of ecological departure of the BpS (Table 5-12). The over-representation of early-seral vegetation in this BpS is due to grassland species, without significant tree cover, occupying the setting. This s-class is expected to persist for approximately 50 years before small ponderosa pine begin to co-dominate with bunchgrasses (LANDFIRE 2007).

Table 5-12. Summary of succession class distributions for reference, current, and future conditions under alternatives 2 and 3 for the ponderosa pine savanna biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference Proportion	10%	5%	20%	60%	5%	0%
Current (Relative Amount)	25% (Over-rep)	1% (Trace)	1% (Trace)	54% (Similar)	0%	19% (Abundant)
Alternative 2 (Relative Amount)	25% (Over-rep)	1% (Trace)	1% (Trace)	54% (Similar)	0%	19% (Abundant)
Alternative 3 (Relative Amount)	25% (Over-rep)	1% (Trace)	1% (Trace)	54% (Similar)	0%	19% (Abundant)
Current Strata VCC	2					
Alternative 2 and 3 Strata VCC	2					

Ponderosa Pine Woodland

Mechanical thinning under alternatives 2 and 3 in the ponderosa pine woodland BpS would restore mid-seral closed conditions to a proportion similar to that under the reference condition but create an over-representation of mid-seral open conditions (Table 5-13). Overall both alternatives would restore the BpS from a high departure Strata VCC 3 rating to a moderate departure Strata VCC 2 rating at this level of analysis. The over-representation of mid-seral open vegetation sets a proportion of the BpS on a trajectory to transition into the much needed late-seral open stage which would improve the vegetation condition and associated Strata VCC rating further. The alternatives will not have an effect on the proportion of the uncharacteristic S-Class.

Table 5-13. S-Class distributions for reference, current, and future conditions under alternatives 2 and 3 for the ponderosa pine forest and woodland biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	10%	10%	25%	40%	15%	0%
Current (Relative Amount)	26% (Over-rep)	50% (Abundant)	12% (Under-rep)	0%	0%	12% (Abundant)
Alternative 2 (Relative Amount)	26% (Over-rep)	11% (Similar)	51% (Over-rep)	0%	0%	12% (Abundant)
Alternative 3 (Relative Amount)	26% (Over-rep)	13% (Similar)	49% (Over-rep)	0%	0%	12% (Abundant)
Current Strata VCC	3					
Alternative 2 and 3 Strata VCC	2					

Alternatives 2 and 3 transition approximately half of the acres currently in a mid-seral closed condition to mid-seral open through mechanical thinning but both S-Classes remain over-represented overall (Table 5-14). As with the ponderosa pine woodland BpS above, the over-representation of mid-seral conditions provides acres that can move into late-seral conditions naturally with time. Even though the alternatives reduce the relative amount of the mid-seral closed vegetation at the stand level the dry-

mesic montane mixed conifer BpS remains moderately departed across the VCNP overall due to the absence of late-seral vegetation conditions.

Table 5-14. S-Class distributions for reference, current, and future conditions under alternatives 2 and 3 for the dry-mesic montane mixed conifer biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	15%	15%	10%	50%	10%	0%
Current (Relative Amount)	13% (Similar)	70% (Abundant)	17% (Over-rep)	0%	0%	0%
Alternative 2 (Relative Amount)	13% (Similar)	38% (Over-rep)	49% (Over-rep)	0%	0%	0%
Alternative 3 (Relative Amount)	13% (Similar)	35% (Over-rep)	52% (Over-rep)	0%	0%	0%
Current Strata VCC	2					
Alternative 2 and 3 Strata VCC	2					

Fire Regime III

Mesic Montane Mixed Conifer

Mechanical thinning under alternatives 2 and 3 would convert mid-seral closed conditions to mid-seral open resulting in a proportion of both S-Classes that is similar to that of the reference condition of the mesic mixed conifer BpS (Table 5-15). This BpS was assessed at the scale of the Upper Jemez River watershed. Even without the presence of late-seral vegetation being mapped to the watershed, each of the proposed alternatives would restore the distribution of S-Classes to within 33 percent of the historic distribution—Strata VCC 1. Over time, natural succession will transition mid-seral into late-seral conditions further restoring the BpS.

Table 5-15. Summary of succession class distributions for reference, current, and future conditions under alternatives 2 and 3 for the mesic montane mixed conifer biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	10%	40%	25%	10%	15%	0%
Current (Relative Amount)	19% (Over-rep)	69% (Over-rep)	11% (Under-rep)	0%	0%	1% (Abundant)
Alternative 2 (Relative Amount)	19% (Over-rep)	47% (Similar)	33% (Similar)	0%	0%	1% (Abundant)
Alternative 3 (Relative Amount)	19% (Over-rep)	50% (Similar)	30% (Similar)	0%	0%	1% (Abundant)
Current Strata VCC	2					
Alternative 2 and 3 Strata VCC	1					

Aspen-mixed Conifer

Implementation of alternatives 2 and 3 would restore the late-seral closed s-class to a proportion similar to that of the reference condition but create a further abundance of the late-seral open condition (Table 5-16). The proposed alternatives do not restore the overall distribution of S-Classes within the preserve—the Strata VCC rating remains at moderate departure. However, over time disturbance from insects, diseases, or wildfire may increase the proportion of early-seral conditions thus creating a reserve from which mid-seral closed conditions will develop with natural succession. Browsing by the preserve's elk herd may inhibit transition from early-seral to mid-seral conditions by initiating an alternate successional pathway that favors conifer establishment and transition to late-seral classes unless browse mitigation measures are undertaken.

Table 5-16. Summary of succession class distributions for reference, current, and future conditions under alternatives 2 and 3 for the aspen-mixed conifer biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	25%	40%	5%	30%	N/A	0%
Current Proportion (Relative Amount)	18% (Similar)	4% (Trace)	15% (Abundant)	62% (Over-rep)	N/A	1% (Abundant)
Alternative 2 Proportion (Relative Amount)	18% (Similar)	4% (Trace)	44% (Abundant)	33% (Similar)	N/A	1% (Abundant)
Alternative 3 Proportion (Relative Amount)	18% (Similar)	4% (Trace)	40% (Abundant)	37% (Similar)	N/A	1% (Abundant)
Current Strata VCC	2					
Alternative 2 and 3 Strata VCC	2					

Aspen Forest and Woodland

The aspen forest and woodland BpS represents only 1,051 acres (1 percent) of the land area within the preserve. At the preserve scale, the mid-seral closed vegetation is under-represented and there is an abundance of early-seral vegetation. The mechanical treatments in alternatives 1 and 2 have no effect on this distribution. At the larger Jemez sub-basin (4th level-HUC) assessment landscape the distribution of s-classes is well balanced and considered to be within the natural range of variation for the BpS (Table 5-17).

Table 5-17. Summary of succession class distributions for reference, current, and future conditions under alternatives 2 and 3 for the aspen forest and woodland biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	5%	35%	60%	N/A	N/A	0%
Current (Relative Amount)	22% (Abundant)	24% (Similar)	49% (Similar)	N/A	N/A	5% (Abundant)
Alternative 2 (Relative Amount)	22% (Abundant)	24% (Similar)	49% (Similar)	N/A	N/A	5% (Abundant)
Alternative 3 (Relative Amount)	22% (Abundant)	24% (Similar)	49% (Similar)	N/A	N/A	5% (Abundant)
Current Strata VCC	1					
Alternative 2 and 3 Strata VCC	1					

Fire Regime IV

Subalpine Dry-mesic spruce-fir

Within the preserve, mechanical thinning under alternatives 2 and 3 would restore the distribution of s-classes in the subalpine dry-mesic spruce-fir BpS to that of the reference condition. At the larger Jemez sub-basin (4th-level HUC) scale at which the BpS was assessed the treatments would restore the late-seral open vegetation to a proportion that is similar to that under the reference condition but the late-seral closed would remain over-represented resulting in no noticeable effect on the overall departure of the BpS (Table 5-18). Early- and mid-seral vegetation is deficit in this BpS requiring stand-replacement disturbance to shift the distribution of S-Classes. Course Scale VCC mapping did not identify the wet-mesic spruce-fir BpS.

Table 5-18. Summary of succession class distributions for reference, current, and future conditions under alternatives 2 and 3 for the subalpine dry-mesic spruce-fir biophysical setting

	S-Class					
	A	B	C	D	E	U
Reference	15%	20%	15%	20%	30%	0%
Current (Relative Amount)	7% (Under-rep)	3% (Trace)	1% (Trace)	9% (Under-rep)	80% (Over-rep)	0%
Alternative 2 (Relative Amount)	7% (Under-rep)	2% (Trace)	2% (Trace)	22% (Similar)	67% (Over-rep)	0%
Alternative 3 (Relative Amount)	7% (Under-rep)	3% (Trace)	1% (Trace)	13% (Similar)	76% (Over-rep)	0%
Current Strata VCC	2					
Alternative 2 and 3 Strata VCC	2					

Understory Vegetation

In combination with past, current, and future actions, alternatives 2 and 3 are likely to result in beneficial effects on understory vegetation. As a result, unique species and the diversity of plant communities on the preserve would be maintained over the long term. The combination of mechanical and pyric

treatments proposed by both alternatives would decrease fire severity potential and the risk of stand replacing events that could adversely affect soil cover and long-term site productivity. Treatments would also help reverse the effects of fire suppression and diversify the structure and age classes of vegetation found in forested stands. Enhancement of forest understories and restoration of grassland vegetation would also benefit the range resource because more area would potentially be available for elk and livestock use. This increased area would allow for increased distribution of livestock and wildlife, reducing the potential for grazing overlap or concentrated use on existing rangelands.

Since federal acquisition domestic livestock grazing on the preserve has been reduced both in intensity and context. In the three decades leading up to federal acquisition 5,000 – 7,500 head were grazed preserve-wide (TEAMS Enterprise Unit, 2007). The trust has reduced stocking levels by 90 percent and over time has reconstructed and relocated fences to exclude live waters of the East Fork of the Jemez River, Jaramillo Creek and the Rio San Antonio from livestock with plans to exclude Sulphur Creek in 2013. This reduction in grazing impacts is anticipated to combine with actions to restore and improve understory vegetation resulting in cumulative benefits by measures of cover, productivity and diversity.

5.3 Wildland Fire Environment

5.3.1 Goals and Objectives

Reducing the potential intensity and severity of future wildland fire is at the heart of the ecological goals identified for the management of the preserve in the Valles Caldera Preservation Act (U.S.C. 2000), in the trust's, 2012 -2018 Strategic Management Plan (Valles Caldera Trust, 2012) and in chapter 1 of this EIS. Chapter 2 identified three measurable objectives for the wildland fire environment in support of goal attainment. These objectives relate to reducing the potential intensity and severity of fire as well as reintroducing fire as a beneficial process. Targets are measures of reduction in acres in classes IV or V on the Fire Intensity Scale (FIS), a reduction in acres with the potential to burn as a crown fire, and a target for acres treated with fire.

5.3.2 Methods

This analysis uses the same terminology, concepts, methods and models as described in chapter 4, *Affected Environment.* Recall from chapter 4 the concept of classifying fire behavior potential according to a fire intensity scale (Scott, 2006) as shown in Table 5-19 below.

Table 5-19. Fire Intensity Scale classes and descriptions

Fire Intensity Class (FIS class)	Description of fire behavior
I	Very small, discontinuous flames, usually less than 1 foot in length; very slow spread rate; no spotting. Fires suppressible by lay-firefighters without specialized tools. Fires of this intensity occur on the flanks and rear of large fires, and near the beginning and end of burning periods. These fires are relatively rare due to their slow spread rate and easy control.

Fire Intensity Class (FIS class)	Description of fire behavior
II	Small flames, usually less than two feet long; small amount of very short-range spotting possible. Fires easily suppressed by trained hand crews with protective equipment and firefighting tools. This intensity class can occur at the head of a fire in a mild fire environment or on the flanks and rear of fires in more severe fire environments. This intensity class is very common, especially on fires not being actively suppressed.
III	Flames up to 8 feet in length; short-range spotting is possible. Hand crews will find these fires difficult to suppress without support from aircraft or engines, but dozers and plows are generally effective. This intensity class occurs at the head and flanks of fires in moderate fire environments, or near the rear of fires in heavy fuel. This intensity class is common.
IV	Large flames, up to 30 feet in length; short-range spotting common; medium-range spotting possible. Direct attack by hand crews and equipment is generally ineffective, indirect attack may be effective. This intensity class is generally observed at the head of fires in moderate fire environments or near the head and flank of fires in moderate to severe fire environments. This intensity class is relatively common.
V	Very large flames up to 150 feet in length; copious short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head. This intensity class is usually observed near the head of fires in severe fire environments. Despite the high spread rate, this intensity class is relatively infrequent due to the rarity of the fire environment and spread direction.
VI	Extraordinary flame size, greater than 150 feet in length; copious spotting; very strong fire-induced winds. Conditions supporting this behavior are rare and short-lived. All suppression efforts are ineffective. This intensity class is usually observed near the head of fires in severe fire environments. Despite the high spread rate, this intensity class is relatively infrequent due to the rarity of the fire environment and spread direction.

Also recall that fuels, weather and topography drive fire behavior. Fire behavior within a particular fuel type can transition to greater intensity under hotter, drier and windier conditions. Conversely, fire behavior class under the most hazardous levels of fuels is greatly reduced under cool moist conditions. Our analysis is focusing on the proposed change in forest fuels and the effects of this change under hot, dry, and windy conditions. The predicted effect to the fire behavior potential was estimated using standard methods and models across the landscape scale. Analysis at the stand level applied the dominant fire behavior potential across the entire stand and applied a single fire behavior potential to each stand post treatment[39].

5.3.3 Environmental Consequences – No Action

Alternative 1 – No Action

As described below in Table 5-20, there would be no direct effect to the wildland fire environment under the no action alternative. The existing fire behavior potential would continue and would increase as forest health declines and fuels continue to build. Indirectly, there is at least the potential if not likelihood for moderate adverse impacts to occur at the landscape level and perhaps extending to the region due to the upward trend in fire behavior potential.

[39] As fuels and fire behavior are highly variable in both time and space, this stand level analysis is used to compare the alternatives and not to serve as input for real time fire behavior prediction post-treatment.

Table 5-20. Environmental consequences summary table: No Action, Wildland Fire Environment

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	↓Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor -moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential

Wildfire Potential

There are no direct effects of choosing the no action alternative on vegetation condition or wildfire potential. Indirectly, the as the current condition and decline persisted the current potential for a high intensity and severity fire would also persist.

As detailed in the affected environment section of this EIS, current wildfire potential exhibits an uncharacteristic intensity, severity and extent in many of the forested ecotypes of the preserve. The risk to structures, communities, and ecological characteristics associated with this level of fire behavior usually warrant a full suppression strategy. Wildfire suppression activities may further exacerbate the current departure of vegetation composition and structure as well as lead to other indirect impacts such as introduction and spread of noxious weeds from firefighting personnel and equipment, soil, and vegetation disturbance.

Cumulative Effects

The effects of taking no action on combined with other past and ongoing management within the VCNP and greater Jemez Mountains landscape are complex. Past management within and around the VCNP has created a distribution of vegetation composition and structure that is dissimilar to that of the reference condition. Past and ongoing management has also created fuel conditions conducive to uncharacteristic wildfire behavior and/or extent in many of the ecotypes in and around the preserve. As seen with the recent Las Conchas fire, large wildfires burning for extended periods of time will burn under a variety of intensities and severities over their course. The variation in fire effects may mitigate the current departure from reference conditions by opening closed stands and creating early-seral

conditions from which deficits in mid-seral conditions may be recruited over time. Large burned areas may also lower overall wildfire hazard across the landscape.

In contrast, the current potential for high intensity wildfire promotes a full suppression strategy to protect communities and other values threatened by wildfire thus exacerbating the current departure of vegetation composition and structure and potential for severe wildfire effects.

Ongoing and future vegetation treatments or natural disturbances outside of the preserve influence the distribution of S-Classes at the landscape scale and may influence the likelihood of wildfires spreading onto the preserve from adjacent forests and grasslands.

5.3.4 Environmental Consequences – Action Alternatives

Both the action alternatives would have the potential for direct, albeit short-term and localized, adverse impacts to the wildland fire environment as well as direct, localized beneficial effects. Indirectly and cumulatively at the landscape scale, both action alternatives would reduce the potential for uncharacteristic wildfire and increase the opportunity to use fire as a beneficial process in fire adapted systems.

Table 5-21. Environmental consequences summary table: forest vegetation and ecological condition; action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level, Landscape level - region	Minor - moderate	Potential
	↑Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	↓Direct	Project level	Minor	Potential
	↑Indirect	Project level, Landscape level	Minor - moderate	Potential
	↑Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	↓Direct	Localized	Minor	None
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Riparian Restoration	↓Direct	Localized	Negligible	Certain
	↑Indirect	Landscape level	Negligible	Potential
	↑Cumulative	Landscape level	Negligible	Potential
Noxious Weed Management	↓Direct	Localized	Negligible	Certain
	↑Indirect	Landscape level	Minor - moderate	Potential
	↑Cumulative	Landscape level	Minor - moderate	Potential
Burn Area Rehabilitation	↑Direct	Localized	Minor	Certain
	↑Indirect	Landscape level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential

Alternatives 2 and 3 would directly modify the fuel profile and potential wildfire behavior in the treated areas by reducing surface and canopy fuel loads, increasing canopy base height, and reducing canopy cover and continuity. Each of the mechanical treatment prescriptions would also include a connected biomass removal activity to address the biomass produced by the treatment itself (activity fuel) as described in chapter 2. Modification of the canopy structure through mechanical treatment followed by removal of activity fuel, especially by prescribed fire, has proven to be a very effective strategy in

reducing the crown fire and high severity burn potential (Agee and Skinner 2005, Peterson, et al. 2005, Evans, et al. 2011).

It should be noted that the biomass that results from thinning, if left untreated can increase the fire potential. Under both action alternatives all biomass created from forest thinning will be treated by removal and utilization where possible. Biomass not removed will be masticated or lopped and scattered to compact the fuelbed and reduce the speed of fire spread. In some cases the material would be piled. Ultimately all fuels remaining on site would be further reduced by prescribed fire.

Ideally removal and utilization and other treatments would occur concurrently with forest thinning. Where we leave biomass on the ground for firewood collection or in piles for later burning, this material presents substantial, albeit short-term and localized hazard.

At the stand level, alternative 2 selects mixed conifer stands for treatment based on the fire behavior potential and alternative 3 selects stands for treatment based on the potential to regenerate aspen. Therefore, it is not surprising that a greater percent of the stands treated under alternative 2 have the greatest fire behavior potential. As shown in Figure 5-16 below, 62 percent of the acres treated under alternative 2 are within an FIS class of IV while only 48 percent of the stands treated under alternative 3 have that degree of fire behavior potential. However, Figure 5-16 also shows that both approaches to selecting treatment areas result in treating stands primarily in FIS classes of IV and V – both high degrees of hazard. Figure 5-17, that follows shows the resulting distribution of FIS class within the treated stands. This analysis assumed that stands with a current FIS class of IV or V would be reduced to an FIS class of III in most cases. Under alternative 2 where stands with an FIS class of V were treated on steep slopes, a proportion of those stands would only be reduced to an FIS class of IV

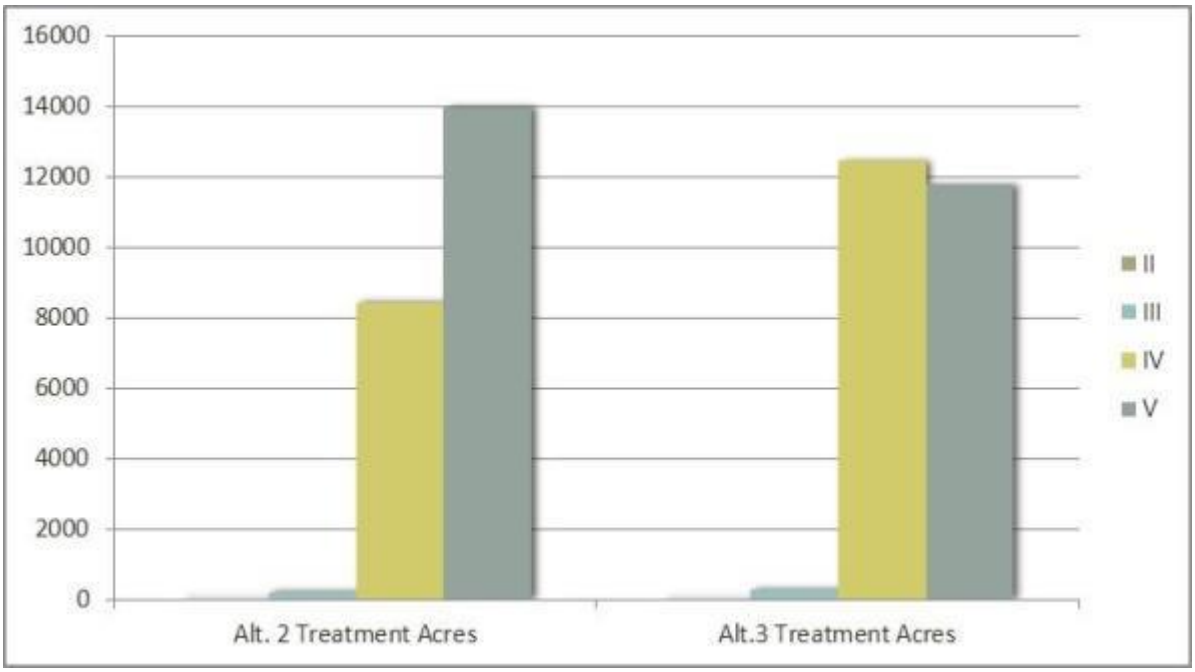


Figure 5-16. Treatment acres by current FIS class

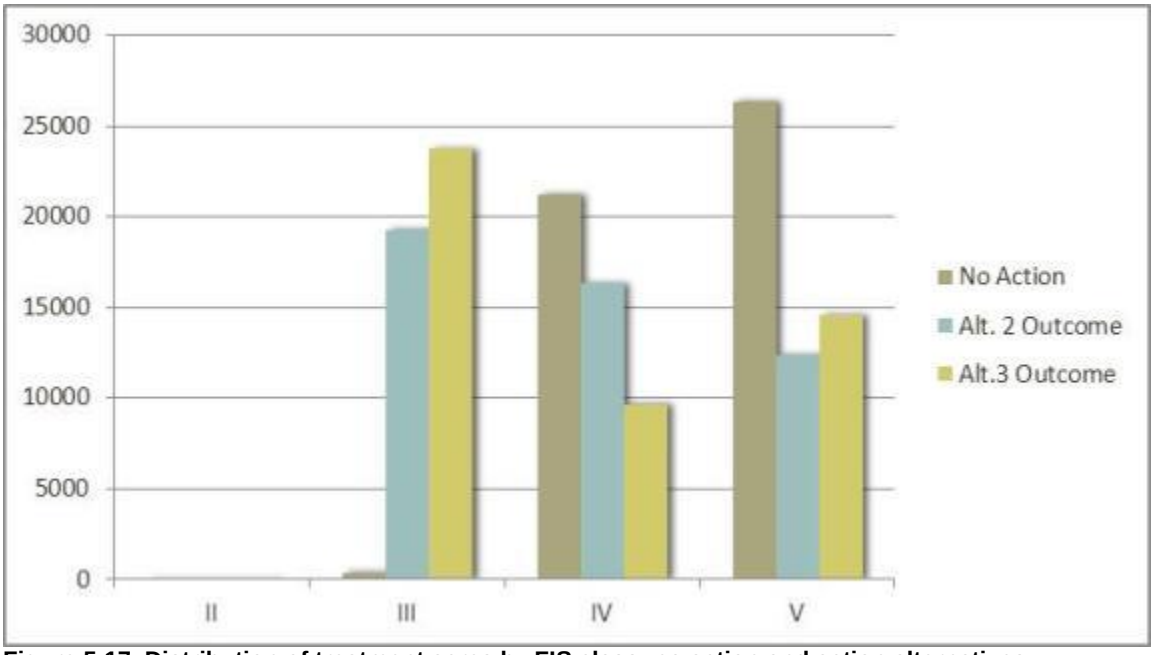


Figure 5-17. Distribution of treatment acres by FIS class; no action and action alternatives

We also analyzed the treatments under various weather scenarios. Table 5-22 below shows the wildland fire behavior potential across the preserve under hot and dry conditions, and under various wind speeds for the no action and each alternative action. As shown, the percent area across the preserve with the potential to burn in classes IV and V (characterized by active crown fire and severe impacts to productivity and forest succession) are reduced preserve-wide by either of the action alternatives while the percent with the potential to burn in class III is increased.

At the class III FIS, hand crews will begin to find suppression difficult without the assistance of mechanized and aerial equipment i.e. hot, dry, windy days would continue to produce fast moving wildfires. However, the potential for the most intense and severe types of crownfire is reduced across the landscape. Under current conditions 26 percent of the preserve has the potential to burn at a class III FIS or greater with no wind at all. The area increases to 53 percent under a 25 mph wind and 63 percent under a 50 mph wind. Alternatives 2 and 3 reduce the area to 14 percent under no wind and 45 percent under a 25 mph wind. Conversely, alternatives 2 and 3 increase the area under a 50 mph wind by 7 percent as acres move from the most intense classes IV and V to class III.

In this environment, where fire is a natural and beneficial process, our goal is not to exclude fire but to reduce the potential for uncharacteristic crown fire. Crown fire is dependent on forest structure as well as the structure of the surface fuels. Canopy base height and crown density both effect the ability of fire to move into the forest canopy and for burning to be sustained. The intensity of the surface fire also enters into the equation. Fire sustained in the canopy independent of the surface fire is generally a rare event (NWCG, 2010). Both alternatives would reduce the potential of uncharacteristic crownfire at the landscape scale.

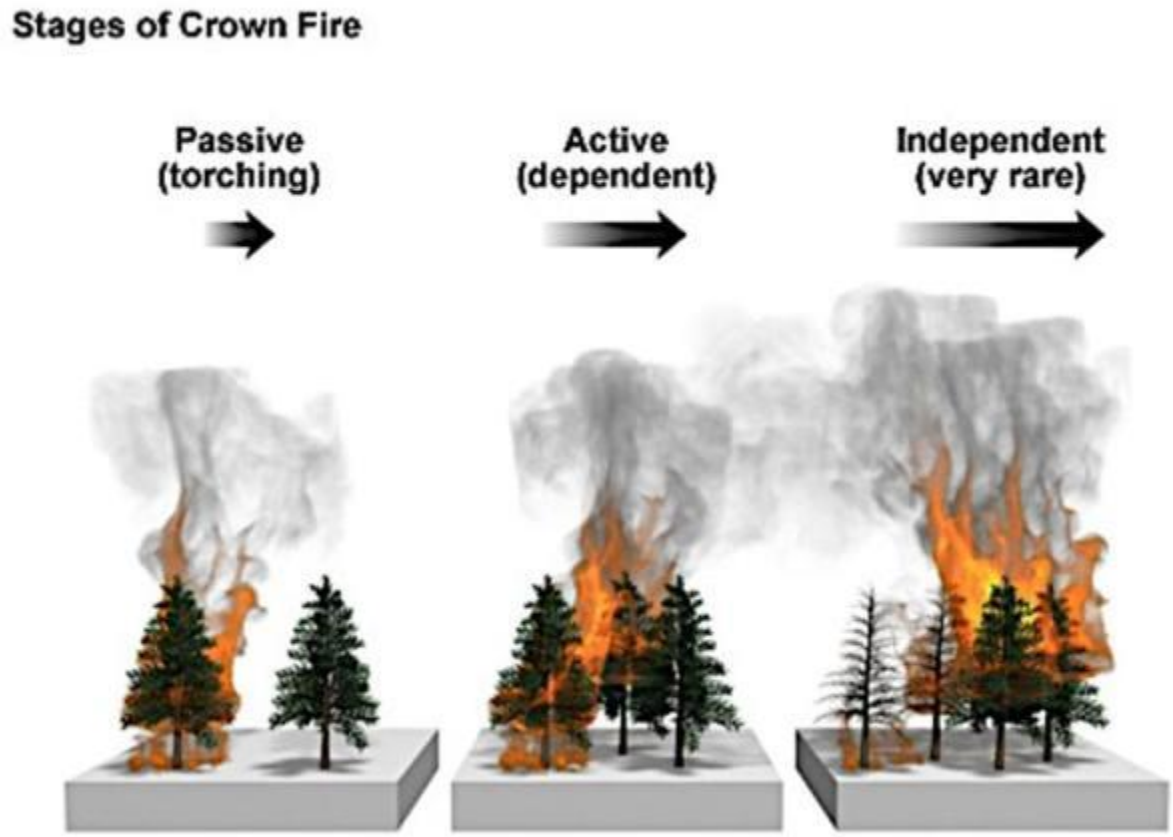
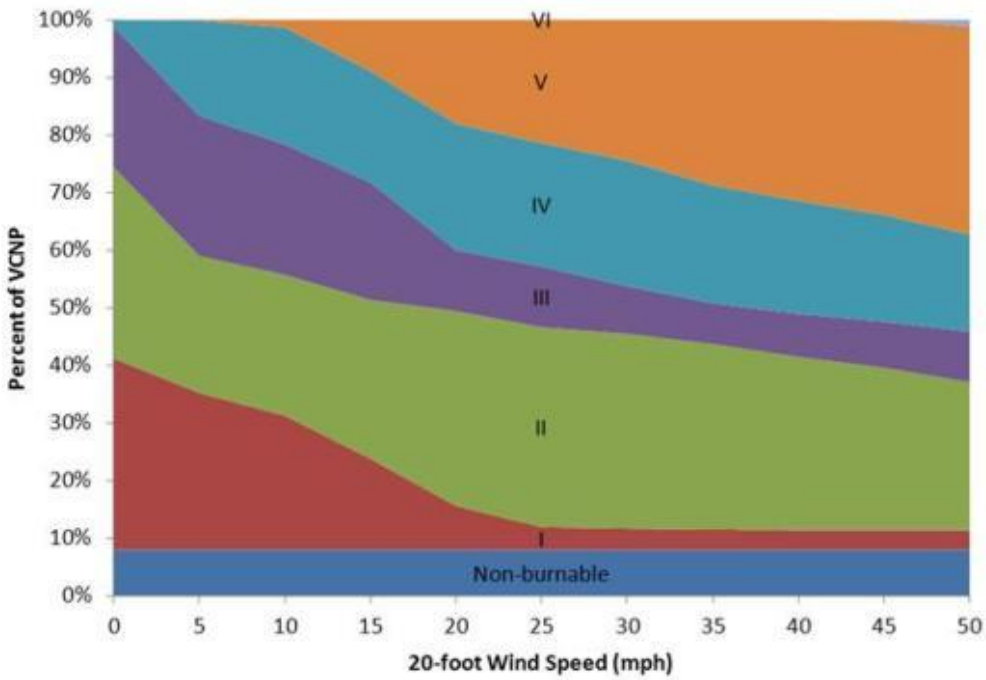
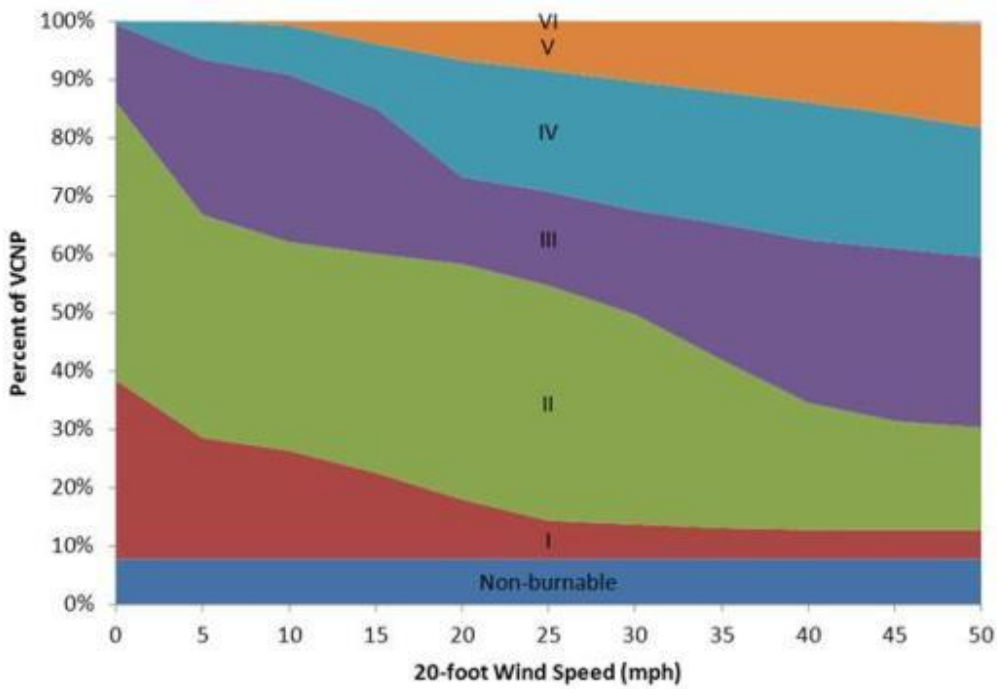
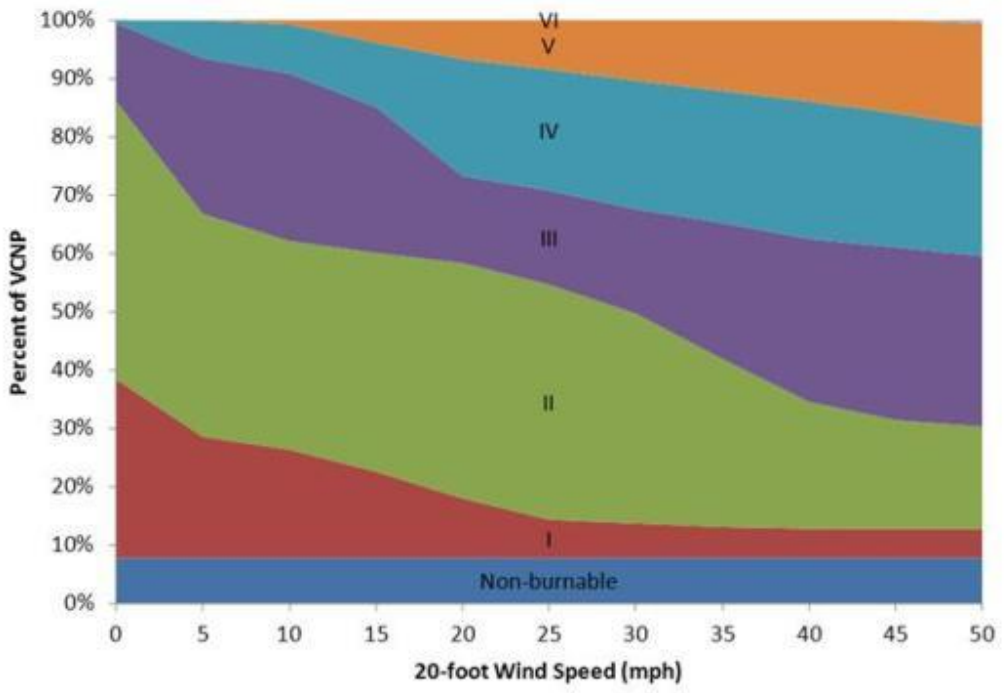


Figure 5-18. Stages of crown fire (NWCG, 2010)

Table 5-22. Percent of VCNP predicted to burn at various classes of the FIS under various wind speeds for each alternative

	Alternative 1 No Action
	Alternative 2 Collaborative Restoration Strategy

	Alternative 3 Aspen Restoration

5.4 Noxious Weeds

What are the potential impacts to the population and distribution of noxious weeds from the implementation of the action alternatives and what are the potential environmental consequences from the proposed treatment of noxious weeds? Ongoing and future management activities have the potential to introduce new populations of noxious weeds onto the preserve, and spread noxious weeds from existing populations on the preserve. Noxious weed control methods such as the use of herbicides also have the potential to directly and indirectly affect plant communities.

5.4.1 Goals and Objectives

The protection of native diversity was identified as an objective in chapter 2. Outcomes identified for monitoring included the prevention, control and eradication existing noxious weeds with targets identified for non-native thistles, oxeye daisy and cheatgrass. We also have identified “no new weeds” as a target.

5.4.2 Methods

The three alternatives have been compared using a modified two-factor noxious weed risk assessment and rating system (Table 5-23). Factor one addresses potential noxious weed spread within the preserve. Factor two addresses the impact of these undesirable plants to displace or degrade the vegetation

communities within the preserve. An overall rating reflects the multiplied sum of these two factors. The risk rating is used to assess the effects of each proposed alternative in the stewardship plan (Table 5-24).

5.4.3 Incomplete/Unavailable Information

A comprehensive noxious weed inventory and mapping exercise has not been conducted on the preserve. Therefore the true extent of noxious weeds on the preserve is not known. All available information about existing noxious weed locations was collected prior to the Las Conchas fire and is disclosed in the chapter 4 - *Affected Environment* section of this report. The potential environmental consequences of the management alternatives are discussed in the context of what is known about these noxious weeds, their populations on the preserve, and their anticipated effects on the preserve's ecosystems.

5.4.4 Context for Effects Analysis

This effects analysis is based on best available science, up-to-date scientific literature, and professional judgment and experience. The analysis area relevant to this discussion is contained within the administrative boundaries of the preserve. Short-term effects represent impacts that occur year to year, or for this analysis, across a time-span of up to five years. Long-term effects, for this analysis, will represent resource impacts that occur across timeframes of five to ten years or more.

Table 5-23. Noxious weed risk assessment and rating system for management alternatives

Rating	Value	Explanation
Factor I: Likelihood of Noxious Weed Spread		
None	0	Weed species not located within, or immediately adjacent to the project level.
Low	1	Undesirable plant species present in areas adjacent to but not within the project level.
Moderate	5	Undesirable plant species located immediately adjacent to, or within the project level.
High	10	Heavy infestations of undesirable plants are located within or immediately adjacent to the project level.
Factor II: Consequence of Undesirable Plant Establishment		
Low	1	Expansion of noxious weed infestations is unlikely. Adverse effects on the native plant community are not expected.
Moderate	5	Possible expansion of noxious weed infestations, likely with limited adverse effects on native plant communities.
High	10	Expansion of noxious weed infestations probable with expected adverse effects on native plant community.
Risk Assessment		
Low	1-10	Low risk that alternative would result in spread of noxious weeds.
Moderate	25	Moderate risk that alternative would result in spread of noxious weeds.
High	50-100	High risk that alternative would result in spread of noxious weeds.

Table 5-24. Risk of weed spread by alternative

Management Alternative	Rating	Explanation
Alternative 1- No Action	High (Factor I = 5 X Factor II = 10; rating = 50)	Ongoing weed treatments would continue, but some existing noxious weeds as well as future species introductions would not be addressed. While the ground disturbing activities in alternative 2 and 3 would not occur, previously authorized activities would continue. Expanding populations of noxious weeds such as cheatgrass are likely to have an adverse effect on native plant communities over the long term, especially in the event of future disturbance.
Alternative 2- Collaborative Landscape Forest Restoration Strategy	Low (Factor I = 5 X Factor II = 1; rating = 5)	A comprehensive and adaptive noxious weed control strategy would address all existing and future noxious weed occurrences. Prevention and treatment strategies are expected to prevent introduction and expansion of weed populations as a result of ground disturbing activities. Adverse effects on native plant communities are not expected.
Alternative 3- Aspen Regeneration	Low (Factor I = 5 X Factor II = 1; rating = 5)	A comprehensive and adaptive noxious weed control strategy would address all existing and future noxious weed occurrences. Prevention and treatment strategies are expected to prevent introduction and expansion of weed populations as a result of ground disturbing activities. Adverse effects on native plant communities are not expected.

5.4.5 Environmental Consequences – No Action

The no action alternative would have direct, indirect and cumulative adverse impacts that could be localized or potential extend to the landscape level or region. These effects could be minor to moderate.

Table 5-25. Environmental consequences summary table: No Action, Noxious Weeds

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	↓Direct	Landscape level	Minor - moderate	Potential
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor -moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential

The current noxious weed management strategy provides a starting place from which to guard against the potential problems presented by noxious weeds on the preserve. Alternative 1 would not adequately address the detection or response to future threats. This is because alternative 1 does not propose to control and eliminate all noxious weeds, an action that the trust's Framework and Strategic Guidance for Comprehensive Management describes as "essential" (Valles Caldera Trust, 2005).

While current management considers some noxious weed species and populations that currently exist on the preserve, it does not take into account future introductions or the ongoing and long-term spread of weeds such as cheatgrass and oxeye daisy which are already present. Further, while current management was based on sound science and exercises restraint in regards to the number of species to be treated, the methods used, and the performance requirements that govern treatment methods, it does not account for new and/or unforeseen threats in a manner consistent with the principles of adaptive management. Finally, while current management strives to manage select weeds species, it does not provide adequate mechanisms to address all noxious weeds and prevent their spread into the preserve or onto adjacent landowner's property.

Over the long-term, existing conditions may begin to significantly depart from reference conditions if we elect to take no action regarding noxious weed control. Alternative 1 does not include effective treatment options for all existing noxious weeds on the preserve, and it does not provide the tools or mechanisms to address new threats in an adaptive manner. Although the process of ecological improvement appears to be ongoing throughout much of the preserve (Valles Caldera Trust, 2007; TEAMS Enterprise Unit, 2007), this process could be slowed or even reversed if noxious weeds were provided with an opportunity to begin moving away from developed sites and into grassland and forest ecosystems. If exotic plants were to gain dominance over native species, landscapes could become less resilient to disturbance resulting in a loss of biotic integrity via the interruption of keystone ecosystem processes.

Direct and Indirect Effects

Eradication of Canada, musk and bull thistles would continue under the authority of previous decisions (Valles Caldera Trust, 2003). These efforts have largely been successful at controlling these noxious weeds using a combination of chemical (herbicide) and mechanical (hand-pulling) treatment methods (Iskra and O'Haver 2009). It isn't known whether or not the Las Conchas fire will result in any set-backs, but over the long-term it is possible that exotic thistle species could be eradicated-- as long as treatment efforts continue and no new populations are introduced or discovered. Eradication of other known noxious weeds would not take place. Populations of cheatgrass and goatheads (not a noxious weed, but a nuisance plant) would likely persist and spread.

Prior to the Las Conchas fire it was likely that Canada and musk thistles would be eliminated from the preserve over the short-term. The accuracy of this projection will rely upon the effects of the fire. As a result of the Las Conchas fire, approximately 16,062 acres of moderately to severely burned vegetation are at increased risk of invasion. If Canada and musk thistle expand into the fire area, eradication efforts could be complicated and become a long-term problem.

Bull thistle has proven difficult to treat with no eradicated populations to date. While significant progress has been made on reducing the size and density of known bull thistle occurrences, a number of small populations continue to expand along roads within the preserve (Iskra and O'Haver 2009). Eradication of

bull thistle populations is likely to be a long-term effort due to the lengthy viability of seeds and their persistence in the soil. If they expand into high-risk areas within the fire perimeter, eradication efforts could be lengthened significantly.

For cheatgrass, oxeye daisy, and goatheads, assuming a “worst case” scenario, up to 1,139 acres are currently considered high-risk locations for weed spread—primarily roadsides. If left untreated there is a high risk that these species will continue to spread into these and adjacent areas (especially cheatgrass and oxeye daisy), resulting in adverse ecological effects because of their ability to establish themselves in disturbed areas and dominate native plant communities.

Cheatgrass has spread at a rapid rate along the road system of the preserve at one mile per year along the major preserve roads (Iskra and O'Haver 2009). Continued spread is likely without immediate and intensive eradication efforts. It is reasonable to assume that spread rates accelerate once isolated populations begin to join (Ibid). This potentially wide distribution would increase the risk of cheatgrass extending into native rangeland settings in the valles of the preserve.

Rangelands at risk to cheatgrass invasion are primarily the drier areas such as Valle Seco, Valle Toledo, Valle San Antonio, ponderosa pine woodlands, or even the upper edges of the Valle Grande. These areas are not as moist and may be subsequently more susceptible to invasion (Iskra and O'Haver 2009). Roadside populations inside the Las Conchas fire perimeter could present great risk of spread as well, especially if populations existed in severely burned areas where understory vegetation was eliminated and is slowly recovering. Some locations like the lowlands in Valle Grande may be too moist for cheatgrass to gain a foothold (Iskra and O'Haver 2009).

Possible effects from cheatgrass (Young and Clements 2009) invasion include increased fire hazard, loss of native forage sources, degradation of wildlife habitat, and soil resource degradation (Ibid). Often established in native ecosystems after some form of disturbance, cheatgrass can be highly invasive and very difficult to eradicate because it is able to effectively compete with more desirable perennial grass species. Upon achieving high site density cheatgrass is capable of excluding seedling establishment by competitors on a given site, allowing it to form monocultures. Both the competitiveness and its propensity to alter natural fire regimes makes cheatgrass a serious threat to native species diversity. Cheatgrass invasion may result in complete type conversion of affected areas into annual grass dominated systems and truncate natural succession.

Like cheatgrass, oxeye daisy is quickly spreading within the preserve. Without immediate and intensive treatment it is likely that it would continue to extend its range outside of Redondo Canyon where it has been rapidly moving up the road (Iskra and O'Haver 2009). A number of Oxeye daisy populations are also known to exist along forested roads in relatively close proximity to the Valle Grande and El Cajete. If oxeye daisy manages to spread out of Redondo Canyon and into Jaramillo Canyon, or infest roadsides adjacent to other grasslands, the risk of it quickly spreading out of control would be quite high (Ibid).

Oxeye daisy presents a threat to native species across a wide range of site conditions. Due to its dense growing habit it has the ability to exclude native vegetation and quickly dominate an area. While it is not poisonous it is not known to be forage either and may replace more desirable species, reducing species diversity and degrading habitat quality for both livestock and wildlife (Bossard, Randall and Hoshovsky 2000).

Siberian elm and goatheads also present a threat although their distribution is relatively limited at this time as compared to cheatgrass and oxeye daisy. Alternative 1 would likely result in both of these species becoming more common on the preserve over the long-term. In addition to its habit of forming dense thickets, which can exclude native vegetation, Siberian elm also tends to establish conditions under which other noxious weeds prosper (Texas A&M 2011). And while goatheads are not likely to take over the preserve (Iskra and O'Haver 2009); this species is a nuisance to people and livestock (Ball, et al. 2001).

In addition to these known populations of noxious weeds found on the preserve, there would continue to be a high risk of new introductions. Not only is it possible that all of the aforementioned weeds could continue to be brought into the preserve even while existing populations are being eradicated, but new noxious weeds, unknown on the preserve may be introduced as well. The lack of a comprehensive weed prevention strategy makes either of these events more likely.

For instance, Dalmatian and Yellow toadflax have known populations close to the preserve and thus pose a risk for invasion. Spread by vehicles is common for both these invasive plants and transport onto the preserve is possible. If these or any other new noxious weeds establish themselves along the roads or elsewhere within the preserve's boundaries, the consequences could be potentially devastating to native plant communities at a localized or even landscape level (Iskra and O'Haver 2009).

Cumulative Effects

While certain noxious weeds would continue to be treated, other existing occurrences as well as introductions of new noxious weed species would not. As outlined in the section above, the lack of a comprehensive prevention and treatment strategy would make it more likely that existing and new noxious weeds will establish themselves on the preserve. Once established, it is likely that they would spread, especially via the road system.

Taking no action to eradicate noxious weeds would combine with the expected continued increase in the likelihood of high severity fire and the associated increased risk of noxious weed invasion or expansion. The trust has recently made a decision to use a shuttle system as the primary means of public access and use onto the preserve. This will minimize recreation as a vector for noxious weed introduction. However, personal vehicles will continue to be a component of public access and use for specific programs and a common means of access for contractors, volunteers, and researchers.

As we have seen with cheatgrass and oxeye daisy, roadbeds and bar ditches appear to provide enough disturbed habitat for these weeds to germinate, grow and persist (Iskra and O'Haver 2009). Other active and inactive infrastructure such as administrative sites, gravel pits, and geo-thermal exploration pads are also known to provide gaps in the native vegetation that are open to colonization by noxious weeds (Iskra and O'Haver 2009). Day-to-day vehicular and foot traffic (both administrative and recreational), would provide a vector for transport of noxious weed propagules along the preserve's roads and between administrative sites. And with past and ongoing routine road maintenance activities planned to continue into the future, it is very likely that roadside noxious weeds would be rapidly spread around the preserve on mechanical road maintenance equipment.

Livestock and wildlife grazing also provide a potential vector for noxious weed introductions and their spread. Weeds could enter the preserve either attached to the animals, attached to transport vehicles

and equipment such as trailers, or within the digestive tracts of the animals themselves. Foraging animals may also consume weeds that are already present on the landscape and transport weeds in their feces. Weed seeds and root fragments could also be transported by the animals themselves by attaching to their coats.

The landscape and ecosystems of the preserve are relatively resistant to noxious weed introductions and spread at this time. Dense and vigorous native plant cover has so far limited the spread of noxious weeds into the grasslands and forests of the preserve. For the most part, existing noxious weed populations are currently confined to roadsides and other heavily disturbed sites. But the likelihood of noxious weed spread will only increase as they continue to expand along the road system, especially if ground disturbing management activities or high severity fire occurs in the future.

Although future fuels and vegetation management activities may not be as extensive as those proposed under alternative 2 or 3 it is reasonable to assume that some project level thinning and prescribed burning would continue. Even management intensities that can be categorically excluded from environmental documentation require the use of equipment and result in ground disturbance, whether by fire or machinery. As suggested by the close proximity of weeds to roads, old skid trails, and on old landings noxious weeds were likely brought in by equipment. Although current projects are implemented with performance requirements to prevent noxious weeds, that risk remains. Without a protocol in place to check and wash equipment, educate staff and the public, and limit operations in and around existing noxious weed populations it is likely just a matter of time before new weed populations are introduced and/or inadvertently spread.

5.4.6 Environmental Consequences – Action Alternatives

The action alternatives both have the potential to have direct, adverse, albeit localized and minor impacts. Both alternatives would also have likely beneficial outcomes that could extend through the planning and regional areas.

The implementation of a comprehensive noxious weed management plan would address current and future risk of noxious weed introduction and spread as a result of management activities on the preserve. Mitigation measures and performance requirements establish safeguards that protect resources as well as health, and human safety from potential harmful effects of herbicide use.

The action alternatives would result in a relatively low risk of noxious weed introduction and spread. Ongoing weed treatments would be expanded to address all existing noxious weeds on the preserve as well as future species introductions. While the ground disturbing activities would occur, performance requirements would be in place to control, and eradicate noxious weeds found on site.

Table 5-26. Environmental consequences summary table: action alternatives, noxious weeds

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized - project level	Minor	Potential
	↑Indirect	Landscape level	Minor	Likely
	↑Cumulative	Landscape level, 5th	Minor	Likely

Activity	Effects	Context	Intensity	Certainty
		code HUC		
Wildland Fire Management	↓Direct	Localized and project level	Minor	Potential
	↑Indirect	Regional	Minor	Likely
	↑Cumulative	Landscape level	Minor	Likely
Road Management	↓Direct	Localized	Minor	Likely
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Riparian Restoration	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor - moderate	Potential
	↑Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	↑Direct	Landscape level	Minor - moderate	Likely
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Moderate	Likely
Burn Area Rehabilitation	↑Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Moderate	Likely

The action alternatives would respond to future threats. This is consistent with the preserve's Framework and Strategic Guidance for Comprehensive Management, which describes management of noxious weeds as "essential" (Valles Caldera Trust, 2005). The action alternatives consider all noxious weed species and populations that currently exist on the preserve, and take into account future introductions. The alternatives are based on professional experience and the best available science. They exercise restraint in the form of performance requirements, which address the protection of resources, health, and human safety. Adaptive management would be used to select the most effective treatment options available for the species of interest. If unforeseen threats were beyond the scope of these alternatives then mechanisms would be in place to analyze for and authorize necessary measures. Finally, the action alternatives not only strive to manage noxious weeds on the preserve, but they would also help prevent the spread of undesirable species onto adjacent ownerships.

We conclude that, if implemented, either action alternative would maintain or move existing conditions towards the reference condition over the long-term. Although some differences in treatment acres exist between the two alternatives, it is not likely that those differences would affect the risk of weed spread given the implementation of a comprehensive weed management strategy. The action alternatives include effective treatment options for all existing noxious weeds on the preserve, and they both provide the tools or mechanisms to address new threats in an adaptive manner. The process of ecological improvement appears to be ongoing throughout much of the preserve (Valles Caldera Trust, 2012)and it is anticipated that these management alternatives would help maintain or accelerate that trend. Preventing, eradicating, and otherwise controlling the spread of noxious weeds would help preserve the dominance of desirable species, biotic and abiotic integrity, the resilience of native ecosystems in the face of human and natural disturbances, and keystone ecosystem processes.

This section presents the impacts to the structure, composition and function of the preserve's watershed(s) as the combined impact of direct, indirect and cumulative effects to soil and water resources. The analysis was an interdisciplinary process lead by a hydrologist and soil scientist with silvicultural, range, wildland fire, and GIS specialist input and review. The report is based on a review of

existing literature, field visits, application of models, and formal and informal monitoring of the impacts of past and present actions on the preserve.

Direct and Indirect Effects

The breadth of proposed vegetation management and restoration would increase the potential for noxious weed spread due to the amount of disturbance across the landscape. Both alternatives propose to treat approximately 50,000 acres using a combination of mechanical treatments and planned wildland fire ignitions. Up to 1,139 acres of roadsides, gravel pits, and landfills were considered high-risk locations where invasion was likely to occur. As a result of the Las Conchas fire, approximately 16,062 acres of moderately to severely burned vegetation are also at increased risk of invasion. Physical disturbance on or adjacent to these sites, as a result of machinery, manual labor, or the use of fire, would temporarily increase the amount of bare soil that is available to noxious weed colonization. Noxious weeds could be transported into these disturbed areas, from within the preserve or from surrounding ownerships, via a number of vectors including machinery, humans, livestock, wildlife, wind, or water. But the risk of noxious weed introduction and spread would be significantly reduced by the implementation of a comprehensive noxious weed prevention and treatment strategy.

It is expected that the VCT would be able to identify and respond to existing and unforeseen threats presented by noxious weeds. The comprehensive treatment options would increase the effectiveness of noxious weed management and make site-specific objectives realistic and achievable. In addition, performance requirements and noxious weed prevention strategies (performance requirements from chapter 2), included under these alternatives, would limit the number of new threats that must be responded to in the future. As a result the trust would be better equipped to steward the preserve in accordance with its stated land management principles.

Canada, bull, and musk thistles will continue to be treated. The proposed action alternatives will also allow treatment of cheatgrass, oxeye daisy, and goatheads as well as expand available treatment options (Appendix B) for all species in order to effectively manage noxious weed populations. By authorizing treatment of these additional species adverse ecological effects would likely be minimized because all existing noxious weeds on the preserve would be treated. Expanding the tools that are available for treatment would also give managers greater latitude to adapt to site-specific circumstances and use the most appropriate and effective treatment options.

The early detection/rapid response (EDRR) strategy proposed under this alternative would also provide for treatment of new noxious weeds not already found in the preserve (such as Dalmatian and Yellow toadflax). Timely management under EDRR would allow new infestations to be treated when they are small in order to prevent their spread, minimize treatment costs, and reduce adverse effects of treatment. Preventing the spread of new noxious weeds reduces the likelihood of adverse ecological impacts that result from new infestations. Treating noxious weed populations when they are small minimizes treatment costs because less time and fewer resources would be needed to be effective. Treating smaller populations would also limit any potential disturbance that may occur as a result of the treatment itself.

Under the proposed EDRR strategy the trust would identify new sites outside of the known treatment areas for potential treatment annually, or as needed. Completion of the trusts ICP ensures consistency

with management priorities and objectives, authorized treatment methods, and site restoration strategies. If the anticipated methods and scope of treatment do not exceed those included in this analysis, treatment would proceed. If expected scope or methods of treatment would exceed those accounted for in this analysis then treatment methods or project scale would be adjusted, or additional NEPA would be necessary before implementation. After a thorough review has been conducted and treatment has been approved, performance requirements would be implemented in order to guide management. Together, this system of checks and balances would maximize treatment effectiveness, minimize detrimental disturbance to native ecosystems, and prevent adverse effects on health and human safety.

Invasive species sites would be prioritized for treatment based on factors such as the current abundance and distribution of the species, the potential for spread, and the type and values of the affected site. For example, noxious weed occurrences located on sites proposed for ground-disturbing management activities may be treated prior to project implementation in order to prevent their spread, or priority may be given to complete treatment and restoration of sites where considerable time and money has already been spent. Opportunities for special funding or cooperative projects may also receive priority where work may not otherwise be feasible. After invasive plant species locations are prioritized for treatment, each site within the preserve would be assigned a treatment objective which would vary depending on the potential negative impacts of a given invasive species, the potential for spread, the value or sensitivity of the treatment site, and the feasibility and costs of treating a site. This allows managers to focus available resources where they will be most efficient and effective at preventing noxious weed spread. Managers will also be able to pair specific sites with the most appropriate treatment method, avoiding potential disturbance to non-target species.

Once prioritized and assigned treatment objectives, noxious weed populations would be treated using a variety of effective methods (Appendix B). Because no single management technique is perfect for all invasive plant control situations more than one option is listed for each species where available. Treatments could be used in combination, or change over time as site conditions change. This allows managers to adapt to site-specific situations and utilize the most efficient and effective treatment method available. Physical, biological, and chemical control methods can disturb soil or damage desirable vegetation, promote establishment of weedy species, or produce debris, which must then be disposed of (Bossard, Randall and Hoshovsky 2000). Some treatment methods may also present health risks if applied improperly. A wide array of effective treatment options would give managers the opportunity to select a method that would be least likely to disturb non-target species, soil, or other important resources. Performance requirements would also be implemented in order to prevent adverse effects on human safety (chapter 2).

Control methods may eliminate or suppress invasive species in the short-term, but the resulting gaps in vegetation and bare soil create open niches that are susceptible to further invasion by the same or other undesirable plant species. However, passive and active site restoration or revegetation would reduce the likelihood that invasive plants could reoccupy a site after treatment. Passive restoration would depend on re-colonization from the existing native plant seed bank and from seed dispersed from surrounding sources, as well as growth and reproduction of native species already within the treatment site. Active restoration would require activities such as seeding, raking (by hand or with a harrow pulled by an ATV), mulching, and/or out-planting of plant materials.

Passive restoration is the most commonly used treatment on small noxious weed occurrences, and cause limited soil disturbance. Having an adjacent native plant community capable of providing seeds for re-colonization increases passive restoration success. Active restoration would be limited to large sites with dense infestations, where considerable bare soil and little native vegetation are present after treatment. Foreseeable active management opportunities include recently disturbed landings and skid trails where restoration would be used as a preventative measure to reduce bare soil, or on roadsides where restoration seedings could be used to re-vegetate and reoccupy recently treated areas. Sites where continual disturbance prevents long-term establishment of vegetation (such as parking areas, and gravel pits) would not be actively restored. Active restoration opportunities such as planting or seeding of native species would be implemented on a site-specific (project by project/treatment by treatment) basis as they are identified in the future, and according to the principles of adaptive management. Individual active restoration treatments will likely be limited to areas that are no more than a few acres in size.

Cumulative Effects

In addition to vegetation management and restoration efforts, past, ongoing and future management activities may combine to increase the amount of disturbance on the preserve and therefore the risk of noxious weed introduction and spread. These ongoing and possible future activities include road maintenance, livestock grazing, forest vegetation manipulation, prescribed fire, administrative traffic, expanded recreation, riparian restoration, research, and wildfire. Some noxious weed management has also occurred in the past and is also ongoing, and likely reduced the potential for cumulative effects by reducing noxious weed populations.

Implementation of either action alternative would not likely result in adverse cumulative effects because efforts to prevent, control, and eradicate noxious weeds would be expanded. All noxious weeds found on the preserve would be treated, preventing their spread. Future management actions would also be subject to consideration regarding the effects of noxious weeds. When intensive ground-disturbing projects are proposed (road maintenance, vegetation treatments, etc.), site-specific assessments would be conducted and mitigation measures employed (chapter 2) to ensure that such actions would not result in the introduction or spread of noxious weeds. More passive actions such as livestock grazing would also be considered in noxious weed management as animals would be temporarily quarantined upon entry into the preserve and only certified weed-free feed could be brought in for livestock. Performance requirements (chapter 2) would also be implemented in order to ensure health and human safety.

5.5 Watershed

How would the proposed restoration activities impact the soil and hydrological resources and ultimate the function of the preserve's watersheds? This section presents the impacts to the structure, composition and function of the preserve's watershed(s) as the combined impact of direct, indirect and cumulative effects to soil and water resources.

5.5.1 Goals and Objectives

Chapter 2 included goals, objectives, and monitored outcomes for the proposed Stewardship Plan. Objectives related to water quality, terrestrial and aquatic habitats, and road management, also directly reflect watershed function. These include closing and decommissioning roads, improving water quality, improving the functioning condition of stream banks, and riparian/aquatic habitats, expanding wetlands, and protecting soil resources. Targets include miles of road to be closed, quantified measures of water quality and streambank condition, increase in wetland acres and the return of species whose present absence is due, at least in part, to current watershed condition.

5.5.2 Methods

The analysis was an interdisciplinary process lead by a hydrologist and soil scientist with silvicultural, range, wildland fire, and GIS specialist input and review. The report is based on a review of existing literature, field visits, application of models, and formal and informal monitoring of the impacts of past and present actions on the preserve.

5.5.3 Environmental Consequences – No Action

The purpose of the proposed activities is to move the natural systems within the preserve towards the reference condition; the need for the action is based on the existing condition and current downward trend as well as future risks under the current change in climate and potential for fire and other disturbance. If no action is taken then there would be no direct impact however, indirectly and cumulatively there would be potentially and likely minor to moderate adverse impacts as shown in Table 5-27 as the existing condition persisted and continued to decline.

Table 5-27. Environmental consequences summary table: watershed - no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level	Moderate	Likely
	↓Cumulative	Landscape level, 5th code HUC	Moderate	Likely
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level to region	Moderate	Potential
	↓Cumulative	Landscape level	Moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Likely
	↓Cumulative	Landscape level	Minor - moderate/adverse	Likely
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential

Activity	Effects	Context	Intensity	Certainty
	↓Cumulative	Landscape level	Minor - moderate	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Likely
	↓Cumulative	Landscape level	Minor - moderate	Likely

Forest Thinning and Wildland Fire Management

Direct Effects

If no action were taken, there would be no disturbance otherwise on forested slopes and the short-term risk of localized erosion from ground disturbing treatments. There would be no increased industrial traffic on the preserve road system and the increased suspended sediment load that would incur.

Indirect effects – Continued downward trend in condition

Indirectly the current condition and resulting downward trend of watershed in relation to forest condition would continue as described in chapter 4. As there would be no thinning of forest canopy, there would be no potential increase in water capture, storage or yield or improvement to watershed function. Stream flow would remain the same, as allowed by the vagaries of annual weather patterns. There would be no potential increase in base flow or peak runoff as might occur with permanent reduction in forest canopy. Optimal thinning has been shown to measureable increases stream flow through increases in ground water flow (Veatch, et al. 2009). This component of the annual hydrograph enhances summer base flow critical factor for aquatic species. A full discussion of research on hydrograph components on VCNP streams and that of stream flow increase through vegetation management is given in effects section for alternative 2 below.

Indirect effects – Severe Fire and Intense Suppression Activities

The most potentially significant impact would be the continued build-up of forest fuels and the sustained potential for uncharacteristically severe fire behavior and extent and associated post fire flooding and erosion.

If the west side of the preserve were to burn under conditions similar to the 2011 Las Conchas fire, we believe post fire effects would be even greater than those that followed the Las Conchas. Our prediction is based on the topography of the preserve's west side where Sulphur, Redondo and San Antonio creeks all flow though steep, forested canyons. This topography lacks the broad *valles*, which significantly buffered the streams from flooding and erosion following the Las Conchas fire. We observed the greatest post fire impact to water came from the Rito de los Indios, which flowed through a severely burned forested canyon. Erosion and debris flows elsewhere on the preserve, although significant were captured and mitigated by the broad *valles*; as demonstrated by the minor degree of impact to the East Fork of the Jemez River where it flows through the preserve.

Under the no action alternative and associated fire behavior potential, the potential for downstream flooding and erosion would be greatest through the communities of Sulphur Springs and La Cueva where

the streams converge. A large and severe wildfire on the west side of the preserve could have potentially damaging and destructive, mid- long-term impacts on the watershed resources that support these communities.

Short-term effects of a fire would be one or two seasons of high-suspended sediment load. Some deposition of coarser material might be expected in the channels. Fish kills from concentrated ammonia might also again occur.

There can also be direct and indirect impacts resulting from fire suppression actions. The intensity of management response is proportional to the fuel and environmental conditions the fire is burning in and the values at risk. Under the no action alternative management response would continue to be aggressive (consistent with safety and cost effectiveness). Bulldozers were used during the Las Conchas fire within grasslands and on steep slopes, backfires were ignited under high severity conditions. Although immediate efforts were taken to ameliorate the impacts of the suppression activities, the effect of these intensive actions combined with the effects of the fire and contributed to post-fire erosion and sediment deposition.

Aerial retardant is used sparingly in wildfire suppression efforts due to the tremendous cost and exposure to risk. Under the no action, aerial retardant use would be more likely and an increase exposure to accidental impacts to streams would persist.

Riparian and Wetland Restoration

Direct Effects – None

Under the no action alternative there would be no direct effects to soils or hydrology.

Indirect Effects – Continued Downward Trend

Under the no action alternative, riparian and wetland restoration designed and prioritized to effectively improve water quality and watershed condition, would continue in the San Antonio and Sulphur 6th level HUC but would not occur in the East Fork Jemez or Jaramillo. The improvements would remain limited to the 6th level HUC in which they occur. Indirectly this would contribute to the current water quality issues, especially temperature, would be expected to continue and increase under forecasted climate trends. Future trends, as described in chapter 4, are predicted to extend the warming season (Running 2006, Westerling, et al. 2006) and increase the average maximum temperature.

Burned Area Rehabilitation

Direct Effects

Under the no action alternative there would be no direct effects to soils or hydrology.

Indirect Effects – Continued Downward Trend

Limited actions described in the Burned Area Emergency Report would address the significant and imminent impacts to infrastructure and thus provide some indirect protection to watershed and water

quality. However, points of erosion or instability, which are not immediately at risk, could increase incrementally and over time could begin to cumulatively limit the preserve's recovery from this severe event.

Road Maintenance

Direct Effects

Under the no action alternative there would be no direct effects to soils or hydrology.

Indirect Effects

Open roads would continue to be maintained however, actions to address ongoing resource damage caused by historic roads, especially those along the *valle* edges would not be implemented thus limiting the potential cumulative benefits of repairing multiple minor issues within multiple watersheds.

Noxious Weed Control

Direct Effects

Under the no action alternative there would be no direct effects to soils or hydrology.

Indirect Effects

If no action were taken the current noxious weed control program would continue and it would be unlikely that Canada, bull or musk thistle, or oxeye daisy would substantively impact the watershed condition. However, the preserve would remain vulnerable to expanding cheatgrass and other new populations that would reduce the watershed's resilience in responding to changing climate, fire, insects or other disturbance.

5.5.4 Environmental Consequences Action Alternatives

As shown in Table 5-28, there are potential direct and adverse impacts to watershed resources resulting from the implementation of any action alternative. However, these effects are predicted to be minor, localized, and short term. These impacts are mostly due to localized ground disturbance and increased traffic and can be limited by the application of performance requirements.

Indirect and cumulative impacts are expected to be moderate and beneficial across the preserve and extend in to the future 5 – 10 years or more. These beneficial outcomes are predicted to occur as a result of both the improvements to ecosystem structure, composition and function; and the armoring of these systems in the event of wildfires or other disturbances.

Indirect, adverse impacts have the potential to occur, primarily due to brush disposal activities. However, these impacts are predicted to be short term and localized.

Table 5-28. Environmental consequences summary table: watershed – action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	Localized and project level	Minor	Potential
	↑Indirect	Landscape level	Moderate	Likely
	↑Cumulative	Landscape level, 5th code HUC	Moderate	Likely
Wildland Fire Management	↓Direct	Localized and project level	Minor	Potential
	↑Indirect	Regional	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Road Management	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Riparian Restoration	Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Moderate	Likely
Noxious Weed Management	Direct	Localized	Negligible	Potential
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Burn Area Rehabilitation	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Moderate	Likely

Forest Thinning and Wildland Fire Management

Forest thinning is planned over a 10-year period closely integrated with prescribed burning. Direct impacts would be localized ground disturbance. The effect of ground disturbance is expected to be minor and localized. Indirectly proposed thinning and prescribed burning is predicted to cause moderate improvements the structure, composition and function of hydrology and soils at a localized and watershed level, mostly due to changes in forest structure. These improvements would extend to the mid-term and could be maintained long-term. Some indirect impacts may be adverse however; these are predicted to be localized and short term.

Direct Effects

Thinning and removing biomass using ground-based equipment may disturb ground cover and compact surface soil. Ground disturbance is predicted to be localized and short-term. Similar activities conducted on the preserve have found this type of disturbance occurs in localized areas especially near landing or unit edges where equipment turns (Figure 5-19). Soil damage from mechanized equipment would be prevented or minimized by the performance requirements identified in chapter 2. These include limiting the use of heavy equipment to slopes less than 30 percent. Forest stands selected for treatment under alternative 2 have an average slope less than 25 percent; those selected for treatment under alternative 3 have an average slope of less than 30 percent. Performance requirements also include standard best management practices to minimize log- skidding disturbance and re-establish ground cover on disturbed surfaces.

Figure 5-19. Localized ground disturbance caused by tracked equipment turning at a landing site

Prescribed burning and connected activities described in chapter 2 can directly impact soils through heating and exposure as well as creating localized areas of disturbance. Prescribed burns, unlike wildfires, are implemented during times of moderate humidity and temperature, and little to light winds. While ground cover may be effectively eliminated over localized areas within a prescribed burn, the pattern is invariably a mosaic of burn and unburned that approaches uniform distribution across a slope.

Indirect Effects

The table below enumerates mechanized and wildland fire management by forest covers type. The following sections will discuss in detail the indirect effects of the proposed restoration activities on watershed resources including the capture, storage, and yield of water; water quality, stream morphology, erosion and soil productivity.

Table 5-29. Proposed mechanical treatments by forest type for both action alternatives

Forest Type	Target Tree Canopy Cover (%)	Alt 2 Acres	Alt 3 Acres
Fire Regime I - Montane grasslands and	<20	3,235	3,235

Forest Type	Target Tree Canopy Cover (%)	Alt 2 Acres	Alt 3 Acres
forest meadows			
Fire Regime I - Ponderosa pine savanna and forest, xeric mixed conifer	20-40	7,860	7,806
Fire Regime III - Mesic mixed conifer, aspen-mixed conifer	30-50	7,500	10,878
Fire Regime III - Mesic mixed conifer, aspen-mixed conifer (steeper slopes)	40-60	1,500	899
Fire Regime IV - Dry-mesic spruce-fir, mesic spruce-fir	40-60	1,200	480
Fire Regime III - Mixed montane shrublands	<20	200	200
Total		**21,495**	**23,498**

Part of the purpose and need of the landscape restoration plan is to increase ecosystem services by increasing streamflow and improving (decreasing) stream temperature. Upslope vegetation treatments would increase snow cover that percolates during runoff to either shallow or deep groundwater paths. Restoring pre-settlement riparian conditions on the valley bottoms would retain baseflow longer on the preserve, decrease summer water temperatures, and increase cover for fish. The San Antonio watershed shows the highest potential to increase upland water budget through canopy alteration given the thick in-growth of ponderosa pine in one-time savannah structure and losses of aspen.

The Valles Caldera has considerable groundwater storage from deep sediment filled valleys, and large alluvial fans (Goff and Gardner 1994, Goff 2002). Reductions in forest canopy cover increases snow depth but there is an optimal range of forest spacing and patch size to retaining snow (Musslemann, Molotch and Brooks 2008). Open spaces accumulate greater snow depth than the forest stands, but are subject to increased losses by radiation and wind. Thinning would limit the size of openings in tree stands, and favor aspen. Trees provide shade and shelter from wind to retain deeper snow cover in adjacent open spaces. Warm aspect slopes would have more open conditions compared to cool slopes. Soils and understory vegetation data would be used to tailor treatments to account for site growth potential. Rocky, well-drained soil conditions promote trees, compared to organic rich, deep soils that promote understory vegetation and savannah forest structure.

Interception of precipitation, mostly snowfall, by the conifer canopy is subjected to sublimation (conversion of snow to vapor), and ablation (wind removal). Open spaces frequently accumulate greater snow depth on the ground than a forest canopy by exposing less of it to solar radiation and wind (Geddes, Brown and Fargre 2005, Musslemann, Molotch and Brooks 2008). The canopy structure spreads snowfall over a greater surface area than it would occupy on the ground below.

There is evidence that canopy reduction from uplands would lead to increase runoff, during snow melt, both in total yield and peak flow (Troendle and King 1987, Burton 1997, Troendle, Wilcox, et al. 2001). Studies of canopy reduction in Colorado Rockies and Wasatch Plateau show significant gains in flow during spring runoff. Also the larger proportion of snowmelt occurs while soil temperatures are cold enough to suppress plant activity.

Reduction of the over story canopy increases soil moisture during runoff, though it also increases variability over an annual cycle. Soil moisture flux, percolation past rooting zone, may be prevalent

during snowmelt runoff because low soil and air temperatures suppress plant activity. Figure 5-20 shows air and water temperatures rise above 35° F only in latter stages of snowmelt.

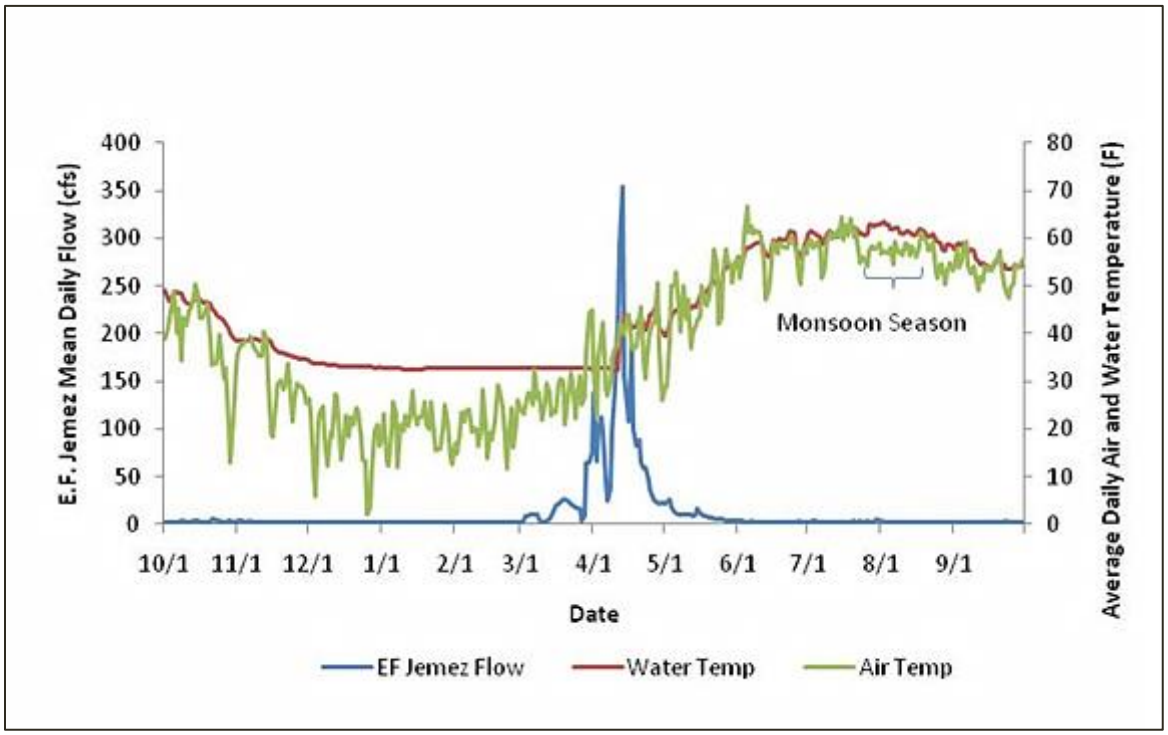


Figure 5-20. Air and stream temperature, East Fork Jemez: water-year 102010

Soil moisture in grass cover had greater variability than adjacent aspen stand with higher moisture coming out of runoff period and lower during summer growing season. These results are consistent with localized research for the preserve (Huxman, et al. 2005, Vivoni, et al. 2008).

Over the past century over a hundred paired catchment studies have been conducted detailing impacts on stream flow of canopy reduction. These studies have been reviewed working with progressively more cases (Bosch and Hewlett 1982, Stednick 1996, Brown, et al. 2005). These reviews have come to similar conclusions summarized as follows:

- Reducing cover virtually always increases runoff
- Canopy reduction of less than 20% does not have measureable effect
- Effects are greatest in runoff months
- Effects are proportionally greater in dry climates
- Effects are highly variable, but gross predictions can be made that changes in water yield will follow in increasing order - Conifer ➔ Deciduous ➔ Grassland – as illustrated in Figure 5-21 below.

Most catchment studies are small basin, less than 200 acres, though the maximum are much larger, about 3500 acres, and the generalizations stated above holds throughout this range (Troendle, Wilcox, et al. 2001).

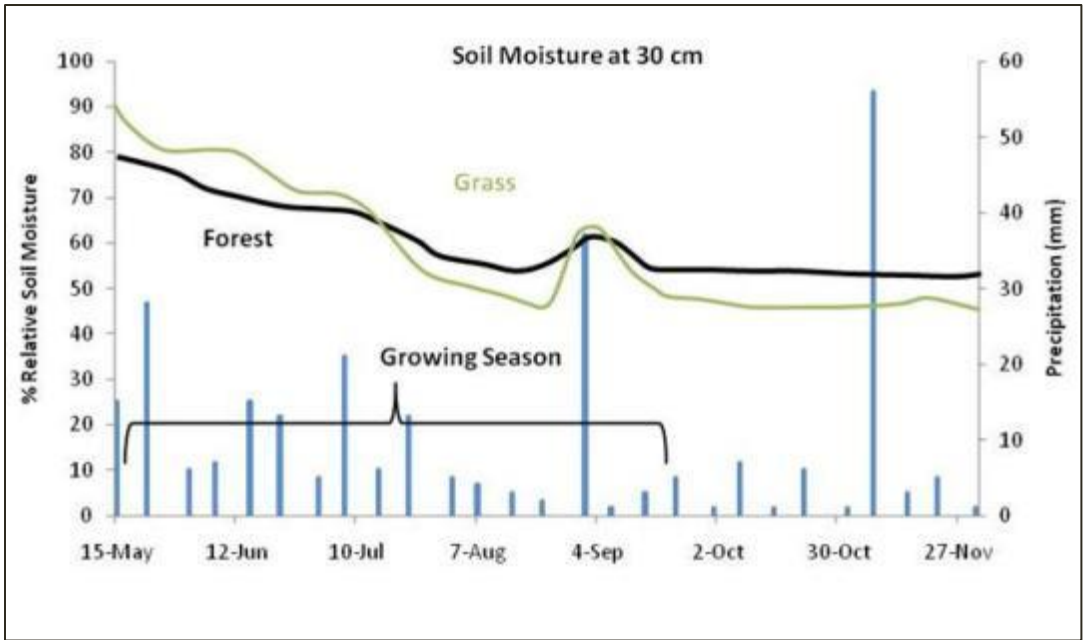


Figure 5-21. Soil moisture flux over a growing season for forest and adjacent grassland (James, et al. 2003)

Water Capture, Storage, Yield

The gain of water from canopy alteration can be described by the duration of the effect as well as the intensity of the effect. The duration of effects depends on the nature of the treatment and site potential for re-growth. Depending on climate, recovery from effects is usually within 5 years. By the end of that term soil moisture flux studies show new vegetation largely uptakes available water, and evapotranspiration (water losses through soil evaporation and plant transpiration) may even exceed initial pre-cut stand condition (Simonin, Kolb, et al. 2006, 2007). For perennial conversion, however, it may take longer to ascertain long-term average. Further, Huxman et al (2005) suggests that the highest changes from woody canopy reduction are where subsurface flow is substantial. For the Valles Caldera, the terraces provide substantial shallow groundwater flow given the perched groundwater from buried lakebed sediments.

A partial over story removal rather than complete may have substantial advantages for runoff increases. In studies on Redondo Peak a pattern of open spaces interspersed within forest cover optimizes snow accumulation (Veatch, et al. 2009). This study indicates that canopy retention of 20-40 percent, located for best shading and shelter, maintained deepest snow pack in adjacent open spaces. This is within the range of treatment prescription for fire regime I dominated encroached grasslands, ponderosa pine savannah and woodland, and xeric mixed conifer. These cover types show a stronger departure from natural conditions than others, and because of changes in grazing use and fire suppression policy these alterations are considered the most likely to persist.

The proposed treatments in the action alternatives would alter forest canopy, though the cover type and site would dictate the length of time these conditions are maintained. Prescribed fire would be re-introduced where appropriate to maintain conditions. Ponderosa pine would have the greatest change from current cover. These sites primarily occur on the warm aspect slope fans in in the valles, on Redondo Peak and the Banco Bonito bench. Cool aspects and higher elevations support mixed conifer

with well-drained soils that would have modest gains, though tempered as forest re-growth returns. Paired watershed studies show an effect of 5 to 7 years (Brown, et al. 2005).

Figure 5-22 illustrates how mollic soil can be used to guide forest thinning treatments. The shading indicates where mollic soils occur within the dry type ponderosa and mixed conifer forest. Thinning would focus on these mollic areas to create larger opening for a sustained savannah type forest. Dry forest types without mollic soils are prone to woody species and thus could have an array of group selection and less thinning. The higher elevation mesic stands highlighted in green would also have gaps from group selection with an emphasis on aspen where appropriate especially under alternative 3.

We speculate that much of the current condition is due to overgrazing in the 1800's that bared soils for tree recruitment. The spring discharge on these fans led to initial establishment of the pines that further expanded with lack of fire. Thus, the targeted savannah thinning on these historically savannah and grassland soils could lead to a more sustainable condition. This sustained opening would therefore lead to long-term gains in interflow.

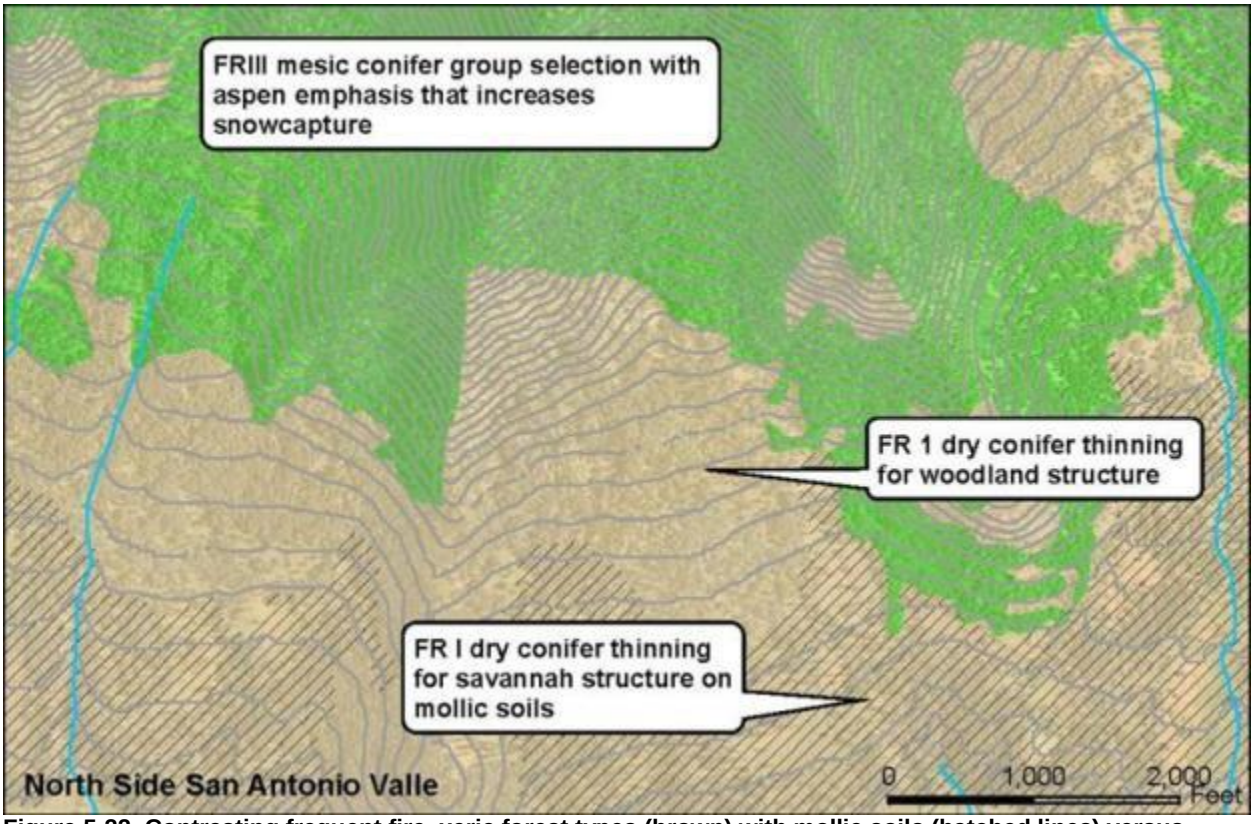


Figure 5-22. Contrasting frequent fire, xeric forest types (brown) with mollic soils (hatched lines) versus mixed fire regime mesic forest (green) on the upper hillslope of San Antonio valle

Average discharge yield in acre-feet was compared with average precipitation amount in the four major drainages exiting the caldera as presented in Table 5-30. Data was acquired using Theisson polygon method with GIS topographic layers. The method calculates precipitation volume for a given area based on data from a nest of weather stations on the preserve.

Table 5-30. Estimate of annual water yield per basin

Basin	Average Precipitation (inches)	Average Precipitation Volume (AF)	Discharge Yield (AF)[a]	Discharge as% of Precipitation
East Fork Jemez	23.9	51,457	9,084	18%
San Antonio	21.3	68,674	8,226	12%
Redondo	24.5	13,518	335	3%
Sulphur	23.5	16,642	515	3%
Total		**150,291**	**18,160**	

a - water year 2010, complete records for all drainages

Assuming that current snow water content would remain proportional then the increase in snow depth is additive to precipitation water available for infiltration into the soil. Assuming further that factors such as evapo-transpiration also remain proportional then there is expected a proportional increase in stream flow. Snow depth increases of between 10 and 20 percent in long term cover types using relationships between canopy density and snow water content in Veatch (Veatch, et al. 2009). Table 5-31 gives increase in annual flow for alternatives 2 and 3 based on conservative treatments and outcomes.

Alternative 2 has roughly 2,300 acres suitable for aspen recovery while alternative 3 has 8,700 acres for aspen emphasis. There are substantial increases in flow in alternative 3 versus 2 largely because of the increase in treatment on ground with long-term alteration potential.

Table 5-31. Increase in annual flow for the action alternatives. Calculations based on an assumed increase of 15 percent snow depth.

	Alternative 2			Alternative 3		
Watershed	**Watershed Area with Xeric Forest and Aspen Emphasis (%)**	**Annual Yield Increase (%)**	**Annual Yield Increase (AF)**	**Watershed Area with Xeric Forest and Aspen Emphasis (%)**	**Annual Yield Increase (%)**	**Annual Yield Increase (AF)**
E F Jemez	6.5	1.0	89	8.7	1.3	118
San Antonio	8.6	1.3	106	13.8	2.1	171
Redondo	24.8	3.7	12	33.0	4.9	17
Sulphur	17.0	2.6	13	28.0	4.2	22

Realized increases in interflow could also occur with the alternative 3 emphasis on aspen. The shift from evergreen to deciduous cover type is shown to increase snow retention (LaMalfa and Ryle 2008). Deciduous trees have a more open canopy than evergreens in winter, retain canopy for summer moderation of soil moisture by shading, and have rooting that facilitates soil drainage for early spring transpiration. Figure 5-23 provides a broad comparison of aspen enhancement that could affect water retention by basin.

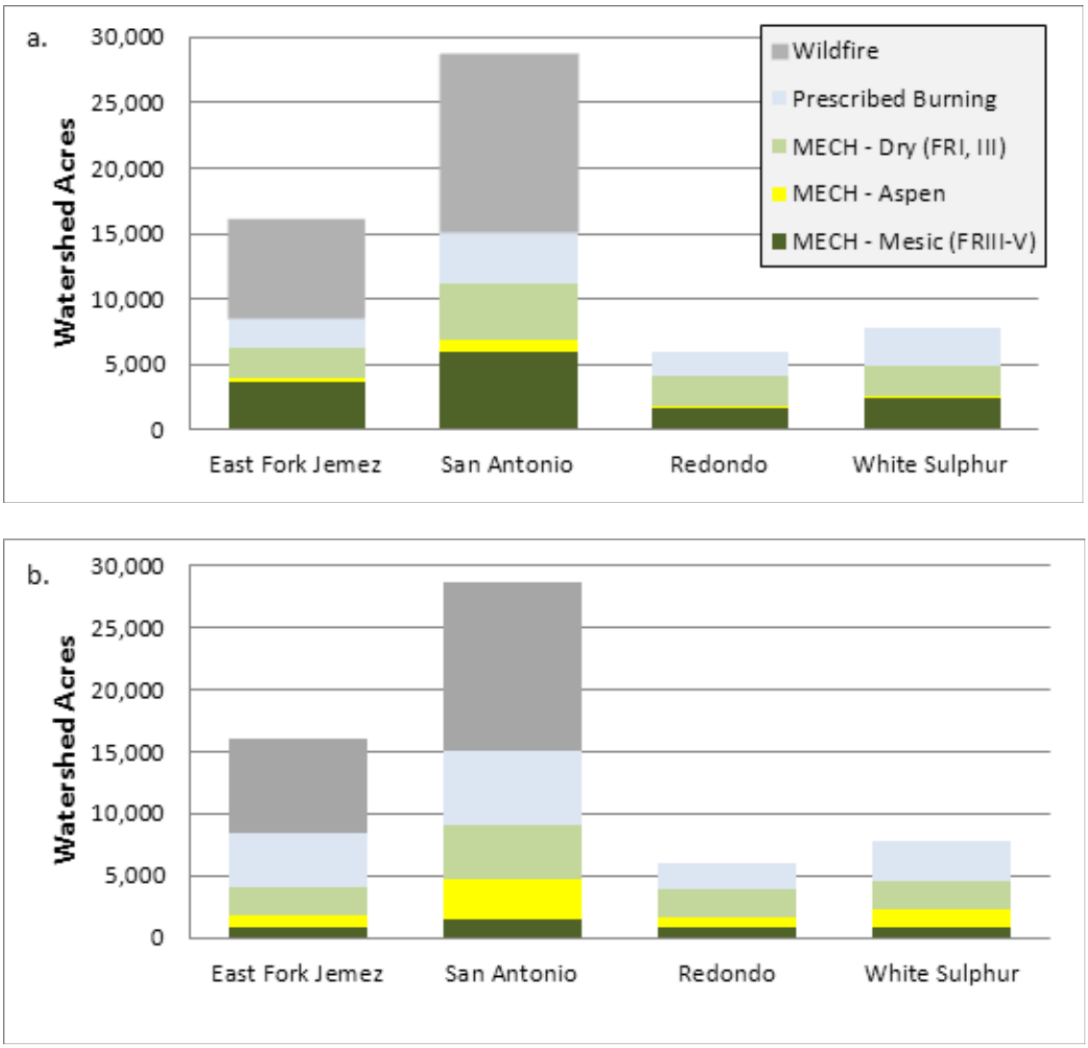


Figure 5-23. Planned mechanical thinning area (acres) within vegetation types and fire regime for major watersheds. Treatment scenarios shown for (a) alternative 2 and (b) alternative 3 where aspen regeneration is emphasized. Cover types within Fire Regime I include ponderosa pine savannah, woodland, xeric mixed conifer forest, and Gambel oak shrublands. Cover types with Fire Regime III thru IV include mesic mixed conifer, blue spruce and aspen mixed conifer forest.

Any increase in flows through the basin outlet would depend, at least partly, upon changes to valley bottom channel vegetation and morphology. Riparian restoration plans, discussed below, may have an effect on evapo-transpiration budget. Efforts to raise the water table and reconnect channel flow to valley floodplain, if realized, may also change total evapo-transpiration as well as the retention time of runoff water.

The steep upper slopes of the domes and rim are largely groundwater recharge zones (Figure 5-24). Except for the fault-aligned perennial streams (Rito de los Indios, Redondo and White Sulphur Creeks) there are only a few intermediate channels and seasonally wet swales originating directly off the upland slopes. Obvious surface discharge occurs at springs in the fan and terrace forms - frequently at distinct breaks in gradient - or from between identifiable strata. These landforms have considerable storage capacity, which in the dry climate can make for long residency time for groundwater before emerging as

surface flow. Liu et al (2008) measured residency time as months to decades in San Antonio Creek and East Fork Jemez River. In Redondo Creek, where the slopes lack deep deposit mantle, residency time was measured in weeks.

Proposed treatments are somewhat evenly divided in recharge and discharge areas (Figure 5-24). Canopy post-treatment would be thinnest on the discharge slopes (outside the area burned by the Las Conchas fire) where predominant cover type is pine savannah. Following the argument above, discharge areas would have the greatest potential for increased snow depth. There is no data available however to differentiate the source of surface flow (recharge versus discharge). We speculate that proximity to valley bottoms and perennial stream channels, at the very least, would result in proportionally higher discharge yield from treated fans than dome slopes.

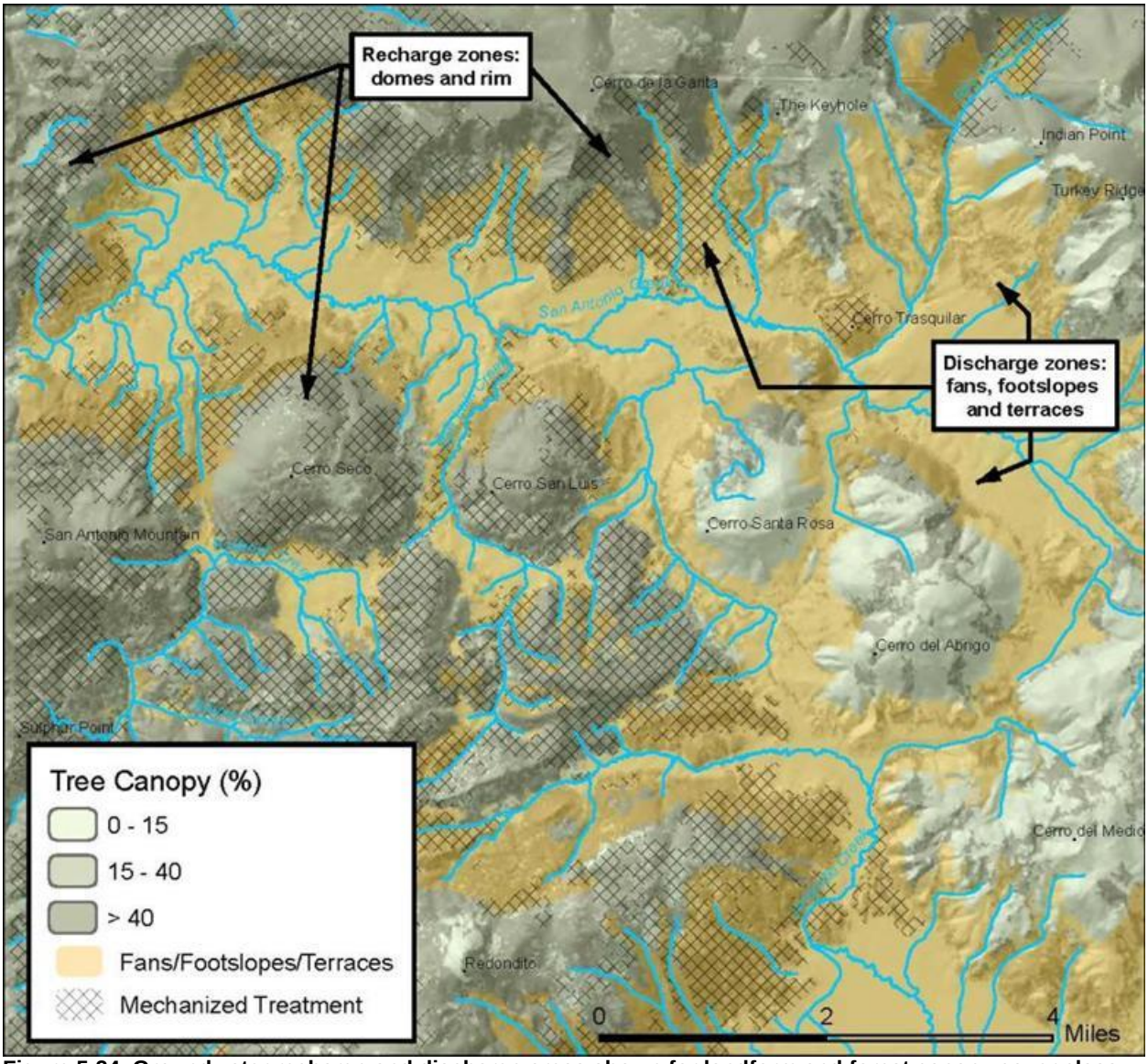


Figure 5-24. Groundwater recharge and discharge areas shown for landform and forest canopy cover class. Hatched show mechanized thinning activities for alternative 2.

Sediment and Pollution

Sediment production from the forestry treatments would be localized depending on slope steepness and extent of ground cover disturbed and open forest condition. Limited areas of steep slopes with the most open tree canopy treatment followed up by prescribed fire may, under certain circumstances, present similar conditions to a moderate severity wildfire. If strong monsoon rains follow treatments, rilling may be expected. The area extent of treated slopes in such erodible condition, however, would be expected to be much less than a wildfire. The vegetation treatment would first reduce the quantity of fuel and alter the arrangement of the fuel bed. The fire severity of a treated hill slope should not exceed a FIS class 2 (tree stems scorched, litter layer and basal vegetation consumed, though soil organics intact; (Keely 2009)).

Periodic review of research on the effect of streamside buffers has found consistent results in terms of maintaining water quality (Castelle, Johnson and Conolly 1994, Castelle and Johnson 2000, Fischer and Fischenich 2000). Forest floors are more effective than grass slopes because they present a higher resistance to shallow surface flow. Buffers of any vegetative type of about 30 meters will remove 80-90 percent of nutrient and sediment load, largely through resistance and dispersal of the transporting sheet wash. Buffers are entirely ineffective however, if dissected by pre-existing channels that concentrate flow.

Filtering of nutrients (N, P and K) is typically within the first 10 meters of a buffer. Since nutrient elements are mostly bound to sediment the first 10 meters is also the most effective for trapping sediment. Material sand size or greater will deposit in a few meters or less, and then progressively longer distances are required for finer particles. Even at 30 meters clay sized particles will not be entirely winnowed out and account for most of the material still entrained. Sediment will deposit in a strip at the beginning of a buffer until the cover is effectively buried. Then the sediment deposition area advances a few meters. The sediment delivery in this scenario is obviously very heavy. The effect of this phenomenon was observed on the grassy fans below the burned slopes in the aftermath of the Las Conchas Fire.

Soil Productivity

The proposed thinning and burning activities would complement soil processes by re-introducing fire according to the natural fire regime and diversifying forest species. In the drier sites, the treatments could increase moisture and bolster nutrient availability. In mesic sites, emphasis on aspen would increase available carbon for biological processes. The increased biological activity could increase nutrient production and incorporate organic matter into soils. The burning would lead to short term pulses in nutrient availability, most pronounced in the dry type forest woodland communities.

Soil Moisture and Site Potential

Increasing moisture is advantageous since the soil nutrient mineralization cycles are biologically driven and depend on moisture. Optimum soil mineralization occurs between 10 percent soil moisture and snowmelt saturation during the growing season. Moisture stress on the preserve is found primarily on the warm aspects and is a function of ecological cover type. Grasslands can have high rates of moisture retention from mollic soils, but subject to strong evaporative draw from sunlight exposure. Forested sites

have less evaporative potential, but exert high soil moisture demands through transpiration. The cooling effect from transpiring trees and shading can temper evaporation (Breshears 2006, Villegas, et al. 2010). Further, tree roots can regulate a minimal soil moisture level in the upper soil levels through hydrologic redistribution that's currently identified in ponderosa pine and Douglas-fir sites in the Pacific Northwest (Brooks 2002), but not reported for the preserve. Optimally, an open and mixed canopy lowers transpiration while decreasing losses from soil evaporation by providing shade (Breshears 2006).

Site-specific soils have a role in regulating gains in site moisture that may result from forest treatments. Adjustments to thinning intensity (prescriptions) based on site soils can help optimize soil moisture benefits. Rocky, well-drained sites would need greater protection from radiation from the forest canopy since these sites lack soil water holding capacity. Woody vegetation is more suited to deep water where rocky soils have poor retention of plant available water. Conversely, deep mollic soils that support grasslands could have more open conditions given the very robust soil water holding capacity that is less prone to drying. Mollic soils have deep aggregations of soil organic matter and finer texture that increases soil water holding capacity. Grass mulch and forest organic mats also enhance the soil water holding capacity. Using data from the recent soil surveys, soils in grassland locations retain 10-25 cm water in the top 50 cm soil, compared to 2-6 cm water for rocky well drained sites on the flanks of the rhyolite domes (USDA-Forest Service; USDA-NRCS, 2011).

Mastication of biomass would also increase soil moistures. In their final report to the Joint Fire Science Program following multi-year, multi-site research in coniferous forests in Colorado, Battaglia et al. showed that mulch elevated soil moisture in general (Battaglia, et al. N.D.).

Group selection treatments produce openings or patches in the forest canopy that would reduce induced losses of soil moisture with diffuse shading. In piñon juniper woodland, Breshears (2006) showed open spaces in a patchy woodland had 300 percent the radiation of the wooded patches, but only 60 percent radiation of completely open conditions. Where forests are thinned to a patchy matrix, tree height and architecture becomes important for reducing radiation and thus tempering soil evaporative losses (Breshears 2006, Villegas, et al. 2010). However, we are less clear on the shifts in transpiration from these forest patches. In Arizona, thinning down to 35 percent basal area did not reduce total transpiration but instead resulted in increased transpiration by understory vegetation and retained trees (Simonin, Kolb, et al. 2006, 2007) perhaps indicating increased moisture availability for plant uptake.

The favoring of aspen, pronounced in alternative 3, could enhance soil water retention. The robust litter mat from the deciduous aspen and the rich organic soils that generally follow from easily decomposed leaf material leads to higher water retention (Burke and Kasahara 2010). From a western Colorado study, the aspen connection to soil properties was inferred with a steady lightening of soil color associated with conifer invasion and aspen decline (Cryer and Murray 1992). The light color indicates a decrease in organics in the soil surface.

The shift to deciduous forest vegetation can also increase moisture by changing canopy architecture. Tree configuration and height is proven to affect site retention of soil moisture by acting as a buffer against wind, and solar radiation (Martens, Breshears and Meyer 2000, Villegas, et al. 2010). When comparing aspen and conifer sites on similar terrain, aspen showed a 43-83 percent higher water status than a pure conifer stand (LaMalfa and Ryle 2008).

To analyze where the planned forest treatments may optimize site moisture, a coarse filter assessment identified stands that would be reduced by more than 40 percent forest cover while retaining a minimal 20 percent. We inferred that dry and mesic forest types on the edge of their climatic range may benefit more from forest opening than snow dominated areas. Further, if the soils have mollic characteristics from past robust understory plant production; these forests would stay open longer. More mesic forests on well drained soils with poor water holding capacity may benefit from group selection prescription that lead to holes in stands for capturing snow and decreasing effects from wind.

The potential range for the forest types was refined using the soil survey. The preserve has three major lifezones - 5 through 7 - with three gradations within each zone. Lifezones correspond to vegetation indicators, physiography and soil characteristics. High sun cold areas indicate cold limited environments, but with the majority of moisture from monsoon rain. Low sun dominated areas have a cold limited growing season but with more than 50 percent annual moisture from snow. The lifezones ultimately clarify where these forests may be transitional. Grassland and ponderosa pine savannah correspond to the lifezone 5, while more mesic mixed conifer is central to lifezone 6. Spruce-fir is within the snow-dominated lifezone 7.

Table 5-32 shows the distribution of the planned mechanized thinning by forest type and climatic zones. Of the approximately 3200 acres of planned treatment on the grassland forest interface, 1300 acres could optimize moisture since these occur within lifezones 5 and 6. The 700 acres in lifezone 7 are regenerating old clear-cuts that lack substantial mature tree cover on high elevation ridges. For ponderosa pine, the bulk of the forest treatments would likely improve moisture. The ponderosa pine and xeric mixed conifer sites were within the lower and central levels within lifezone 6, transitional between monsoon and snow dominated regimes. Dry forest types with snow-dominated climate occupy higher elevation sites on dry ridges above 9000 feet or cold pocket drainages and would likely tend to a mixed species mix with aspen. The results in Table 5-32 illustrate the aspen emphasis in alternative 3 compared with alternative 2 with more acres treated in the mesic mixed conifer and more acres treated with the more intensive aspen regeneration prescription.

Table 5-32. Climate regimes within planned mechanical thinning acres by fire regime and forest cover type. High sun cold areas receive proportionally more of site moisture from monsoon than low sun cold areas.

Forest cover type	Total Mechanical Thinning (Acres)	Potential stands to increase site moisture (acres)		
		High Sun Cold - Lifezone 5[a]	High Sun Cold - Lifezone 6	Low Sun Cold Lifezone 7
FR I Montane Grasslands/Forest Meadows	3235	71[b]	1,234	696
FR I Ponderosa Pine Woodland and Savanna and Dry-mesic Mixed Conifer	7860	450	7,183	266
FR III Aspen Mixed Conifer and Mesic Mixed Conifer	7,500 (Alt. 2) 11,358 (Alt. 3)	46 (Alt. 2) 11 (Alt. 3)	4,964 (Alt. 2) 3,165 (alt 3)	1,913 (Alt. 2) 1,441 (Alt. 3)
Aspen Restoration Emphasis within FR III Mesic Mixed Conifer	2,020 (Alt. 2) 11,358 (Alt. 3)	0 (Alt. 2) 10 (Alt. 3)	63 (Alt. 2) 3,135 (Alt. 3)	66 (Alt. 2) 1,107 (Alt. 3)

a – Lifezones from soil mapping (USFS and NRCS 2011).
b - Alternatives specified only where different.

During project implementation, finer scale soil data would be used to refine the forest treatment prescriptions. Vegetation associations from the VCNP ecological assessment and vegetation mapping (Muldavin and Tonne 2003, Muldavin, Neville, et al. 2005) provide guidance on evaluating the site potential along with the Terrestrial Ecosystem Unit Inventory that ties together soil and vegetation potential (USDA-Forest Service; USDA-NRCS, 2011). These soil and vegetation associations give insight where understories are most robust to respond from forest thinning.

Initial estimates using the soil mapping show thick tree growth on mollic soils for half of the planned alternative 2 mechanized treatment (3235 acres), with 3083 acres corresponding to in fire regime I. The action alternatives differ slightly in acres, although mostly in forest species emphasis. Along the south facing fans in the Valle San Antonio, the planned thinning of ponderosa pine encroachment would be sustainable over the long term with fire. The soils are Pachic Argiudolls, a grassland affiliated soil with deep accumulations of organic matter in the topsoil, which would support continued grassland growth. Proposed thinning in spruce and sub-alpine fir along the grassland ecotones at the upper treeline, termed as sub-alpine balds by Coop and Givinish (2007), corresponds to Pachic Haplocryoll soils. These soils have deep organic matter accumulations, but with lighter soil textures than the valley bottoms. The prominent ponderosa pine and Douglas-fir encroachment along the Valle Grande fans, footslopes on the cerros, and upper valles and footslopes along Redondo Creek are on Vitrandic Hapludalfs, which include substantial ash flows and are lacking deep organic accumulations. These soils indicate a forest cover rather than a savannah.

Conversely, the rocky soils primarily on Redondo, and the steep sloped areas of the rhyolite domes and Banco Bonito indicate more patch and woodland conditions with less robust understories. Soils in these locations are poorly developed, with shallow accumulations of organic matter. Soil drainage is rapid, and soils have less water holding capacity compared to the mollic and clay rich soils abundant elsewhere. Under a third bar pressure, emulating field conditions for plant water availability, the Banco Bonito soils has a rating of 13 percent plant available water expressed volumetrically compared to 21 percent for nearby soils with higher organic accumulation.

Nutrients and Carbon

Fire is recognized as an important ecological attribute that increases nutrient availability and ameliorates soils with charcoal. The re-introduction of fire typically increases available nitrogen and phosphorus in the first few years after burning (Chromanska and DeLuca, 2002; Erickson and White, 2008; Hart, et al., 2005). The extent may vary depending on the intensity of burning and the type of vegetation. Higher intensity burning produces available N from the heat-induced decomposition of organic-N to ammonium (White 2012). Charcoal increases water-holding capacity as well as lowering the impact of allopathic chemicals in soil that limit nutrient cycling (DeLuca and Aplet 2008).

The xeric mixed confer forests could realize the highest boosts in available N. These sites are adapted to a frequent fire regime. In the absence of fire, the accumulating stocks of recalcitrant organic matter, conifer needles and woody litter resist decomposition. The high C:N ratio of this organic matter leads to low levels of available N from bacterial immobilization. The conifer needle litter also has high levels of terpenes that can inhibit nitrification (White 1991). Prescribed burning in these forests directly increases the amount of ammonium for mineralization in relation to plant available nitrogen while increasing the available carbon for soil microbial processes. Burning the grassland intergrade sites would lead to less substantial changes in nutrient status (White nd). Grassland litter and fine roots have C:N rates more

conducive for microbial decomposition and thus available carbon is not as limiting as in the forested sites.

The low severity burning applied to these areas would lead to a net benefit for soil condition. Localized hotspots could lead to moderate and severe heating effects within the more heavily wooded areas; predominantly the fire regime III forest types. These hotspots would have bare ground that would be subject to runoff from summer rains. The mosaic pattern and the relatively small areas for runoff to develop would minimize erosion on these bare areas and these effects would be expected to be short-term and localized.

Masticating material on site may also affect soil nitrogen (Battaglia, et al. N.D.). In their final report to the Joint Fire Science Program, Battaglia et al. found the effect of mastication on soil nitrogen to be mixed with few negative effects on either ammonium (NH_4-N) or nitrate (NO_3-N) at the operation scale. They found positive effects in ponderosa pine and mixed conifer ecosystems with negative effects in piñon juniper and lodgepole systems (Rhoades, et al. n.d., Battaglia, et al. N.D.). Battaglia et al. also noted in their final report (Battaglia, et al. N.D.) that the effects on soil nitrogen increased with mulch depth and that due to the high C:N ratio of the masticated material, the added N is largely unavailable to plants in the short term. In general they found the effects on soil N to be short-term, depth dependent, and not significant at the operational scale due to the variability that is typical over treatment areas. In general mulching elevated soil moisture, depressed soil temperature during the growing season and blunted temperature extremes.

Infiltration

Heavy equipment would be used to accomplish some of the planned mechanized thinning, where appropriate slopes and access exist. As previously noted, this equipment traffic could compact and displace surface soils.

Grassland intergrade areas would rebound quickly given the robust understory fine root mat. Rocky well-drained soils have higher soil strength, and spreading slash or mulch would protect displacement of fines from bared soil surfaces.

More intense and longer-term damage to soils can result from equipment concentration at staging areas and slash pile burning. The effects would be limited by favoring the use of old log landing sites and road beds as landing and staging areas and reclaiming these areas after use by breaking up compaction and applying effective groundcover (slash and mulch). Breaking up the charred or compacted surfaces increases soil infiltration capacity; applying slash adds nutrients and protective groundcover to temper soil evaporation and raindrop impacts. Adaptive management and monitoring would be used to establish the best approach.

Burning slash piles is more extreme than typical wildfire and even more so than low severity prescribed burning since the forest floor is consumed and organic matter distilled in the top 5 to 12 cm soil (Jiménez, et al. 2007, Meyer 2009). Slash pile burning focuses heat deep into the soils toward the center of the pile that kills seeds, soil microbes and plant roots. The heavy ash residue that can retard growth is also less distributed than with a fast moving fire front.

Recovery within burn piles occurs slowly as microbes recolonize. Soil bacteria rebound within a year's time while funguses are more heat sensitive (Jiménez, et al. 2007) with lower abundance up to 2.5 years post treatment (Owen, et al. 2009). The slower recovery of soil fungus could relate to increased pH in ash, loss of fungal propagules from heating, the harsher environment with temperature and moisture flux from lack of plant cover, and the changes in organic matter quality for decomposition (Jiménez, et al. 2007).

The deleterious effects from the slash piling can be somewhat reduced by performance requirements identified in chapter 2 which include: removing material for utilization where possible, masticating, or lopping and scattering slash, in lieu of piling; constructing piles at landing sites or on road beds, limiting the size of piles, and limiting the size of material that may be burned in a pile. All these measures would reduce the area affected by pile burning and the downward flux of heat associated with pile burning.

Trade-off exists between stacking slash into many small piles versus hauling to large piles located at log landings. Small piles can still generate enough heat to leave persistent burn scars, though with reduced heat intensity. When comparing the burn pile center to the edge, research findings have mixed results. A Colorado study found the edge of the burn piles had similar adverse effects on soil microbes as the burn center despite the higher heating intensity and duration in the pile's center done (Jiménez, et al. 2007). Possibly the heating spike over the 100-degree lethal range for bacteria and fungi in addition to the altered charred environment could be enough to alter the growing environment when compared to a fast moving surface fire. In Montana, significant differences were found between the pile edge and pile center for fungal and microbial biomass one year after burning. Perhaps the soil attributes and moisture availability affect the recovery potential. We assume the burn piles on the pine encroached grassland soils rebound quicker than the well-drained forest soils on the hillslopes.

Soil Erosion Potential

As described in chapter 2, thinning on steeper slopes will be less intense than gentle slopes. The remaining canopy cover on the steeper slopes will further intercept and moderate the intensity of monsoonal storms. The extent of any impact caused by a short-term loss of vegetative cover after thinning and burning would be a fractional percent of the preserve in any given year. Consider that implementation would be scheduled over a ten-year period, over approximately 60 percent of the preserve area in roughly equal subdivisions, or around 6 percent in a year.

As described in chapter 4, severe wildfires usually occur in late spring and early summer. Powerful summer monsoons follow these fires, unleashing torrential rains onto the still exposed earth. Prescribed burns, are implemented in the fall or, occasionally, in the early spring. Generally a full growing season occurs between the time of a prescribed burn and the next monsoonal event. Further, the occurrence of storms sufficient to cause rilling is at most on a biannual basis, and the coverage is at most 5 square miles, which induces a partially random element to erosion effects for any given event.

Recalling also from chapter 4, the load at the foot of a burn slope is not the contribution from the entire slope but from the lower portions. Topsoil movement on a burned slope is accomplished in a series of short moves, feet at a time. The distance traveled and the total volume delivered at the foot slope is a function of exposed soil, rainfall duration as well as intensity.

Performance requirements will ensure that ground disturbance in areas adjacent to perennial and seasonally flowing channels and swales (low order drainage pathways that serve as conduits for shallow interflow) is minimized or prevented altogether. It may incur shallow surface flow, mostly during snowmelt, but would not have an existing scour channels. Thinned materials can be used to support rehabilitation of channels that were historically used as roads.

Surface erosion on bare slopes after mechanized thinning activities is expected on skid trails, roads and landings. The use of ground based tractor skidding typically lead to 15 to 25 percent of the unit with bare mineral soil surfaces (Rawinski and Page-Dumroese 2008, Han, et al. 2009), More modern equipment which bunch and carry stems have far less ground disturbance. Steeper slopes pose higher erosion hazard by concentrating erosive stormwater during summer rains. For the preserve, limiting tractor equipment to slopes less than 30 percent and covering roads and skid trails with slash or mulch following any tree removal, avoid this erosion hazard. The extensive network of roads and skidtrails already in place gives ample opportunity for access and limits new construction needs. These impervious surfaces show surprisingly minimal sign of rill and gully erosion when compared to the footslope fans and valley forms, where compacted surfaces from animal trailing along fences lead to gullies. Alternative 2 has proposed 19,795 acres with mechanical harvest opportunity compared to alternative 3 having 22,396 acres.

The effects of the Las Conchas fire showcased the extent of erosion possible from contiguous charred surfaces and steep slopes followed by strong monsoon rainfall. The runoff from the moderate and high severity fire that leaves very little forest floor and plant cover is two to seven times that of unburned areas (Cannon, Bigio and Mine 2001, Shakesby and Doer 2006). In contrast, the planned prescribed burning for both action alternatives would use a more conservative approach to re-introduce fire. The planned burning results in a mosaic of burn and unburned patches with an overall low burn severity. The burn patches would have localized runoff generation from hotspots, but not encompass an entire hillside. The retained forest canopy would reduce erosion potential by intercepting and diffusing rainfall impacts.

The debris flows that followed Las Conchas wildfire emanated from contiguous bare slopes across sub-watershed catchments and occurred after successive monsoon rainstorms. The debris flows re-activated the footslope fans below these severely burned drainages depositing thick layerments of boulder, cobble and gravel material. The monsoon rains were mostly within 1 to 2 year storm return intervals and a major contributing factor to the soil destabilization was mounting soil moisture from successive storms. Based on these events, the unburned areas above the headquarters were identified as having potential hazard if wildfire burned the La Jara catchments and subcatchments on Redondo. Planned treatments involve restoration and hazardous fuels reduction for both action alternatives. We believe these treatments could lower potential wildfire effects within these catchments to deter debris flows since mixed unburned and low severity burn catchments within the Las Conchas did not release large debris flows.

Wetland and Riparian Restoration, Road Management, and Burned Area Rehabilitation

Road closure decommissioning and maintenance as well as post fire rehabilitation are being prioritized based on the current and potential impacts to watershed resources. Most wetland and riparian restoration actions include addressing issues caused by the current location, condition, or alignment of roads. Therefore these activities are being considered together.

Direct Effects – Ground Disturbance

Activities being proposed to restore wetland and riparian resources and rehabilitate areas of the Las Conchas fire range from planting sod plugs, shrubs or trees to stabilize stream banks, building small erosion control structures such as one rock dams and Zuni bowls as described in chapter 2, to using ground-based equipment to move the stream channel, remove historic impoundments or armor streams at crossing points. All these activities create ground disturbance within or in close proximity to live streams.

Most low intensity work would introduce sediment at a level that would not be detectable from background levels as demonstrated by monitoring ongoing restoration activities within San Antonio creek. Even projects that use heavy equipment have created only pulses of sediment that are localized minor and short term.

It is widely accepted that the routine maintenance and repair of roads does not have a significant impact on the environment (Federal Register 2003). Closure and decommissioning of roads would create localized ground disturbance to address site-specific erosion and control access.

Indirect Effects – Stream Condition and Habitat

Planting willow in major valley channels of East Fork Jemez River, San Antonio Creek, Jaramillo Creek, and lowest reaches of Redondo and Indios Creeks is predicted to yield effective results in the short-term and into the future. Vigorous willow growth on channel bars and banks would increase resistance to flow, slow and deepen flow, capture and deposit fine sediments. These indirect effects would lead to improved fish habitat and thermal regulation. The valley soils infiltration capacity and transmissivity would improve. Our field investigations found evidence that the natural state overbank flooding was much more frequent and water table much closer to, or at the surface, throughout the growing season. In the process of restoration, channels would narrow, banks stabilize and undercuts develop. Bank vegetation would provide shading and further cover for fish. Ultimately some of the flow now contained in main channels would disperse, at least seasonally, over the valley bottoms, initiating a trend from the present single-thread channel pattern to the historic multi-threaded pattern. A 2-D model was constructed to test the validity of this recommendation.

Data collected with LiDAR data was used to build topography for a reach on the lower San Antonio creek. The LiDAR-derived Digital Elevation Model (DEM) is converted to a Triangular Irregular Network (TIN) mesh of elements, which represents the model domain. A 2-dimensional numeric computer model was used to form an initial and boundary condition of the reach and to predict velocity vector and magnitude, and flow depth.

The model was calibrated using known discharge and stage information at an existing stream gauge one-half mile downstream of the model reach. Initial runs employed an iterative approach to determine depth and velocity at nodes (the corners of elements) based on initial conditions of depth and discharge. Calibration of the model involves adjusting the roughness coefficient and the eddy viscosity, until model predicted stage equals observed stage at a given discharge volume (Figure 5-25 right). The roughness coefficient is based on factors that comprise resistance to flow (bed substrate size and form, channel pattern, bank and floodplain vegetation profile and type). The coefficient is used to specify the resistance to flow. Eddy viscosity is used to specify the rate of turbulent energy diffusion and dissipation.

Once a calibrated model was built we were able to “roughen” up the channel banks and floodplain to simulate plantings of riparian woody species and subsequent growth of the plantings. The model runs allowed us to evaluate the effect of plantings in flow depth and velocity.

As expected, roughening of the channel provided, for the same flow volume, a deeper water column with greater lateral spread over near bank floodplain (Figure 5-25, left). Additional channel roughness could accomplish multiple goals: hasten narrowing of the channel through capture of fine sediments concomitant with deepening of the water column for a given discharge, and greater connection with side channels and near bank floodplain. Additionally it will provide bank protection through rooting and branching, shade and detritus (leaf litter) for macro invertebrate food source.

Given that stream power is a function of depth and slope, change in bank resistance might induce bed scour, but some decrease in slope is also expected due to backing of flow.

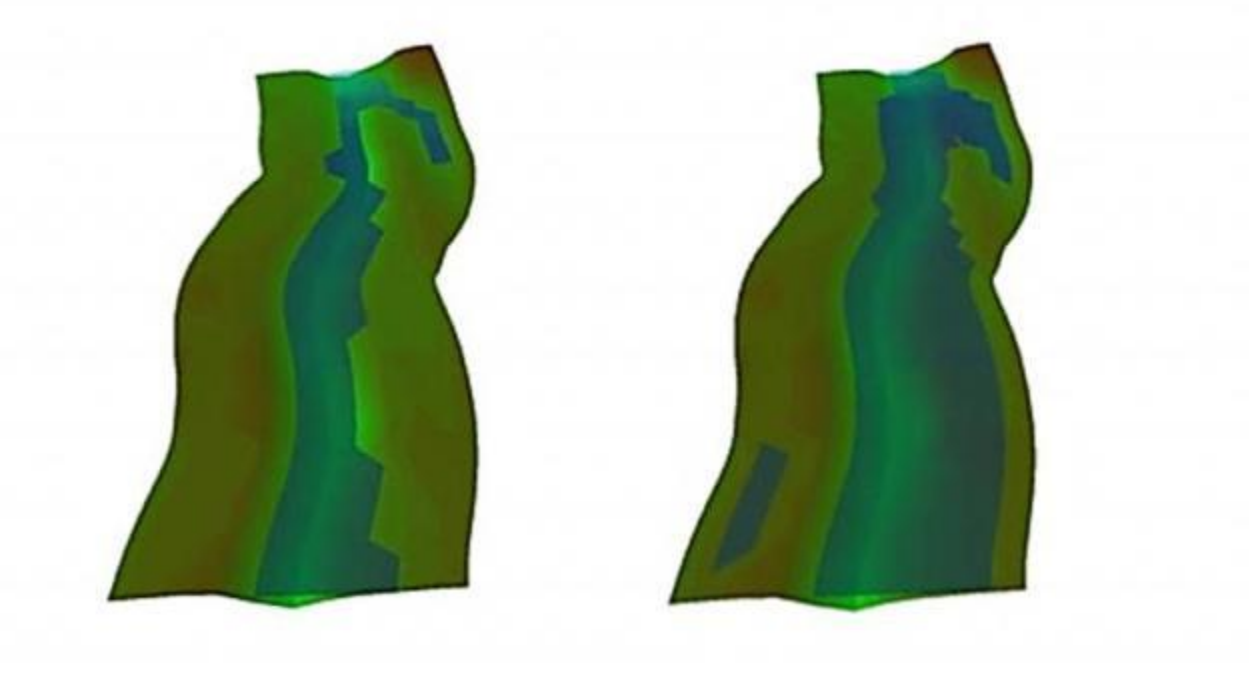


Figure 5-25. Topography and water stage output under existing conditions (right) and following channel restoration and planting (left)

Planting and stabilization of stream banks would indirectly lead to a decreased temperature with as the channel narrows cover is increased. This effect would be minor in the short term as there is little potential for the complimentary scouring to occur as discussed in chapter 4. Establish overhanging bank vegetation, like willow, that provides protection from shear stresses of moving water, thermal insulating, and physical cover. As banks finally stabilize the undercut would redevelop further increasing the stream cover (relative to width) of the deeper water column. Minimizing surface width also helps regulate temperature. We predict increase in channel roughness, along with assumptions of current bed resistance to shear, will force greater depths with same flow rate, somewhat compensating for the lack of scour.

As described above, restoration actions would move the stream towards NMED standards and initiate a trend towards a pre-settlement condition. Additional wetland restoration is expected to be achieved in the short term by the removal of barriers (roads, berms) and other diversions in order to restore wetland flows.

Indirect Effects - Sedimentation

One of the primary sources of sediment into perennial streams is from roads that have direct drainage. Research has shown definitively that the majority of sediment produced by roads is caused by increase in traffic and is in the form of very fine sediment (<.004 mm) washed from the running surface during fall rainstorms (Reid and Dunne 1984, Bilby, Sullivan and Ducan 1988, Sheridan, et al. 2005). It is these particle sizes that stay in suspension under even mildly turbulent stream flow, cause turbidity, and when settling plug interstitial spaces in streambed gravels. Fines within surface pore spaces in the bed will reduce water flow and thereby oxygen to fish eggs and emergent fry. Road maintenance, decommissioning and closure implemented in the lower fans and *valles* will combine with riparian restoration activities to improve water quality and stream condition.

However, related to road maintenance is the impact of the increased use of the roads in support of restoration activities. Traffic and maintenance of roads in the VCNP, particularly principal haul routes for wood products (semi-trucks, pick-ups, trailers, log trucks) will increase during periods of implementation of selected actions. Road maintenance activities would direct input from road drainage into perennial streams that are fish bearing.

Re-opening, maintenance and heavy traffic on forest roads, whether native surface or hardened with aggregate, are all factors in creating mineral fines <0.004 mm that may be carried as suspended sediment by surface wash. Currently the Jemez River is listed for turbidity and has an established TMDL. Buffers emplaced along all mapped perennial and intermittent channels can filter out up to 90 percent of sediment from road wash and from treatment units, but not if runoff is effectively channelized to the streams.

Heavy truck traffic especially is effective in wearing down aggregate and natural surface to very fine grain. Maintenance typically prescribed for heavy trafficked routes results in mounds of un-vegetated side cast or berms of graded material posed for surface erosion. To the extent that a road surface has direct and channelized drainage into a stream it will affect water quality in terms of turbidity or suspended sediment load, depending on how it might be measured, as well as pollutants from engine drippings of oil, gasoline, diesel and antifreeze. While vegetative buffers are very effective at reducing or

eliminating altogether road wash effects, as has been described above, there is no effective buffering when runoff is channelized directly to the stream.

The effects of suspended particles on steam biota are covered in detail in the fisheries report of this statement. Most of the roads, despite a very high density per unit area, have no direct surface connection to any stream bodies, either perennial or seasonal. Such connections typically are at crossings and a minor area of potential road runoff. Exceptions are the perennial mountain streams of Los Indios, Redondo, White Sulphur, and upper portions of Jaramillo Creeks. In each of these cases the primary road is parallel and mostly within 100 feet of the stream throughout the valley length. Table 5-33 below details the road length in perennial stream buffers that is adjacent to proposed treatment throughout the preserve. These segments would most likely catch runoff from treated ground that would add to road runoff. It is critically important to note that roads do not demarcate the edge of a buffer, but that the full width of a buffer is applied even if it overlaps a road.

Buffers are 100 feet (30.53 meters) and arranged around all mapped perennial and seasonally flowing pathways. The buffers will be implemented across the full width, measured from either side of channel banks or middle of swale. In some cases roads are contained within the margins of the buffer, notably in Sulphur, Redondo and Los Indios Creeks.

Widths of 100 feet will suffice in capturing up to 90 percent of all sediments and associated nutrient compounds in the event that severe surface wash and erosion is induced by treatment. Beyond that width, in terms of sediment capture, effectiveness diminishes rapidly (Davies and Nelson 1994).

Table 5-33. Miles of roads in perennial stream buffers and proposed treatment area

Basin	Area, square miles	Alternative 2	Alternative 3
		Miles of road in perennial buffers	Miles of road in perennial buffers
East Fork Jemez (Includes Jaramillo)	48.86	0.98	0.58
Jaramillo	16.09	0.93	0.54
San Antonio (includes Los Indios)	53.75	1.00	0.82
Los Indios	7.07	0.82	0.82
Redondo	10.89	0.17	0.17
Sulphur	13.64	1.78	1.47
Total	**127.14**	**3.93**	**3.04**

Noxious Weed Control

Noxious weed control is not intended to have direct impacts to soil or water resources. Indirectly, the control of noxious weeds would protect and enhance watershed resources. Indirectly, watershed resilience is enhanced and protected by the control of noxious weeds, which can alter species composition and diversity and reduce the resilience of plant communities in the event of a fire or drought.

Direct Effects – Water Quality

There would be no direct effects to water from the proposed control of noxious weeds including the use of herbicides. Performance requirements in chapter 2 include practices to protect water from direct application of herbicide.

As described in chapter 4 and under the noxious weed section of this chapter, when applied as directed (chapter 2) there would be no direct impact to water resources. This conclusion is based on care in the application of herbicides near water.

The effectiveness of a vegetative strip in capturing harmful compounds of herbicide is detailed in the noxious weeds section of this statement. Table 5-34 below shows manufacturer suggested buffer widths for various compounds. The trust is proposing primarily spot and hand applications of herbicide.

Table 5-34. Suggested buffer widths on streams and wetlands for selected herbicides

Herbicide	Broadcast	Spot	Hand/Select
Wetlands and Flowing Streams			
Aquatic Glyphosate	100	Water's edge	Water's edge
Imazapic	100	15	High watermark
Clopyralid	100	15	High watermark
Glyphosate	100	50	50
Imazapic + Glyphosate	100	50	50
Dry Streams			
	Broadcast	Spot	Hand/Select
Aquatic Glyphosate	50	0	0
Imazapic	50	0	0
Clopyralid	50	0	0
Glyphosate	100	50	50
Imazapic + Glyphosate	100	50	50

Indirect Effects - Protection of Herbaceous Groundcover

Indirectly, the control of noxious weeds protects watershed resources by supporting cover by native plants and preventing bare ground and erosion (Valles Caldera Trust, 2003, Reviewed 2008, 2010).

Cumulative Effects

Beginning from the baseline condition as impacted by past actions, climate, and fire the cumulative impacts on the watershed from the proposed actions is likely to be increased base flow by restoration of fan slope and valley bottom vegetation cover, and changes to forest structure on uplands and slopes. We do not anticipate any negative cumulative impacts resulting from the localized ground disturbance, and anticipate improvements to soil productivity.

Water Capture, Storage, and Yield

Current research is not adequate for us to be able to predict definitively that this increase will be measurably significant. Calculations of stream flow yield increase range from 0.9 to 7 percent, which is in the lower end of detectable levels of change using short-throated flumes such as the Parshall currently in use on the preserve (USBR 1997).

In the pre-settlement condition peak flows might have been lower, on an annual average basis, yet critical base flows might have been higher. Water temperature of channel flow was also likely lower throughout the summer season; closer to that issuing from footslope springs than the present, which closely follows daytime air temperatures.

Given the current complete absence of willow in the valley bottoms, it is questionable as to whether willows were ever present. Nonetheless, the incised channel form with newly developed floodplain—in form of gravel bars—has created an environment where willow may be established. There is one lone example plant in the lower San Antonio elk enclosure. Willow might be established for channel restoration purposes and eventually give way to *carex* spp., which is assumed to take hold in replacement of the willow as the saturated conditions return.

Because the preserve (and thus the proposed action) is contained primarily within a single 5th level HUC watershed (and includes the headwaters for its live streams) and the trust has instrumentation in all first and second order streams for a baseline period, we are optimistic that we will be able to quantify this improvement within the planning period.

Sedimentation

Although all proposed activities have the potential to produce minor amounts of sedimentation resulting from ground disturbance, it is unlikely that this sedimentation would move from the localized point of disturbance and therefore would not combine to produce any measurable cumulative effect.

Past harvest disturbance left a legacy of roads and log landings. Passive and active road restoration efforts would continue to stabilize these surfaces. Proposed thinning activities would reopen roads and re-use existing landing sites. Such use may undo natural rehabilitation that may have occurred over the past half century. Performance requirements would reduce the intensity of this impact.

Soil Productivity

Clear-cutting along Redondo's broad ridge left sparse or clumped regrowth and open Kentucky bluegrass meadows. Residual compaction from past logging activities persists, while heavy elk grazing on the Kentucky bluegrass continues to favor its spread. The shift in the understory from native grasses and forbs that has occurred here and the poor forest regeneration indicate impaired forest growth conditions. Planned thinning efforts may expand forest growth by thinning the clumped trees. However, burning within these meadows could push the site back into early successional state that favors Kentucky bluegrass expansion. Organic matter character and stocks are much reduced from comparable sites nearby. Applying slash or masticated litter from thinning activities could prove valuable to re-establish organic matter consistent with the desired forest type.

The Las Conchas fire was a substantial event that changed the geomorphology of many of the suborder draws with substantial ash flows that ran down San Antonio and the East Fork Jemez. Only minor mechanical thinning and mastication are planned in support of rehabilitation within the burn perimeter and would mitigate some of the cumulative impacts. The ash deposition, though having initial negative effects that led to fish kills, could improve planned restoration efforts along the main streams. The fire ameliorated the lower valley floodplains with nutrient rich ash and sediment filled departed channel areas in some locations. The re-activation of the footslope fans by the debris flows accentuated mineral decomposition that adds potassium and micronutrients to downstream floodplain soils. However, ongoing restoration efforts in Los Indios were set back as extreme incision/erosion occurred within this drainage.

5.6 Carbon

How will the actions being proposed or taking no action affect the sequestration of carbon in the environment or the release of carbon as CO_2 into the atmosphere? What are some of the trade-offs and uncertainties involved in using forest management as part of a strategy to mitigate carbon emissions? In chapter 4, carbon sequestration is discussed in in the section on soil productivity. Taking no action or implementing either of the action alternatives could result in changes to carbon sequestration or its release into the atmosphere that could either be discussed in relation to soil productivity or air quality. We thought this topic could be presented most effectively as a stand-alone topic in this chapter.

5.6.1 Goals and Objectives

Carbon sequestration is included as an outcome of the objectives related to ecosystem function, reduction in fire behavior potential, and wildlife habitat objectives for protecting large logs.

5.6.2 Methodology

Impacts to carbon related to the impacts to soils, productively and forest succession. This section also discusses impacts to carbon as climate effects and mitigations i.e. effects that can exacerbate or mitigate contributions to greenhouse gases. Climate adaptations, and the ability for a resource to respond to climate change or events is discussed in each resource area.

This analysis is based on basic principles of the carbon cycle in a forest system. Forests are biological systems that continually gain and lose carbon through processes such as photosynthesis, respiration and combustion (Ryan, et al. 2010) as depicted in Figure 5-26.

This analysis looks only at the potential differences in carbon sequestration and release under the alternatives. The sequestration and release of carbon at any significant scale is the cumulated impact of all human activities in context with the environment. As such, all actions are important in their contribution to the overall carbon footprint of human activity even though the contribution of any one action is negligible beyond the project level.

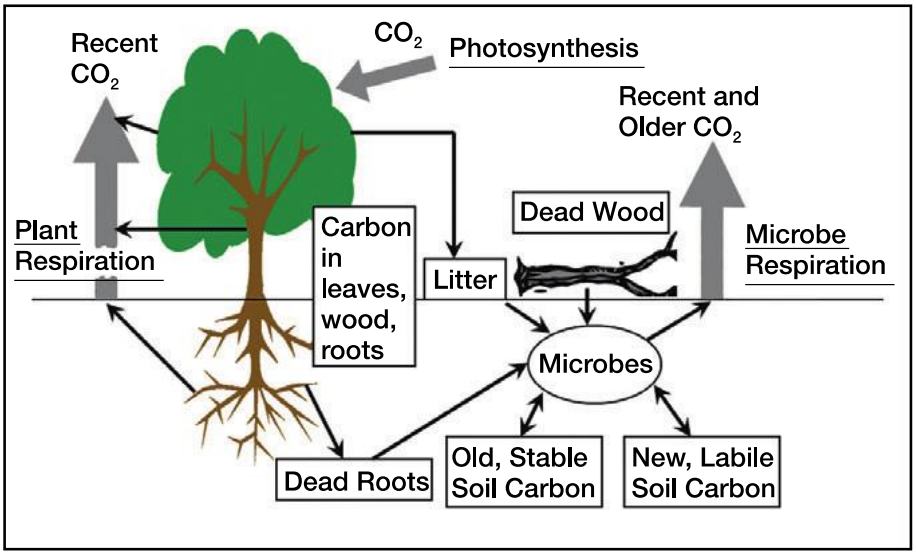


Figure 5-26. Illustration of forest carbon cycle from (Ryan, et al. 2010)

5.6.3 Environmental Consequences – No Action

The sequestration of carbon would not be directly affected by taking no action. However, indirectly the potential for minor to moderate adverse impacts would persist (Table 5-35) in association with persisting fire behavior potential.

Table 5-35. Environmental consequences summary table: carbon, no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Uncertain
	↓Cumulative	Landscape level	Minor	Uncertain
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Road Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Negligible	Potential
	↓Cumulative	Landscape level	Negligible	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Localized	Negligible	Potential
	↓Cumulative	Localized	Negligible	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Project level	Minor	Potential
	↓Cumulative	Project level	Negligible	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Project level	Negligible	Potential
	↓Cumulative	Landscape level	Negligible	Potential

By taking no action we would not directly increase or decrease carbon sequestration or release. In fact, generally more carbon is sequestered in an un-thinned forest compared with a thinned forest (Ryan, et al. 2010). Under a natural fire regime, frequent fires result in the release of a portion of sequestered carbon on a regular basis. By excluding fire, one could theoretically extend the storage of carbon. However, the accumulation of carbon in an untreated forest equates to the accumulation of forest fuels. The buildup of forest fuels in a frequent fire regime ultimately results in more severe burning, a greater release of carbon into the atmosphere, and reduced productivity. A reduction in productivity directly equates to a reduction in the capacity of the forest to sequester carbon (Ryan, et al. 2010). Therefore, a lack of forest management, especially fuels reduction, would indirectly contribute to an increased release of CO2 and a reduced capacity for carbon sequestration in the future.

Not taking action to close roads, restore riparian areas or rehabilitate the burned area would not lead to any future release of CO2 but increased capacity to sequester carbon by increased vegetative cover and productivity would not be achieved. The context, intensity, and certainty of direct, indirect and cumulative effects are summarized above in Table 5-35.

5.6.4 Environmental Consequences – Action Alternatives

Both action alternatives could result in minor, short-term effects; beneficial as well as adverse. Indirectly moderate, beneficial effects are likely with reduced wildland fire potential and improvements in forest health and productivity (Table 5-36).

Table 5-36. Environmental consequences summary table: carbon – action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Project level	Minor	Certain
	↑Indirect	Landscape level	Minor	Uncertain
	↑Cumulative	Landscape level	Minor	Uncertain
Wildland Fire Management	↓Direct	Project level	Minor	Certain
	↑Indirect	Landscape level	Minor	Uncertain
	↑Cumulative	Landscape level	Minor	Uncertain
Road Management	Direct	None	None	None
	↑Indirect	Project level	Negligible	Potential
	↑Cumulative	Project Level	Negligible	Potential
Riparian Restoration	↓Direct	Project Level	Negligible	Certain
	↑Indirect	Landscape level	Negligible	Potential
	↑Cumulative	Landscape level	Negligible	Potential
Noxious Weed Management	↓Direct	Localized	Negligible	Likely
	↑Indirect	Project level	Negligible	Potential
	↑Cumulative	Project level	Negligible	Potential
No Burn Area Rehabilitation	↓Direct	Project level	Negligible	Certain
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Project level	Minor	Potential

Ultimately the proposed activities could result in minor beneficial impacts by preserving long-term capacity of the environment to sequester carbon, reducing the potential for large releases of CO_2 into the atmosphere from wildfire, and increasing the recovery and productivity of the burned area. Restoration of riparian areas, creating wetlands, and rehabilitating decommissioning roads would also have a beneficial albeit negligible increase in carbon sequestration due to some increase in vegetative cover.

In their report stating the synthesis of knowledge on the role of forests in the carbon cycle, Ryan et al. (2010) described practices such as thinning to reduce loss from wildfire and re-establishing vegetation as strategies that use forest management as a mitigation aimed at slowing the release of CO_2 into the atmosphere. While thinning may result in a reduction in carbon sequestration, any reduction would be offset by the associated increase in productivity in the residual trees and protection from wildfire (Ryan, et al. 2010). However, other studies have found that while forest thinning is necessary to restore the structure and function of fire adapted forests and reduces fire behavior potential there is little evidence that such actions have the added benefit of increasing terrestrial carbon stocks (Campbell, Harmon and Mitchell 2011). In their study Campbell et al. found that Carbon losses from fuel removal generally exceed what is protected if the treated area were to burn. However they also noted that the fossil fuel costs of conducting fuel treatments were relatively small, ranging from 1-3 percent of the above ground carbon stock.

The study by Campbell also did not take into account the long term storage of the carbon in small diameter material as a product. Such utilization of biomass as wood products (vigas, latillas, posts, landscaping material, etc.) could further offset any reductions in sequestration by storing the carbon for the life of the product. Biomass used for bioenergy or firewood is somewhat carbon neutral as it is usually replacing another CO_2 producing energy source when used for heating. Overall, the science to date does not support a conclusion that fuel treatments in fire prone forests have measurable benefits regarding carbon sequestration.

5.7 Air Quality

What effect will taking no action or implementing the proposed action have on air quality? How great or small an area will be impacted? Will the activities affect the health of area residents? While most people are familiar with the idiom, “Where there is smoke, there is fire”, the inverse also generally proves true - where there is fire, there is smoke. This section compares the potential impacts to air quality primarily from smoke produced from wildland fire.

5.7.1 Goals and Objectives

Goals and objectives from chapter two relating to the protection of natural resources and reducing the potential for uncharacteristic wildfire apply to this topic. Targets include the reduction of fire behavior potential at the landscape level.

5.7.2 Methods

This analysis focuses on the impacts from wildland fire. Although other activities may cause localized impacts in the form of dust or vehicle exhaust, those effects would not be measurable against the current background pollutant sources.

We will focus our analysis on the potential impacts relative to a comparison of the alternatives rather than a quantitative prediction of any particular ignition base our predictions on literature review rather

than site-specific modeling. The actual impacts to air quality vary significantly in space and time based on multiple variables that affect the volume of biomass consumed, emissions produced, and the dispersion and transport of the smoke (Sandberg, et al. 2002). The actual impact of smoke from fire also relates to the ambient quality of the air prior to the event and the sensitivity of the receptors.

In general smoke from wildland fire relates to the volume of fuel being consumed, the moisture content, and the size and arrangement of the fuel particles being consumed; all of which relate to the efficiency of combustion.

5.7.3 Environmental Consequences No Action

Taking no action would not directly affect air quality. Indirectly, increased potential for severe burning correlates to an increased potential for smoke impacts. These impacts, albeit severe, would be likely to be short-term but could extend to the region. Taking no action to address erosion on roads and within the burned area could result in increased dust. These impacts would be negligible to minor, localized and short term.

Table 5-37. Environmental consequences summary table: air quality, no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Regional	Minor - moderate	Likely
	↓Cumulative	Landscape level	Minor - moderate	Likely
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Regional	Minor - moderate	Likely
	↓Cumulative	Landscape level	Minor - moderate	Likely
Road Management	Direct	None	None	Certain
	↓Indirect	Localized	Negligible - minor	Potential
	↓Cumulative	None	None	Potential
Riparian Restoration	Direct	None	None	Certain
	Indirect	None	None	Certain
	Cumulative	None	None	Certain
Noxious Weed Management	Direct	None	None	Certain
	Indirect	None	None	Certain
	Cumulative	None	None	Certain
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Localized	Negligible - minor	Potential
	↓Cumulative	Localized	Negligible - minor	Potential

If no action were taken, there would be no change to ambient air quality and no direct impacts to air quality. Indirectly the increased likelihood of a wildfire and severe burning as described in the previous sections crates an increased threat to air quality. Impacts to air quality correspond well to burn severity, with increasing severity creating more smoke.

Table 5-37 above, summarizes the potential effects that may result if no action were taken. Besides the potential effects from increased wildfire potential, some minor localized effects may occur from dust originated from erosion within the burned area or unrepaired roads.

The actual impacts to any receptor are difficult to predict. In 2011, smoke from fires burning in Arizona raised the concentration of fine particulate matter in the air in Santa Fe to over 150 micrograms per cubic meter (typical ambient air quality levels in Santa Fe have less than 10 micrograms per cubic meter) (State of New Mexico 2011). This demonstrates the extensive potential area of impact from a large wildfire.

Impacts to air quality from wildfires are episodic and do not impact the overall ambient air quality outside of the event. Particulate standards are based on 24-hour and annual averages, whereas smoke plumes may significantly degrade air quality in a community for just a few hours before moving or dispersing. These short-term, acute impacts likely cause discomfort at the least, and possibly even affect health, but may not result in a violation of the National Ambient Air Quality Standards (NAAQS).

Although the duration of impacts is short and would result in no change to the ambient air quality condition, episodes of smoke from wildfire can be serious to those who are sensitive to smoke. Also episodic smoke can impact visibility and create dangerous driving conditions.

5.7.4 Environmental Consequences – Action Alternatives

Both action alternatives would have localized adverse effects to air quality resulting from prescribed burning and potential dust resulting from operations. However, both alternatives would reduce the potential for more severe impacts resulting from wildfire. Indirectly, by addressing erosion on roads and within the burned area would likely result in an increase in vegetative cover and would reduce localized dust impacts.

Table 5-38. Environmental consequences summary table: air quality – action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Project level	Negligible-minor	Certain
	↑Indirect	Regional	Minor - moderate	Likely
	↑Cumulative	Regional	Minor	Likely
Wildland Fire Management	↓Direct	Regional	Minor - moderate	Certain
	↑Indirect	Regional	Minor - moderate	Potential
	↑Cumulative	Regional	Minor	Potential
Road Management	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Project Level	Minor	Potential
Riparian Restoration	↓Direct	Project Level	Negligible	Certain
	Indirect	None	None	None
	Cumulative	None	None	None
Noxious Weed Management	↓Direct	Localized	Negligible	Likely
	Indirect	None	None	None
	Cumulative	None	None	None
No Burn Area Rehabilitation	↓Direct	Project level	Negligible	Certain
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Project level	Minor	Potential

The activities being proposed under the action alternatives (except wildland fire management) can create minor short-term impacts to air quality through dust and emissions. Relative to the current condition these impacts would not be measurable at the regional or even Landscape level but could be

visible locally. Even the removal of biomass that could include 6-10 trucks per day on some days is not measurable against the existing background traffic levels; the volume of weekday traffic on NM 4 through the village of Jemez Springs averages 1700 vehicles (MRCOG 2012).

Proposed wildland fire management activities (prescribed fire and the management of natural fires) would create smoke. In general, where ambient air quality is within standards, smoke from prescribed fire has not been found to move conditions out of attainment (Sandberg, et al. 2002). This is likely because prescribed fire is managed within a regulatory environment that includes plans and mitigations to minimize impacts to sensitive receptors from smoke.

However, visible smoke can be a nuisance and even a health hazard even when standards are not exceeded. Chapter 2 identifies several mitigating measures the trust would adopt to reduce potential impacts from smoke. The most effective measure is to thin forested areas prior to burning – less fuel, less smoke. This is especially applicable the boles of trees which combust less efficiently and tend to smolder for longer periods, producing greater amounts of smoke (Figure 5-27).

Figure 5-27. Smoke during ignition of activity fuels at Banco Bonito (September 2012)

Another effective mitigating measure is to burn when the duff and large woody debris is still moist on the inside. This dense material tends not to burn, or burns for a shorter duration if the moisture content is high enough. The small material (twigs, branches) burns more efficiently and creates less smoke.

Another important mitigating measure is communication. Local residents can take precautions to reduce smoke impacts (by closing windows, staying indoors, leaving the area or postponing planned visits to the area) if they know that prescribed burning is planned.

5.8 Wildlife and Terrestrial Habitats

How will terrestrial wildlife respond during and after management action? How will forest thinning, burning and other proposed management actions affect terrestrial habitats? Do all species respond the same? This section will describe the direct, indirect and cumulative impacts of no action or the proposed restoration activities on the forest, grassland, shrubland, and riparian habitats measured at the landscape scale. We have focused on the potential effects of the alternatives on those species of greatest concern due to their status under the Endangered Species Act or their importance to the management of the preserve or importance as an overall indicator of ecological condition or goal attainment.

5.8.1 Goals and Objectives

Chapter 2 included goals, objectives, and monitored outcomes for the Stewardship Plan. Two primary objectives are to: 1) move the structure, composition, and function of the preserve's natural systems towards the reference condition and 2) reduce the potential for wildland fire to burn with uncharacteristic severity or extent.

The objective specifically related to terrestrial wildlife is simply to protect, improve and maintain diverse wildlife and habitats. The ecological condition of the ecotypes is also reflective of the quality and sustainability of the habitats; therefore those goals and objectives are not repeated here. Monitored outcomes include protection and recruitment of old-growth characteristics that are relatively rare in the preserve's second growth forests i.e. maintain 70 percent of large down logs; move 35 percent of closed forest to open forest.

5.8.2 Methods

This section focuses on species of status (threatened, endangered, and species of concern), sensitive species, and species of interest as described in chapter 4. Species eliminated from consideration in chapter 4, are not discussed further in this chapter.

Species presence/absence determinations were based on habitat presence, wildlife surveys, recorded wildlife sightings, and non-Forest Service databases. Effects of the project on habitats are discussed, with the assumption that if appropriate habitat is available for a species, then that species occupies or could occupy the habitat. This strategy is based upon science that demonstrates connections between species populations and viability and the quantity and condition of habitat at appropriate scales of analysis (Baydack, Campa III and Haufler 1999).

The potential effects to these species as result of taking no action or implementing the alternative actions are primarily indirect – affecting the habitat and thus indirectly affecting the species. Therefore we have organized the effect analysis to focus on the effects to habitat.

5.8.3 Environmental Consequences – No Action

Taking no action would result in no direct effect to any special status species, species of interest or their habitats. No disturbance would result; no habitats would be modified. Indirectly the current downward trend described in chapter 4 and potential adverse impacts identified in the previous sections on vegetation, wildfire environment, and watershed would persist.

Table 5-39. Environmental consequences summary table: wildlife and terrestrial habitats, no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor -moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential

Special Status Species

Chapter 4 identified nine species listed by the FWS as special status under the ESA; the bald eagle is no longer listed but its status is still being monitored and therefore we are including it in this section. Table 5-40 below lists these species, habitats, and summarizes the impacts of no action.

Table 5-40. Threatened, endangered, species of concern and candidate terrestrial wildlife species impact summary

Common Name	Habitat	Effect
Canada lynx	Spruce-fir, old growth closed forest	Potential adverse, loss of habitat from wildfire
Gunnison's prairie dog	Grasslands and shrublands in low valleys and mountain meadows	No effect
Jemez Mountains salamander	Only in the Jemez Mountains, in rotten logs in settings with deep, igneous sub-surface rock	Potential adverse, loss of habitat from wildfire; continued downward trend in structure
New Mexican meadow jumping mouse	Riparian areas with tall vegetation	Potential adverse, post fire flood
American peregrine falcon	Open country, rock cliffs overlooking rivers/water	No effect

Common Name	Habitat	Effect
Bald eagle	On the preserve, roost trees adjacent to open water	Potential indirect adverse impacts to fisheries from wildfire
Goat Peak pika	Talus slopes	No effect
Northern goshawk	Uneven-age mature mixed conifer	Potential adverse, loss of habitat from wildfire, continued downward trend in structure
Townsend's big-eared bat	Caves near water	Potential adverse impact to foraging areas from wildfire, post fire flood and erosion

Fire regimes—that is, patterns of fire occurrence, size, uniformity, and severity—have been a major force shaping landscape patterns and influencing productivity throughout North America for thousands of years. Faunal communities have evolved in the context of particular fire regimes and show patterns of response to fire itself and to the changes in vegetation composition and structure that follow fire.

The impacts of high severity fire in a species population or community are highly variable and depend on the timing, intensity, severity and scale of the burn. Responses may include injury, mortality, immigration, or emigration. Animals with limited mobility, such as young, are more vulnerable to injury and mortality than mature animals. Bird populations for example, respond to changes in food, cover, and nesting habitat caused by fire. Fires during the nesting season may reduce populations more than fires in other seasons; and migratory populations may be affected only indirectly, or not at all, by burns that occur before their arrival in spring or after their departure in fall (Lyon, et al. 2000).

Jemez Mountain salamanders may not be affected by the burning, as they are subterranean except when conditions are saturated (generally exclusive of burning periods). However, large decomposing logs, habitat characteristics critical to the salamander, are frequently completely consumed by high severity fire. Often the associated mortality in a burned forest creates quick replacements. Unfortunately, the preserve is critically lacking in large and old live trees that would serve as replacements. Although it is too soon to tell, we believe areas severely burned in the Las Conchas fire could be lost as potential habitat for the salamander for the foreseeable future. Depending on the cumulative impacts of past logging, the severe burning and current and anticipated climate trends, the loss could be permanent. These large, decomposing logs are a characteristic of old-growth forest habitat that is lacking preserve wide.

The highest elevations on the preserve and those species that occupy it are perhaps most at risk to a total loss of habitat in the event of a severe fire depending on climate trends. Warmer and drier climate trends may stress an existing vegetation type but may actually result in a change to the composition of a forest growing back following a severe disturbance. At low to mid-elevations this phenomenon may produce a shift in composition; at higher elevations it could produce a localized loss of vegetative suites. We will be following vegetation and wildlife compositional developments following the Las Conchas fire to better understand this potential.

Under the no action alternative, some degree of riparian restoration, noxious weed control, and road maintenance and repair would condition under current project level plans. This work would improve habitats in the San Antonio and Sulphur Creek watershed as described in those project level analysis(Valles Caldera Trust, 2009, Valles Caldera Trust, 2003), but similar benefits would not occur in

the East Fork of the Jemez River watershed, which includes Jaramillo Creek. Noxious weed control activities would not be expanded to include the control of cheatgrass. Currently, this invasive is restricted to roadsides (Iskra and O'Haver 2009). However, a severe burn could greatly expand its coverage (Jackson 2012).

Sensitive Species

Chapter 4 identified 11 sensitive species. The bald eagle is technically considered a sensitive species, however because it is recently delisted and being monitored we considered it in the previous section. The remaining 10 species use habitats that are either rare in the SWJML or include characteristics that are rare, or both. These include: Old growth high elevation conifer forests or cool moist forests with old growth characteristics, (large down wood debris, large and old snags, large and old trees; talus slopes, riparian areas; montane wet meadows, or grassy openings; or cliffs, rocky outcrops and caves.

Table 5-41. Sensitive species impact summary

Species	Habitat	Impact
American marten	Spruce-fir and mesic mixed conifer	Adverse, potential loss of habitat from wildfire, continued downward trend in structure
Boreal owl	Mesic spruce-fir	Adverse, potential loss of habitat from wildfire, continued downward trend in structure
Dwarf shrew	Talus, mesic forests	No effect
Ermine	Montane meadows	Potential benefit, increase habitat from wildfire
Long-tailed vole	Mesic mixed conifer, open	Adverse, potential loss of habitat from wildfire
Northern leopard frog	Riparian	Adverse, no new habitat would be developed potential loss of habitat from wildfire and post fire flooding and erosion.
Pika	Talus	No effect
Southern red-backed vole	Mesic mixed conifer, spruce-fir	Adverse, potential loss of habitat from wildfire, continued downward trend in structure
Spotted bat	Cliffs, rock outcrops or caves near water	No effect
Water shrew	Riparian forest and shrubland	Adverse, no new habitat would be developed potential loss of habitat from wildfire and post fire flooding and erosion.

Habitat for sensitive species dependent on mature forest and old growth characteristics would not benefit from improved structure; no trend towards mature forests would occur without transition to more open classes. Habitat characteristics would continue to be at risk to loss from wildfire. Species dependent on riparian habitat would not benefit from the new habitat that would be created under the proposed action; riparian habitats would continue to be at risk from effects from wildfire and post fire flooding and erosion.

Species of Interest

Chapter 4 described nine species of interest. These species are fairly common. They tend to be mobile and have large ranges and can respond to changes in habitat. Chapter 4 described the relationship and benefits of fire and disturbance to these species.

Table 5-42. Species of interest impact summary

Species	Habitat	Impact
Elk	Wide variety of forest and rangeland habitats with good cover and forage	No effect, current habitat not limited, responds positively to wildfire
Mule deer	Wide variety of forest and rangeland habitats with good cover and forage	No effect, current habitat not limited, responds positively to wildfire
Black bear	Wide variety of forest and rangeland habitats with good cover and forage	No effect, current habitat not limited, responds positively to wildfire
Merriam's turkey	Xeric forests and woodlands where there is surface water, roosting trees and forest openings	Adverse, will not benefit from improved structure, roost trees at risk to loss from wildfire, continued downward trend in structure
Mountain lion	Montane forests, woodlands	No effect, current habitat not limited, responds positively to wildfire
Coyote	Wide range of habitats	No effect, current habitat not limited, responds positively to wildfire
Bobcat	Wide range of forest and woodland habitat	No effect, current habitat not limited, responds positively to wildfire
Gray fox	Xeric forest and woodland	No effect, current habitat not limited, responds positively to wildfire
Abert's squirrel	Uneven-age ponderosa pine stand	Adverse, no improvements to structure, loss of mature forest from wildfire
Blue grouse	Uneven-age mixed conifer forest	Adverse, no improvements to structure, loss of mature forest from wildfire

5.8.4 Environmental Consequences - Action Alternatives

Both action alternatives have the potential adversely affect wildlife, but these effects would be negligible to minor, short-term and localized. Both action alternatives are likely to benefit wildlife and improve habitats. The effects would like extend through time at all levels Table 5-43.

Table 5-43. Environmental consequences summary table: wildlife and terrestrial habitats, action alternatives

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level, Landscape level - region	Minor - moderate	Likely
	↑Cumulative	Landscape level - region	Minor - moderate	Likely
Wildland Fire Management	↓Direct	Project level	Minor	Potential
	↑Indirect	Project level, Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level -region	Minor - moderate	Likely
Road Management	↓Direct	Localized	Minor	None
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Riparian Restoration	↓Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely

Activity	Effects	Context	Intensity	Certainty
Noxious Weed Management	↓Direct	Localized	Negligible	Potential
	↑Indirect	Landscape level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Burn Area Rehabilitation	↑Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor -moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely

Effects to species were determined by assessing how activities affect the structure and function of vegetation relative to current and historical distributions. Some habitats may either not be impacted or are impacted at a level which does not influence the species or their occurrence. The level of analysis depends on the existing habitat conditions, the magnitude and intensity of the proposed actions, and the risk to the resources.

Special Status Species

These species were the subject of a Biological Evaluation submitted to the FWS. We also completed formal consultation regarding the potential impacts to the Jemez Mountains salamander due to the imminence of listing and designating Critical Habitat. It is possible that other candidate species could be listed during the life of this project, at which time we would initiate formal consultation with the FWS. Due to their status the potential environmental consequences are provided for each species. This will ensure the adequacy of this analysis for the duration of the project.

Table 5-44. Threatened, endangered, species of concern and candidate terrestrial wildlife species impact summary, action alternatives

Common Name	Habitat	Effect
Canada lynx	Spruce-fir, old growth closed forest	Benefit, protection from wildfire, trend towards old growth
Gunnison's prairie dog	Grasslands and shrublands in low valleys and mountain meadows	Some minor benefit through habitat improvement
Jemez Mountains salamander	Only in the Jemez Mountains, in rotten logs in settings with deep, igneous sub-surface rock	Benefit, protection of habitat from wildfire, trend towards old growth
New Mexican meadow jumping mouse	Riparian areas with tall vegetation	Benefit protection from wildfire, post fire flooding and erosion. Direct improvements to riparian habitats.
American peregrine falcon	Open country, rock cliffs overlooking rivers/water	No effect
Bald eagle	On the preserve, roost trees adjacent to open water	Benefit from protection from wildfire
Goat Peak pika	Talus slopes	No effect
Northern goshawk	Uneven-age mature mixed conifer	Benefit from protection from wildfire and trend towards clumpy and more mature forest
Townsend's big-eared bat	Caves near water	Benefit, protection from wildfire and post fire impacts to foraging areas.

Canada lynx *(Lynx canadensis)*

Recall from chapter 4 that the availability of sufficient suitable habitat (spruce and spruce-fir) and the lack of snow shoe hare (a major prey species are the potential limiting factors for supporting a sustainable resident breeding lynx population in the VCNP.

Impacts of Proposed Actions:

Given that the VCNP can only support the occasional dispersing individual lynx, our proposed actions for forest restoration should have minimal impact on this species. The existing habitat is already broken up into smaller patches of mixed conifer forests growing at higher elevation on the volcanic domes within the preserve (see map above) and thinning or burning (low intensity fire) in patches of mixed conifer will contribute only moderately to this habitat patchiness. The prevention of stand-replacement wildfire is the largest threat to this habitat, and our proposed actions are directed at reducing this possibility. The proposed actions obviously will not affect the primary lynx prey base, as the snowshoe hare does not occur on the VCNP or elsewhere in the Jemez Mountains. As such, the proposed restoration projects the proposed actions are *not likely to jeopardize* the candidate species. It is possible that the lynx could be listed during the planning period. If this were to occur we would request a formal conference and opinion from the USDI – FWS on a finding of *may affect, but are not likely to adversely affect*, the occasional dispersing individual lynx on the VCNP.

Gunnison's Prairie Dog (*Cynomys gunnisoni*)

Recall from chapter 4 that surveys demonstrated that Gunnison's prairie dog is common on the preserve (USDI- National Park Service 2002), with some activity recorded in approximately 75 areas on 4,428 acres total, and past activities noted on 2,444 acres; mean active colony area is estimated to be approximately 60 acres.

Impacts of Proposed Actions:

As prairie dogs live only in the open grasslands, the only proposed action that will have a short-term direct effect on Gunnison's prairie dog populations would be prescribed or natural fire. Fire in grassland valles will remove aboveground standing vegetation (usually dead, cured grasses), making this material unavailable for prairie dog foraging. The prairie dogs themselves will be unaffected by the fire, as they will stay underground as the fire moves across the colony (assuming there is sufficient dried fuels to carry the flames). Indeed, during the Las Conchas fire in 2011, prairie dogs survived in their burrow systems, and were observed active aboveground in the eastern and northern burned sections of the VCNP within days after the fire burned through the area (R. Parmenter, personal observations). Prairie dogs also store grasses in underground larders, and can feed on this food supply until the grasses regenerate their leaf blades. Post-fire re-growing grasses on the VCNP have been found to have increased nitrogen (protein) and calcium, and reduced fiber, making the forage more nutritious to grazers. Overall, no decline in prairie dog populations has been noted in the burned areas of the Las Conchas fire on the VCNP. Fire also removes encroaching woody vegetation (pines and shrubs) in the

grassland/forest ecotone, maintaining the grassland habitat for prairie dogs. Thus, the overall effect of grassland fire regimes on prairie dog populations on the VCNP is beneficial.

In addition to fire treatments, road closures will reduce the number of prairie dogs killed by vehicle traffic. While this number is generally small (less than 10 per year Preserve-wide), road closures and vehicle restrictions will reduce this loss to near zero in affected areas.

Over all the benefits of the proposed restoration plan are likely to outweigh any adverse impacts and the proposed actions are *not likely to jeopardize* the candidate species. It is possible that the prairie dog will become listed during the planning period. At that time the trust would request a formal conference and opinion on a determination that the proposed activities *may affect but is not likely to adversely affect* populations of Gunnison's prairie dog or its habitat on the VCNP.

Jemez Mountains Salamander (*Plethodon neomexicanus)*

Recall from chapter 4 that surveys for Jemez Mountains Salamanders (JMS) were conducted on the VCNP from July to September of 2002. Three out of ten locations revealed positive results (Cummer, Christman and Wright 2002). Nearly half of the preserve's forested landscape has been identified as potential habitat.

Impacts of Proposed Actions:

Forest thinning and use of fire will be the primary actions that could negatively affect JMS populations. Based on our knowledge of JMS thinning and prescribed fire in mesic mixed conifer and aspen mixed conifer stands have the greatest potential to affect JMS habitat and possibly individual salamanders. The emphasis on more thinning and more intensive prescriptions in alternative 3, create a greater potential for impact. However, the actions are not likely to jeopardize the salamander and indirectly, the actions under both alternatives would protect and improve JMS habitat.

Performance requirements from chapter 2 include restricting activities in potential habitat when conditions are saturated and preserving large, down woody debris. Microhabitat changes will be minimized and the preservation of large down woody debris, especially old logs and stumps that are preferred by JMS are emphasized. Following forest thinning, soil moisture will decrease in some microsites (open areas exposed to the sun) and increase in others (areas that receive greater through-fall of snow in winter and rain in summer). This effect is measurably increased under alternative 3. However, both approaches to restoration would reduce the risk of high severity, stand-replacement forest fire that would have a destructive impact on the JMS populations. Leaving patches of moist microhabitat and downed woody debris should still provide sufficient habitat to support JMS populations in restored forest stands.

The VCT has been collaborating with US Fish and Wildlife Service, the NM Department of Game and Fish, The Nature Conservancy, and the US Forest Service to develop effective monitoring procedures to detect the presence/absence and the abundances of JMS in various habitats in the Jemez Mountains. These protocols are still in development, and the our staff have been trained in current methods of monitoring, and will be assisting in the development and testing of new approaches (e.g., use of artificial cover [wood planks] to attract JMS, allowing a "relative abundance" index to be developed for a given area).

Monitoring for JMS prior to and following forest treatments is written into the CFLRP monitoring program, and will be initiated for every local project.

While there is great uncertainty about the abundance and distribution of the JMS, as well as management actions that affect JMS populations, we believe that our forest treatments, when undertaken in potential microhabitats of JMS, will be more beneficial in preventing catastrophic stand-replacement wildfires than detrimental to populations of JMS especially with the retention of important habitat characteristics. In their September 12, 2012 news release and request for public comment regarding the proposed listing of the salamander, the FWS stated, "*The greatest threat to the salamander is the warming and drying of its habitat as a result of severe wildfire. We believe that this risk of wildfire is one of the most significant threats facing this species, and projects attempting to reduce the threat of wildland fire will need to be implemented over a large part of the landscape before significant risk reduction for the salamander is achieved*.

If mechanical treatment and hazardous fuels activities are conducted in a manner that minimizes [direct] impacts to the salamander and its habitat, while reducing the risk of severe wildland fire, the salamander could ultimately benefit from both the reduction in the threat of severe wildfire and the improvement in the structure and composition of the forest." (U.S.D.I. Fish and Wildlife Service 2012)"

Overall, we believe that the proposed restoration projects are *not likely to jeopardize* the candidate species. Due to the imminence of this species listing and associated designation of Critical Habitat Units, we have consulted with the FWS and received an opinion (FWS 2013) concurring with our determination that the proposed activities *may affect but is not likely to adversely affect* populations of JMS or its habitat on the VCNP.

New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*)

Recall from chapter 4, that this species is considered an extreme habitat specialist that relies on riparian areas that have tall, dense herbaceous vegetation, especially sedges, on perennially moist soil (Frey 2006).

Impacts of Proposed Actions:

The proposed actions (planting riparian vegetation, and forest thinning/prescribed fire on the watersheds) that could directly affect the jumping mouse are related to on-site restoration activities in riparian areas. These activities include human foot traffic during planting periods, and vehicle affects during construction of elk and livestock exclosures and pole-planting of woody vegetation. Trampling of vegetation during these could impact resident populations if they exist on VCNP streamsides; however, as noted above, extensive sampling for this species did not detect their presence. Other direct effects would include prescribed fires, during which the ground fire may burn through streamside vegetation; however, previous experience with prescribed fire on the VCNP has shown that burning in early spring or late fall, when riparian zones are still wet and green, usually results in the fire going out as it begins to enter the riparian zone. Hence, this direct impact will likely be negligible on habitat structure. Potential post-fire flooding is much more severe after a stand-replacing wildfire, and our efforts are being directed at avoiding that scenario.

Once the riparian areas have been restored, we anticipate that beavers will once again colonize the VCNP streams. While beaver-related ponds and habitat are not required for jumping mouse populations, they do have positive effects on enhancing habitat as described in chapter 4. As such, the effect of having beavers back in the preserve streams is expected to be positive.

Overall, the cumulative effect of riparian restoration, coupled with reintroduction of beaver, will have a positive impact on New Mexico jumping mouse habitat. If the jumping mouse does not actually occur on the VCNP, then we anticipate working with US FWS and the New Mexico Department of Game and Fish to re-introduce the jumping mouse to the VCNP once the habitat is in suitable condition to support a sustainable population. Therefore, we conclude that the proposed activities are *not likely to jeopardize* the candidate species. It is possible that the New Mexico meadow jumping mouse may become listed or that critical habitat for the mouse could be designated during the planning period. At that time we would request a formal conference and opinion on a determination that the proposed activities *may affect but is not likely to adversely affect* populations of New Mexico meadow jumping mouse or its habitat on the VCNP.

American Peregrine Falcon (*Falco peregrinus anatum*), and Arctic Peregrine Falcon (*Falco peregrinus tundrius*)

Recall from chapter 4 that comprehensive surveys of potential nesting sites on the VCNP was conducted in 2001 and 2009, and no suitable peregrine nesting habitat was found within the VCNP (Johnson, 2001; Keller, 2009). However, peregrine falcons do nest on the cliffs just to the west in San Antonio Canyon (Jemez District of the Santa Fe National Forest) and use areas within the VCNP as foraging habitat, such as the large stock pond in Valle Seco and the Valle Grande (Johnson, 2001; Keller, 2009).

Impacts of Proposed Actions:

The proposed actions of forest and watershed restoration (thinning, prescribed fire, riparian restoration) are not predicted to have negative direct effects on the peregrine falcon, as no nest habitat occurs within the VCNP, and foraging habitat (stockponds and open valle wetlands) will remain intact. Restoration efforts of stream banks will be done on a very limited geographical area at any given time, so the vast majority or peregrine falcon foraging habitat will remain available to visiting falcons and their bird prey species. Forest thinning and prescribed fire on the VCNP, aside from smoke temporarily cutting down visibility of foraging peregrines, should have no direct effects on peregrine activities, and will, in the long run, improve hydrology and riparian areas to maintain wetlands for waterfowl and other species that form the prey base of peregrine falcons. As such, we conclude that the proposed actions *may affect, but are not likely to adversely affect*, the peregrine falcon on the VCNP.

Bald Eagle *(Haliaeetus leucocephalus)*

Recall that the VCNP supports a small population (up to 20) of migratory bald eagles during the late fall/early winter. Wintering bald eagles begin to arrive on the VCNP in October and leave when all streams have been frozen over and have become inaccessible for fish, usually by early January (although eagles may visit periodically all winter if snow/ice conditions permit).

Impacts of Proposed Actions:

Forest thinning and use of fire will preclude habitat and roost tree use by bald eagles during the actual activities when crews are on site (direct effect), but this effect will be localized and temporally ephemeral, allowing for continued use by eagles as soon as the activities are completed. Known roost trees will be left along streams for eagle use. Watershed benefits of thinning the forests include increased streamflow and hydrologic function, which will increase water in the streams, benefitting fish populations and enhancing food resources for eagles. Road closures will decrease traffic and human disturbances on roosting eagles. The cumulative effects of forest restoration, improved watershed function, and reduced disturbance by human vehicle traffic through road closures, will lead to enhanced habitat quality for the eagles. As such, the proposed restoration projects *may affect, but are not likely to adversely affect*, the bald eagles on the VCNP in late autumn/early winter.

Goat Peak Pika (*Ochotona princeps nigrescens*)

Recall from chapter 4 that in New Mexico, these animals are confined to Felsenmeers, talus slides and boulder fields in alpine and sub-alpine areas. Goat Peak pikas occupy virtually every patch of appropriate open rocky slope ("Felsenmeers") in the Jemez Mountains. Although no formal surveys have been conducted, we know from repeated sightings that Goat Peak pika currently occur within the VCNP (R. Parmenter 2002-2012) wherever suitable habitat exists.

Impacts of Proposed Actions:

None of the proposed actions will have a direct effect on the Felsenmeer habitats of the VCNP, except that a fire would temporarily remove dried grasses from around the edges of the Felsenmeers; however, even fires cannot enter the rocky slopes, as there is no fuel load present to burn. Thinning of forests surrounding patches of Felsenmeer will allow more snow to reach the ground (as opposed to the snow being hung-up in the tree canopy), and will be partially shaded by the remaining trees. This should enhance the snowpack on the Felsenmeer, at least around the edges, and help mitigate the effects of climate warming on snowpack depth and duration. In addition, the thinned and/or burned forests surrounding each Felsenmeer will experience increased growth of understory grasses and forbs, creating greater quantities of potential forage resources for the pika adjacent to the Felsenmeer burrow/nest habitat. We also predict that a more open forest architecture would make inter-site movements of dispersing pikas easier; pikas clearly prefer open, rocky habitats for both shelter and predator detection, and may, by extension, find moving through more open forests preferable that dispersing through dense, second growth forest stands.

In summary, the direct effects of the proposed actions (forest thinning, followed by prescribed or managed fire) will have a temporary negative effect of removing dried fine fuels (grasses), as well as beneficial effects of opening up the forest for snowpack retention and greater production of herbaceous forage. Dispersal of pikas among Felsenmeer sites may be enhanced by forest thinning (but this has not been studied, and as such, is hypothetical at this time). The cumulative effects of more forage production/accessibility and enhanced snow pack retention are beneficial, and may counteract the negative effects of climate warming. As such, the proposed restoration projects *may affect, but are not likely to adversely affect*, the populations of Goat Peak pikas on the VCNP.

Northern Goshawk (*Accipiter gentiles*)

Recall from chapter 4 that formal survey for goshawks was conducted in 2009 (Keller, 2009), and three sightings were recorded. Searches for nests were unsuccessful, but it is assumed that goshawks do indeed nest on the VCNP. In addition, several known designated foraging areas overlap onto the VCNP from the Santa Fe National Forest. These areas are located on the east, west, and northwest edges of the VCNP. Goshawks have been observed foraging on the preserve (Keller, 2009), R. Parmenter, personal observations). Breeding, roosting, and foraging habitat is available on the VCNP within the mixed conifer and ponderosa pine forests, although historic logging targeted large trees and clear-cut all trees leaving a dearth of these important habitat characteristics.

Impacts of Proposed Actions:

The changes to forest structure in the pine and mixed conifer forest types as described in 5.2 *Forest Vegetation and Ecological Condition,* are predicted to improve goshawk habitat by converting large areas of relatively homogeneous dense, second growth forests of pine and mixed conifer to more open forest structure that will be on a new successional pathway to “old growth” condition. The VCNP has very few areas that have large-diameter, tall trees, and therefore the thinning prescriptions will retain what large trees exist and remove small-diameters in a pattern that will lead to improved goshawk habitat structure as the stand matures. In addition, we will retain large downed woody debris to maximize habitat structure for small mammals (a component of the goshawk prey base). Direct effects of forest thinning and prescribed fires may temporarily displace goshawks during actual localized operations; therefore, forest operations in the vicinity of potential nest locations will be conducted during late fall and winter months to avoid nest disturbances (Goshawk surveys will be undertaken prior to all activities during the planning phase, to document any nest locations). Overall, forest restoration will improve goshawk habitat and increase populations on the VCNP, and thus we conclude that the proposed actions *may affect, but are not likely to adversely affect*, the goshawk on the VCNP.

Pale Townsend Big-eared Bat (*Corynorhinus townsendii*)

Recall from chapter 4, that there is habitat for this species within the VCNP, although local distribution is limited to the limited distribution of caves and similar structures across the landscape.

Impacts of Proposed Actions:

The proposed forest and watershed restoration actions (thinning, prescribed fire, riparian restoration) are not predicted to have negative direct effects on Townsend's big-eared bat, and should improve their habitat in terms of forest structure and food resources.

Changes to forest structure and understory as described in section 5.2 *Forest Vegetation and Ecological Condition* would benefit the bat. Greater vegetation diversity and productivity will lead to increases in the diversity and abundances of insect species, making more prey available to the bats. Riparian habitat also will be improved, increasing hydrologic function and ensuring that water sources remain available, even during extended drought periods. At present, no known caves or old mines (potential roost and hibernacula sites) have been identified on the VCNP, but if any are eventually discovered, they will be evaluated and protected. All existing buildings on the VCNP, should they be used by the bats as temporary shelters, are currently being protected from fire, and nearby forest thinning should enhance protection. Therefore, we conclude that the proposed actions *may affect, but are not likely to adversely affect*, the population of Townsend's big-eared bat on the VCNP.

Sensitive Species

Chapter 4 identified 11 sensitive species. The bald eagle is technically considered a sensitive species, however because it is recently delisted and being monitored we considered it in the previous section. The remaining 10 species use habitats that are either rare in the SWJML or include characteristics that are rare, or both. These include: Old growth high elevation conifer forests or cool moist forests with old growth characteristics, (large down wood debris, large and old snags, large and old trees; talus slopes, riparian areas; montane wet meadows, or grassy openings; or cliffs, rocky outcrops and caves.

As shown in Table 5-45 below most of these species will benefit from the proposed restoration activities. Species requiring old growth habitats and characteristics would benefit indirectly by the prevention of loss from wildfire and the trend towards old-growth. There is a potential for localized adverse impacts resulting from thinning and prescribed burning as these activities can destroy, large down logs and snags. However, performance requirements have been identified which are known to be effective at minimizing these impacts.

No effects to talus and cliff habitats would be anticipated; sensitive species associated with these habitats are likely more at risk from warmer and drier climate than current ecological condition or the consequences of the proposed action.

Those species that prefer montane wet meadows would benefit as prescriptions intended to expand or maintain these habitats. Species that prefer riparian shrublands and forests would benefit as the proposed action includes creating these habitats and includes restoration activities that would expand wetlands and ultimately the extent of the wet meadow and riparian vegetation.

Cumulatively, the proposed action would support greater resiliency in the cool, moist habitats of these species in the event of warmer and drier climatic conditions. However, the degree and rate of change of temperature could limit the effectiveness of the protections.

Table 5-45. Sensitive species impact summary

Species	Habitat	Impact
American marten	Spruce-fir and mesic mixed conifer	Benefit, trend to old-growth, protect from fire
Boreal owl	Mesic spruce-fir	Benefit, trend to old-growth, protect from fire
Dwarf shrew	Talus, mesic forests (7,000-9000)	No effect
Ermine	Montane meadows	Benefit, restore and maintain meadows
Long-tailed vole	Mesic mixed conifer, open	Benefit, create and maintain open forest
Northern leopard frog	Riparian	Benefit, restoration of riparian habitat
Pika	Talus	No effect
Southern red-backed vole	Mesic mixed conifer, spruce-fir	Benefit, trend to old-growth, protect from fire
Spotted bat	Cliffs, rock outcrops or caves near water	No effect
Water shrew	Riparian forest and shrubland	Benefit, recruitment of riparian shrubland forest

Species of Interest

In general the benefits to vegetation and watershed conditions would benefit most species. Disturbance, especially fire, stimulates the production of food for grazing, browsing and foraging, which in turn improves the habitat for those that prey on the grazers, the browsers and the foragers. The species would also benefit from more uneven structure and age in the forest that would result from the proposed action.

Table 5-46. Species of interest

Species	Habitat	Impact
Abert's squirrel	Uneven-age ponderosa pine stand	Benefit from improvements to forage and structure, protection and recruitment of mature forest
Black bear	Wide variety of forest and rangeland habitats with good cover and forage	Benefit from improvements to forage and structure
Blue grouse	Uneven-age mixed conifer forest	Benefit from improvements to forage and structure, protection and recruitment of mature forest.
Bobcat	Wide range of forest and woodland habitat	Benefit from improvements to forage and structure for prey
Coyote	Wide range of habitats	Benefit from improvements to forage and structure for prey
Elk	Wide variety of forest and rangeland habitats with good cover and forage	Benefit from improvements to forage and structure
Gray fox	Xeric forest and woodland	Benefit from improvements to forage and structure for prey
Merriam's turkey	Xeric forests and woodlands where there is surface water, roosting trees and forest openings	Benefit from improvements to forage and structure and protection of roost trees and mature shrublands
Mountain lion	Montane forests, woodlands	Benefit from improvements to forage and structure for prey
Mule deer	Wide variety of forest and rangeland habitats with good cover and forage	Benefit from improvements to forage and structure

Migratory Birds

Figure 5-28. Audubon's warbler is a migratory bird abundant on the preserve

In general, the action alternatives would protect, preserve and enhance habitats for migratory birds as previously described for other species. Noise and disturbance from restoration activities, especially during the spring and early summer, could impact individuals. However, performance requirements that protect large trees, snags, and down logs will ensure that characteristics that are rare on the landscape endure. Further, noise and disturbance is localized to areas where restoration is active. Effects would be greatest for species preferring conifer habitats such as the abundant[40] Audubon warbler shown in Figure 5-28.

5.9 Fisheries and Aquatic Habitats

5.9.1 Goals and Objectives

Goals and objectives from chapter 2 related to water quality, stream condition, aquatic and terrestrial habitats, and road management, also apply to fisheries and aquatic habitats. These include closing and decommissioning roads, improving water quality, improving the functioning condition of stream banks, and riparian/aquatic habitats, expanding wetlands, and protecting soil resources. Targets include miles of road to be closed, quantified measures of water quality and streambank condition, increase in wetland acres and the return of species whose present absence is due, at least in part, to current watershed condition.

5.9.2 Methods

Effects to fisheries were analyzed using the physical elements described in the Rio Grande cutthroat trout table in the Region 3 stream survey results (USDA-Forest Service, 2002; USDA-Forest Service, 2003) with the addition of flow. All of these elements are also discussed as important elements for fitness in

[40] Breading bird surveys conducted on the VCNP from 2002-2012 showed an 18% cumulative abundance of Audubon warbler.

the technical reviews for Rio Grande chub and Rio Grande sucker (Rees, Carr and Miller 2005, Rees and Miller 2005). These elements are:

- Temperature
- Sediment/turbidity/substrate
- Pool development/pool quality
- Peak/base flow
- Streambank condition

This section brings forward specific outcomes to these important elements from 5.5 *Watershed* that relate to fisheries and aquatic habitats.

5.9.3 Spatial and Temporal Boundaries

Effects are analyzed for fisheries within the Valles Caldera. Effects are unlikely to be large enough to spread downstream of the preserve. Short-term effects are defined as from project implementation to three years post-implementation. Long-term effects are defined as three to ten years post implementation.

5.9.4 Environmental Consequences - No Action Alternative

Direct and Indirect Effects

Under this alternative there would be no decisions regarding landscape restoration or management of the preserve's natural resources. Actions covered under existing Stewardship Registers would continue as described in chapter 2. There would be no direct effect to fisheries or aquatic habitats. There is a potential for indirect effects to aquatic habitats.

Indirect effects of no action alternative would be a projection of existing condition. Stand density would increase and or fuel loading of down wood would increase increasing the risk of stand replacing fire such as Las Conchas Fire. Short-term effects of a fire would be one or two seasons of high volumes of suspended sediment load. Some deposition of coarser material might be expected in the channels. Fish kills from concentrated ammonia might also again occur. There would be no disturbance otherwise on forested slopes and the risk of surface erosion that poses. There would be no increased traffic on the preserve road system related to restoration work, and the increased suspended sediment load that would incur. These effects may be considered long term given the length of the proposed treatment. Stream flow would remain the same, as allowed by the vagaries of annual weather patterns. There would be no potential increase in base flow or peak runoff as might occur with permanent reduction in forest canopy.

Table 5-47. Environmental consequences summary table: no action, fisheries and aquatic habitats

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential

Activity	Effects	Context	Intensity	Certainty
	↓Cumulative	Landscape level - region	Minor - moderate	Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level - region	Minor - moderate	Potential
	↓Cumulative	Landscape level -region	Minor - moderate	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor -moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential

This alternative would not have direct or indirect effects on the native and non-native fisheries of the VCNP or their habitat components (temperature, turbidity, substrate, pool quality/development or peak/base flows) because no new activities are authorized by this alternative. Implementing this alternative could lead to an increase in fuels within the VCNP that could lead to another large-scale wildfire which could lead to a decrease in available habitat for native fish species.

Cumulative Effects

From the watershed report (Moser and Archer 2012): There would be no cumulative effect that would result directly as a result of this alternative. Effects of on-going thinning and restoration may have indirect effects on sedimentation, decreasing as a result of channel stabilization, and stream flow increasing as a result of canopy thinning. In the event of a wildfire that may indirectly be the result or may be exacerbated by lack of thinning sedimentation in channel of the degree associated with the Las Conchas fire may occur.

5.9.5 Environmental Consequences – Action Alternatives

The action alternatives could potentially result in direct, adverse albeit localized, minor and short-term impacts to aquatic species and their habitats on the preserve. Direct, indirect and cumulative beneficial impacts would also be likely to occur. These beneficial effects would be localized and would extend through the planning and regional area and may be minor to moderate as shown in Table 5-48 below.

Table 5-48. Environmental consequences summary table: action alternatives, fisheries and aquatic habitats

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level, Landscape	Minor - moderate	Likely

Activity	Effects	Context	Intensity	Certainty
		level - region		
	↑Cumulative	Landscape level - region	Minor - moderate	Likely
Wildland Fire Management	↓Direct	Project level	Minor	Potential
	↑Indirect	Project level, Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level -region	Minor - moderate	Likely
Road Management	↓Direct	Localized	Minor	None
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Riparian Restoration	↓Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Noxious Weed Management	↓Direct	Localized	Negligible	Potential
	↑Indirect	Landscape level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Burn Area Rehabilitation	↑Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor -moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely

Both alternatives propose a similar suite of restoration activities including forest thinning, wildland fire management, riparian and wetland restoration, post wildfire rehabilitation, road closure, decommissioning, and maintenance and erosion control; and noxious weed eradication. Descriptions of the proposed restoration activities that comprise the action alternatives were presented in Chapter 2 – *Issues and Alternatives*. The following performance requirements from chapter 2 have been considered in our assessment of the potential environmental consequences to fisheries and aquatic habitats resulting from the implementation of either action alternative:

- Use hand tools including chainsaws in lieu of heavy equipment in riparian areas.
- Where heavy equipment is being used to restore stream channels, create water-crossings, decommission roads, create exclosures, or other beneficial restoration work; project plans shall specify access, rehabilitation, and short-term actions to minimize erosion.
- When closing, maintaining, or decommissioning roads on hill slopes or former wet meadows the roadbed should be out sloped to allow water to drain evenly across the road.
- Bar ditching and use of culverts to drain the uphill sides of roads should be avoided and replaced by outsloping, and using rolling dips to improve drainage.
- Road management activities shall include best management practices to limit short term impacts to soils including:
    - Erosion control plan
    - Timing of construction activities
    - Road slope stabilization
    - Control of road drainage
    - Maintenance of roads
    - Control of sidecast material

- Traffic control during wet periods
- Timely erosion control measures on incomplete roads and water crossings
- Road Surface Treatment to prevent loss of materials
- Construction of stable embankments (fills)
- Restoration of borrow pits and quarries

- Where streamside vegetation is likely to burn in a prescribed fire, the prescribed burn plan shall include mitigating measures such as:
  - Prescription parameters for live fuel moisture content or "greenness" of riparian vegetation.
  - Ignition patterns to limit spread of fire in riparian areas.
  - Buffers to keep fire outside of riparian areas.
- The application of aerial retardant in or within 300 feet of waterways, wet meadows, or wetlands will only be permitted when human life or safety is threatened and the application of aerial retardant is reasonably likely to alleviate that threat.
- When in stream construction is expected to be extensive, modify existing road/stream crossings, used for project activities, to allow fish passage

Direct Effects

During culvert modifications and in stream channel work fish could be stepped on or impinged by equipment causing injury or death to individual fish. Given the localized, small-scale extent of in-stream work any direct effects are likely to be minimal and are unlikely to affect fish populations on the scale of the preserve.

Direct effects could also occur from the application of herbicides to vegetation. If these herbicides are applied to close to the stream channel there could be inputs of herbicides into occupied fish habitat. A 2010 study (Salbego, et al. 2010) found that glyphosate affected brain and metabolic functions in piava (*Leporinus obtusidens*). While this is a South American ray-finned fish it is likely that this herbicide could have similar effects on the fish species found in the VCNP. The guidelines for the distance from fish-bearing streams for the application presented in chapter 2 would prevent these herbicides from entering fish-bearing waters and therefore any direct effects from herbicides would be avoided or minimized.

Indirect effects

Forest Thinning and Wildland Fire Management

Temperature

Tree removal along ephemeral and intermittent channels would be minimal. Given the hydrology of the preserve, upwelling cold springs; it is unlikely that vegetation treatments will have a noticeable effect on stream temperature.

Flow

From the watershed report (Moser and Archer 2012): Part of the purpose and need of the landscape restoration plan is to increase ecosystem services by increasing streamflow and improving stream temperature. Upslope vegetation treatments would increase snow cover that percolates during runoff to either shallow or deep groundwater paths. Restoring pre-settlement riparian conditions on the valley bottoms would retain base flow longer on the preserve, decrease summer water temperatures, and increase cover for fish. The San Antonio watershed shows the highest potential to increase upland water budget through canopy alteration given the thick in-growth of ponderosa pine in one-time savannah structure and losses of aspen.

The actions associated with these activities will likely increase the amount of flow within occupied fish habitat. Increased flow could potentially increase the amount of available fish habitat as the water spreads out as well as providing more space within the water column for occupation. Rio Grande chub are a part of a guild preferring cool, fast-flowing reaches with gravel or cobble substrate (Platania 1991 *in* (Rees, Carr and Miller 2005). Stream flow (or lack thereof) was one of the major issues identified by Bestgen et al. 2003 *in* (Rees, Carr and Miller 2005) affecting Rio Grande chub populations.

Sediment/substrate

From the watershed report: (Moser and Archer 2012) Sediment production from the forestry treatments would be localized depending on slope steepness and extent of ground cover disturbed and open forest condition. If strong monsoon rains occur immediately following treatment, rilling may be expected. The area extent of treated slopes in such erodible condition, however, would be expected to be much less than a wildfire. Strips of untreated and vegetated ground (buffers) will be left around all perennial and seasonally flowing channels and swales. Periodic review of research on the effect of streamside buffers has found consistent results in terms of maintaining water quality (Castelle, Johnson and Conolly 1994, Castelle and Johnson 2000, Fischer and Fischenich 2000),

Increased sediment load can cover substrate, decrease pool depth, diminish suitable spawning habitat, and reduce fitness by decreasing the nutritional value of the food base. Severely reduced stream flows may lead to increased water temperatures, changes in the algal community, and reduced dissolved oxygen levels especially in smaller tributary systems. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is reduced, Rio Grande chub fitness will also decline (Rees, Carr and Miller 2005). The deposition of fine sediments has been found to negatively impact the abundance and condition of Rio Grande suckers ((Swift-Miller, Johnson and Muth 1999, Rees and Miller 2005). The Rio Grande sucker may have an affinity for larger substrate because the stability associated with coarse substrate provides a greater opportunity for algal growth and macroinvertebrate production (Calamusso and Rinne 1996) *in* (Rees and Miller 2005), which comprise the dominant proportions of the Rio Grande sucker's diet (Rees and Miller 2005).

Untreated vegetation around watercourses should prevent the majority of sediment mobilized from treatments from entering fish-bearing waters. Some sediment will likely end up being conducted into perennial waters but the effect will likely be localized and minor. Additional sediment could lead to localized increases in turbidity and changes in substrate. Increased turbidity can decrease feeding opportunities and changes in substrate can lead to decreases in available spawning areas. However,

given the small, localized nature of the effect this sediment may impact individuals in the short-term but is unlikely to cause changes in populations in the long-term.

Pool Quality and Pool Development

While some sediment will enter the stream channel it is unlikely that it will be enough to change the characteristics and/or number of pools within the perennial fish bearing streams of the VCNP. This is due to the small, localized nature of the sediment inputs.

Streambank Condition

Streambanks in perennial fish bearing waters are unlikely to be affected by upslope vegetation treatments given the distance between the streambanks along occupied fish habitat and the treatment areas.

Noxious Weed Control

From the watershed report (Moser and Archer 2012): The effectiveness of a vegetative strip in capturing harmful compounds of herbicide is detailed in the noxious weeds section of this chapter. Buffers of any vegetative type of about 30 meters will remove 80-90 percent of nutrient and sediment load, largely through resistance and dispersal of the transporting sheet wash. Filtering of nutrients (N, P and K) is typically within the first 10 meters of a buffer. Applying herbicide at the appropriate distances as described in chapter 2 will prevent impacts to fisheries.

Flow, Temperature, Pool Quality and Pool development, Sediment/Substrate and Streambank Condition

Direct effects could but are not likely to occur (see direct effects analysis). It is unlikely that there will be indirect effects to fisheries from herbicide application given the nature of the application, away from the riparian areas. It is unlikely that the application process will disturb ground leading to alterations in sediment input, pool quality and other characteristics because of the buffer around streams. Therefore the activities associated with applying herbicides should not affect these components of fish habitat.

Road closure, decommissioning, and maintenance

From the watershed report (Moser and Archer 2012): Traffic and maintenance of roads in the VCNP, particularly principle haul routes for logs will increase during periods of implementation of selected actions. One of the primary sources of sediment into perennial streams is from roads that have direct drainage. Research has shown definitively that the majority of sediment produced by roads is caused by increase in traffic and is in the form of very fine sediment (<.004 mm) washed from the running surface during fall rainstorms (Reid and Dunne 1984, Bilby, Sullivan and Ducan 1988, Sheridan, et al. 2005). It is these particle sizes that stay in suspension under even mildly turbulent stream flow, cause turbidity, and when settling plug interstitial spaces in streambed gravels. Fines within surface pore spaces in the bed will reduce water flow and thereby oxygen to fish eggs and emergent fry. To the extent that roadwork is continued on the VCNP, attention should be paid to minimizing direct input from road drainage into perennial streams that are fish bearing. While vegetative buffers are very effective at reducing or

eliminating altogether road wash effects, as has been described above, there is no effective buffering when runoff is channelized directly to the stream. Most of the roads, despite a very high density per unit area, have no direct surface connection to any stream bodies, either perennial or seasonal. Such connections typically are at crossings and a minor area of potential road runoff. Exceptions are the perennial mountain streams of Los Indios, Redondo, White Sulphur, and upper portions of Jaramillo Creeks. In each of these cases the primary road is parallel and mostly within 100 feet of the stream throughout the valley length.

Temperature

Riparian shade will not be affected by road activities. There is little shading by vegetation in perennial streams and the roadwork will not remove any of the stream shading. Further improvements to stream/road crossing by constructing low water crossings, culverts, and bridges are being proposed to reduce widening of the stream at road crossings. This would reduce warming of streams at these points.

Sediment/turbidity/substrate and Pool Quality/Development

Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, irrigation, and overgrazing in riparian areas. These can all lead to increased sediment load in the system and a subsequent change in stream channel geometry (e.g., widening, incision). These modifications alter width: depth ratios, pool: riffle ratios and other aspects such as pool depth that affect the quality of habitat occupied by Rio Grande chub. Once in the watershed, the increased sediment load can cover substrate, decrease pool depth, diminish suitable spawning habitat, and reduce fitness by decreasing the nutritional value of the food base. Severely reduced stream flows may lead to increased water temperatures, changes in the algal community, and reduced dissolved oxygen levels especially in smaller tributary systems. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is reduced, Rio Grande chub fitness will also decline (Rees and Miller 2005).

Roadwork activities will likely add sediment to fish bearing streams in the short-term although a reduction in the number of roads and the improved condition of the roads is expected to reduce the amount of sediment that could potential enter streams in the long-term. Several road repair areas (see watershed report) will have direct connections to streams; this will likely lead to inputs of sediment. These events will be localized in nature and time. In the long-term there is likely to be a reduction in existing sediments entering the stream because sediment run-off from roads will be reduced by the maintenance activities. Decommissioning of roads will likely lead to short-term effects of sediment input but there will be a long-term effect from the reduction in road sediment input into streams. Replacement of culverts will also add short-term sediment inputs but in the long-term have the potential for reducing sediment impacts and providing better fish passage. Substrate in the short-term will be altered in spots, this could lead to short-term effects to spawning; in the long-term substrate will not be noticeably altered on a preserve scale.

Streambank Condition

Streambanks are unlikely to be altered by road actions. Most of the roadwork will occur away from streambanks. Sediment inputs may build up on the banks in the short term but this build up is likely to

be negligible and will not persist in the long term given the small, localized nature of the activities. Under the action alternatives roads that are currently impacting stream condition would be repaired or realigned.

Flow

Streamflow could be slightly altered by road activity. Road maintenance may lead to more flow entering the stream where there are direct road/stream connections. However this effect will likely be negligible and unlikely to affect fish fitness or populations.

Riparian and Wetland Restoration

From the watershed report (Moser and Archer 2012): As expected, roughening of the channel provided, for the same flow volume, a deeper water column with greater lateral spread over near bank floodplain. Additional channel roughness could accomplish multiple goals: hasten narrowing of the channel through capture of fine sediments concomitant with deepening of the water column for a given discharge, and greater connection with side channels and near bank floodplain. Additionally it will provide bank protection through rooting and branching, shade and detritus (leaf litter) for macro invertebrate food source.

The preservation or restoration of stream flows that are adequate to maintain complex habitat, interconnectivity of habitats (longitudinally and laterally onto the floodplain) and in stream cover would be a focal point of the restoration strategy. Conservation elements would address the function of the entire aquatic and riparian ecosystem, with particular attention to downstream populations. It is important to remember that most of the Rio Grande sucker habitat that has been lost in southern Colorado in the San Luis Valley at low elevations in the Rio Grande National Forest or downstream of forest boundaries. Any future plans for the conservation of Rio Grande sucker should take a watershed approach to restore historical riverine functions (e.g., flows and their timing) and, therefore, assist the entire native fish assemblage. This assemblage may also include the Rio Grande cutthroat trout and the Rio Grande chub. These fish would all benefit from the management related to restoration of historical flow regimes and the associated channel maintenance (Rees and Miller 2005).

Sediment/Substrate and Pool Quality/Development

There will likely be short-term effects to and sediment/substrate from activities associated with restoration. Working on the streambank and within the channel could lead to an increase in short-term sediment inputs. Additionally pool quality could be negatively affected by in stream work. These effects will likely be localized, minor, and short-term. In the long-term this work will likely lead to a decrease in sediment inputs with the addition of vegetation, the roughening of channels etc. Pool quality will return in the long-term and may also be improved. Past restoration projects that included in stream work have been reviewed by New Mexico Game and Fish during planning and have not been found to lead to declines in native fish populations (Rodriguez pers. comm. 2012).

Temperature

There is little to no vegetative cover in the valley bottoms along fish-bearing water. It is unlikely that temperature will be negatively altered by these activities.

Streambank Condition

Some areas of streambanks would likely be disturbed during project activities. These disturbances would be localized and the streambanks will likely revegetate and stabilize. Fish populations will likely lose some habitat while these banks are stabilizing which could result in reduced fitness of some individual native fish. However, the disturbance of these banks will lead to more diverse habitat in the long-term, which could lead to increased fitness of fish populations. Reviews of previous work on the VCNP annual fish monitoring has not indicated negative impacts are expected or have occurred affected by short-term habitat alteration (Rodriguez pers. comm. 2012).

Flow

Restoration activities may increase the amount of flow spreading out from the main channel. This could increase the amount of off-channel habitat available for juvenile fish rearing away from predators. This would be a beneficial, long-term effect to native fish populations.

Cumulative Effects

From the watershed report (Moser and Archer 2012): Any effects would be cumulative to those on-going thinning and restoration projects. Likely the combine effect will be at a minimum increase in summer base flow, although perhaps not statistically significant outside the typical error involved in measurement. During summer monsoon rains, sedimentation from proposed restoration activities could combine with future transportation and infrastructure development in support of public access and use, as well as some continued sedimentation from the area burned during the Las Conchas fire leading to localized minor, impacts to aquatic habitats.

Restoration activities would tend to limit or attenuate effects in downstream direction by slowing flow velocity and capturing fine sediment of the type most likely to be produce. Past harvest disturbance left a legacy of roads and log landings. Passive and active road restoration efforts would continue to stabilize these surfaces. Using this infrastructure would minimize new construction and landing construction and allow for reclaiming these areas after thinning is completed. Clear-cutting along Redondo's broad ridge left sparse or clumped regrowth and open Kentucky bluegrass meadows. Residual compaction from past logging activities persists, while heavy elk grazing on the Kentucky bluegrass continues to favor its spread. The shift in the understory from native grasses and forbs that would be expected here and the poor forest regeneration indicate impaired forest growth conditions. Planned thinning efforts may expand forest growth by thinning the clumped trees. However, burning within these meadows could push the site back into early successional state that favors Kentucky bluegrass expansion. Organic matter character and stocks are much reduced from comparable sites nearby. Using slash application or masticated litter from nearby could prove valuable to re-establish organic matter consistent with the desired forest type.

5.9.6 Determination of Effect to Threatened, Endangered, Candidate, or Sensitive Species

Rio Grande Cutthroat Trout (Oncorhynchus clarkii virginalis)

Recalling from chapter 4, Rio Grande cutthroat trout are not currently found within the project area. Historically RGCT was found in streams throughout the VCNP. The stocking of non-native trout in the late 1800's and early 1900's was probably the main cause of the extirpation of RGCT from the streams of the Valles Caldera but current conditions probably preclude its successful reintroduction at this time.

Impacts of Proposed Actions:

The proposed activities including forest thinning, prescribed burning, riparian and watershed restoration, road management and noxious weed eradication could directly and indirectly affect fish and fisheries habitat. Direct affects to individual fish could potentially occur from culvert modifications and in stream channel work. Fish could be stepped on or impinged by equipment causing injury or death to individual fish. As the RGCT is not currently present on the VCNP, individuals would not be affected. If any fish were to occur throughout the 10-year planning period the localized, small-scale extent of instream work any direct effects are likely to be minimal and are unlikely to affect fish populations on the scale of the preserve.

Direct effects could also occur to fish from the application of herbicides to noxious weeds. If herbicides were applied close to the stream channel there could be inputs of herbicides into fish habitat. A 2010 study (Salbego et al. 2010) found that glyphosate affected brain and metabolic functions in piava (*Leporinus obtusidens*). While this is a South American ray-finned fish it is likely that this herbicide could have similar effects on the fish species found in the VCNP. Guidelines for the distance from fish-bearing streams for the application of herbicides have been incorporated into the proposed actions as performance requirements. These guidelines would prevent herbicides from entering fish-bearing waters and therefore any direct effects to RGCT (should RGCT occur within the VCNP during the planning period) from herbicides would be prevented.

Table 5-49. Performance requirements for the application of herbicides near streams

Herbicide	Wetlands		
	Broadcast	Spot	Hand/Select
Aquatic Labeled Herbicides			
Aquatic Glyphosate	100	water's edge	water's edge
Low Aquatic Hazard Rating			
Imazapic	100	15	high water mark
Clopyralid	100	15	high water mark
Greater Aquatic Hazard Rating			
Glyphosate	100	50	50

Herbicide	Wetlands		
	Broadcast	Spot	Hand/Select
Imazapic + Glyphosate	100	50	50

Other proposed activities including forest thinning, prescribed fire, road management could indirectly impact RGCT habitat including water temperature, stream flow, sediment/substrate, and pool quality, and stream condition. Tree removal along ephemeral and intermittent channels would be minimal. Given the hydrology of the preserve, upwelling cold springs; it is unlikely that vegetation treatments will have a noticeable effect on stream temperature.

Upslope vegetation treatments would increase snow cover that percolates during runoff to either shallow or deep groundwater paths. Restoring pre-settlement riparian conditions on the valley bottoms would retain base flow longer on the preserve, decrease summer water temperatures, and increase cover for fish. Landscape scale forest thinning would likely increase the amount of flow within occupied fish habitat. Increased flow could potentially increase the amount of available fish habitat as the water spreads out as well as providing more space within the water column for occupation.

Sediment production from the forestry treatments would be localized depending on slope steepness and extent of ground cover disturbed and open forest condition. If strong monsoonal rains follow immediately have treats that expose mineral soil, rilling could be expected. The spatial extent of treated slopes in such erodible condition, however, would be expected to be much less than a wildfire. Strips of untreated and vegetated ground (buffers) will be left around all perennial and seasonally flowing channels and swales. Periodic review of research on the effect of streamside buffers has found consistent results in terms of maintaining water quality (Castelle, Johnson and Conolly 1994, Castelle and Johnson 2000, Fischer and Fischenich 2000). It is unlikely that sedimentation would occur to the degree that it would change the characteristics and/or number of pools within the perennial fish bearing streams of the VCNP. This is due to the small, localized nature of the sediment inputs. Streambank conditions along perennial fish bearing waters are unlikely to be affected by upslope vegetation treatments given the distance between the streambanks along occupied fish habitat and the treatment areas.

Overall the proposed activities would not result in any take or harm to any RGCT as the species is not currently present. If the RGCT were to occur on the preserve during the 10-year planning period, proposed in-channel work could potentially harass, harm, or take an individual. Overall the benefits of the project will outweigh any adverse effects and the proposed actions are *not likely to jeopardize* the candidate species. It is possible that the RGCT may become listed or that critical habitat for the trout could be designated during the planning period. At that time the trust would request a formal conference and opinion on a determination that the proposed activities *may affect but is not likely to adversely affect* populations of RGCT or its habitat on the VCNP.

Activities proposed under the action alternatives may impact Rio Grande chub and Rio Grande sucker, but these effects would not lead towards listing. Short-term effects such as sediment input and alteration of pools could result; these effects will likely be localized and not continue in the long-term. In the long-term native fish habitat will likely be improved by project related activities.

5.10 Cultural Resources

What impact, if any, will the proposed activities have on the layers of prehistoric and historic artifacts deposited through the preserve? What is the relationship between protecting and preserving the natural resources and the protection and preservation of the cultural resources?

This section will present the potential impacts of the proposed action(s) as well as the indirect impacts that the current downward trend in ecological condition and fire behavior potential could have on the cultural resources.

5.10.1 Goals and Objectives

From chapter 2, our objective is to have no significant damage to cultural resources result from the proposed action and to complete surveys on 30 percent of the VCNP. Goals and objectives related to wildland fire environment and watershed also relate to cultural resources, which benefit indirectly from soils stability and hazardous fuels reduction.

5.10.2 Methods

The potential environmental consequences as well as the effectiveness of planned mitigation measures on cultural resources are well understood. The proposed actions and presence of cultural resources are common on public lands and measures to minimize effects are known to reduce potential effects to insignificant levels when implemented at the project level (Federal Register 2003). Compliance with federal laws requires discovery, recording and considering any site that is eligible or potentially eligible for inclusion into the National Register of Historic Places as well as any sites that are a Traditional Cultural Property (TCP). A TCP may or may not be associated with material features – objects, buildings, structures, architecture, art; a TCP may be related simply to a place and its religious importance (Banks, Giesen and Pearson 2000).

As such the record of sites, activities and impacts is quite extensive. Wherever possible we use site-specific information from the Landscape level. Impacts to cultural resources parallel the impacts to soil especially with regard to soil heating and erosion. This section frequently refers to the effects discussed in section 5.5 *Watershed* and we try to minimize any repetition.

5.10.3 Environmental Consequences – No Action

If no action were taken there would be no direct effect to cultural resources. Indirectly the downward trend in ecological condition and continued and increasing potential for severe wildfire would present a continuing and increasing potential for loss and destruction resulting from severe burning and post fire erosion.

Table 5-50. Environmental consequences summary table: cultural resources - no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Likely
	↓Cumulative	Landscape level	Minor - moderate	Likely
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Road Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor - moderate	Potential
	↓Cumulative	Landscape level	Minor - moderate	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Localized	Negligible	Potential
	↓Cumulative	Localized	Negligible	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Project level	Minor	Potential
	↓Cumulative	Project level	Negligible	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Project level	Negligible	Potential
	↓Cumulative	Landscape level	Negligible	Potential

Direct and Indirect Effects

The most potentially significant impact would be the continued build-up of forest fuels and the sustained potential for uncharacteristically severe fire behavior and resulting direct effects to artifacts and other cultural resources. Indirectly, the continued and growing likelihood and susceptibility to uncharacteristic wildland fire would result in post fire flooding and erosion, which could have significant adverse impacts to cultural resources and the information contained therein. Also if no action were taken, localized erosion from old logging roads and head cuts may continue to have minor to moderate, localized effects on cultural resources. Finally, if the no action alternative were selected we would survey fewer acres and indirectly we would accumulate less knowledge about the resource, especially spatially explicate knowledge. This would reduce our ability to protect important features in the event of a wildfire.

As discussed under the wildland fire section, the wildfire behavior potential under the no action alternative remains high. The cultural resources most vulnerable to fire are combustible materials that lie atop or occur above ground surface. These include the diverse wooden remains left behind by 19th and 20th century land-use activities such homesteading, hunting and trapping, livestock grazing, and logging. Ironically, these are activities associated with 20th fire suppression that has increased the overall potential for uncharacteristic fire severity in the Jemez Mountains landscape. In contrast, prehistoric elements of the archaeological record have long been exposed to the direct effects of recurring fires, and most of the exposed combustible materials from these sites were lost long ago.

The historic archaeological record of the 19th and 20th centuries on the preserve exhibits many burnable elements, including wooden corrals, cabins, hunting blinds, shrines, and markers. There are at least 55 known sites in the preserve with vulnerable combustible materials. In addition, marked trees such as aspen arborglyphs and cross-marked conifers can be damaged by burning and are common within the preserve. Over 1,000 carved aspens have been recorded in the preserve to date, but likely this

is less than 20 percent of the total. The potential for fire damage to these carvings was demonstrated during the Las Conchas Fire when numerous carvings were consumed in the fire or lost when the death of the tree resulted in detachment of bark.

The discussion below addresses effects of fire to prehistoric cultural deposits and artifacts. A recent review by Ryan et al. 2012 provides a thorough discussion of diverse materials and conditions; the discussion here highlights the materials and conditions most relevant for the preserve.

The effects of fire on soil are discussed under the watershed section of this report, and the effects of fire to subsurface artifacts and cultural deposits mirrors those of soils. The greatest potential impact to non-combustible archaeological resources, especially those that lie atop the ground surface (such as artifacts), occurs from a severe fire that ignites and consumes duff and organic soils layers. Ground fuels are good insulators and protect deeper organic strata and the mineral soil from heating during the passage of surface and crown fires (Figure 5-29). However, when ground fuels are dry enough to burn, they are ignited by the passage of the flaming front. Surface fire penetrates the litter and fermentation layer where pinecones, branches, or rotten wood create a localized hot spot. Once ignition is established in the humus or peat soil, the fire propagates laterally evaporating moisture and raising dry organic soil up to combustion temperatures (endothermic phase) where smoldering combustion occurs (exothermic phase) (Ryan and Koerner 2012). It is this type of severe burning and downward flux of heat that has the greatest potential to impact cultural resources. This type of severe burning and downward flux of heat has a high potential to impact cultural resources; burning in the upper canopy during crown fires is of a lesser concern for surface and subsurface cultural resources.

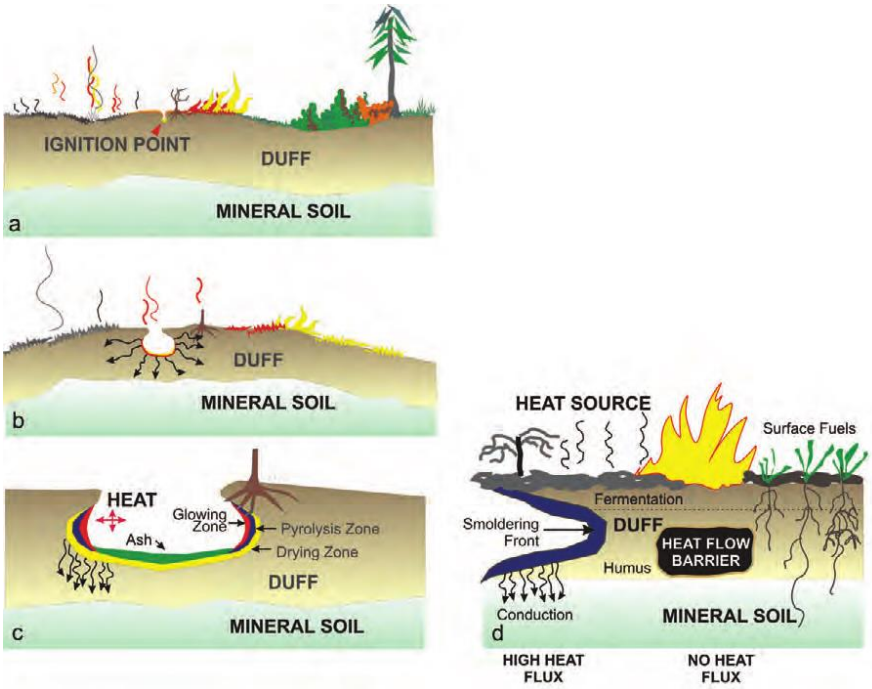


Figure 5-29. Schematic of duff burnout (Ryan and Koerner, 2012)

Damage to subsurface resources will be greatly increased where ground fuel-loads are uncharacteristically high due to fire build-up of forest fuels. Of great concern to archaeologists are the effects of stump burnouts. The subsurface combustion of roots of living and dead trees can penetrate into otherwise intact cultural soil deposits and into and under cultural features such as masonry fieldhouses. Significant effects of root burnouts are summarized by Oster et al. 2012 and can include thermal alteration of otherwise buried artifacts, alteration of datable materials such as archaeomagnetic samples, and the introduction of contemporary carbon into cultural deposits (potentially altering radiocarbon dating outcomes). Root burnouts are more likely and more common with uncharacteristically severe fire behavior and where tree densities are high. The no-action alternative does not improve these conditions.

Effects to artifacts in the preserve will be most notable for prehistoric pottery and stone artifacts. Surface artifacts tend to be altered more than those located in subsurface contexts, with protection often afforded by even a few centimeters of soil. Fewer negative effects are noted in light fuels, with increasing effects in moderately and heavily fueled fires, or at specific locations within fires where fuels are heavy, such as near or under logs. Most researchers suggest that effects in heavier fuels are a result of the increased amount of time artifacts are exposed to heat (Deal 2012).

The fire effects to ceramics that most concern archaeologists are those effects that decrease the usefulness of sherds to identify the cultural identity and temporal placement of prehistoric peoples who produced these wares. These effects include alteration of the decoration and appearance of ceramics (through sooting, spalling, and oxidation), and damage to the fabric of the sherds (through breakage and spalling). A study of fire effects to prehistoric pottery was done following the 1991 Henry fire, which burned on Holiday Mesa within the SWJML. This study found that fire at all severities affected pottery but not all effects resulted in significant damage. The study also found a direct relationship between fire severity and fire effects to the ceramics, noting that even localized severe burning (i.e. large logs) could impact artifacts at that particular site (Rude and Jones 2012). Damage to ceramics is a less likely outcome at archaeological sites in the preserve as these artifacts are much less common than in most other areas of the southwestern U.S. However, the information potential of these sherds is actually of higher value; because they occur in lesser abundance, the usefulness of each sherd is higher than where sherds are more common.

Lithic (stone) artifacts may also be impacted by fire. Despite its durability, stone can be affected by fire, as well as by efforts to suppress wildfires and to rehabilitate burned areas following fires. Stone artifacts include building stones, ground stone artifacts, hammer stones, and flaked stone artifacts. Reported fire effects include breakage, spalling, crenulating, crazing, potlidding, microfracturing, pitting, bubbling, bloating, smudging, discoloration, adhesions, altered hydration, altered protein residue, and weight and density loss. The potential effects of fire to obsidian artifacts are of particular concern because prehistoric obsidian artifact scatters and quarries are the dominant archaeological resource type within the preserve. Obsidian from distinct volcanic flows has unique chemical compositions, allowing researchers to determine the geological source of obsidian tools and debris left on sites in prehistoric contexts. As noted in the affected environment, obsidian artifacts found as far as Mississippi have been sourced back to the Jemez Mountains. Several studies including local studies have used X-ray fluorescence to obtain source information from surface samples subjected to intense fires. This research has demonstrated that the sourcing property of obsidian is not significantly affected even by very high heat (e.g., Shackley and Dillian 2002; Steffen 2002, 2005).

Steffen Obsidian is thermally affected at varying temperatures and at differing lengths of exposure to heat. In field and lab fire experiments, obsidian has been reported to fracture, crack, craze, potlid, exfoliate, shatter, oxidize, pit, bubble, bloat, vesiculated, melt, become smudged, discolored, covered with residue, or rendered essentially unrecognizable. Steffen used these definitions to standardize these effects:

- *Matte finish*: A dulling of the surface resembling weathering or a lusterless patina;
- *Surface sheen*: A metallic-like luster, with a reported "gun-metal" sheen attributed to organic buildup on the surface of obsidian, and a "silvery, reflective" sheen attributed to shallow microscopic crazing and the formation of small bubbles;
- *Fine crazing*: A delicate network of very shallow surface cracks (similar to, but contrasted with, the internal crazing observable on fire altered chert) that form a network of closed polygons, probably caused by differential thermal expansion and/or cooling;
- *Deep surface cracking*: Shallow crevices splitting the surface, probably due to the continued expansion and stretching of finely-crazed surfaces;
- *Fire fracture*: Fracture initiating from within the object, resembling deliberate reduction, but lacking bulbs of percussion, and often resulting in the complete fracture of the artifact;
- *Incipient bubbles*: Individual bubbles developing below the surface; and
- *Vesiculation*: Abundant, interconnected bubbles on the surface and interior resulting in the "puffing up" of thermally altered obsidian; in its extreme form, vesiculation can transform artifacts into a frothy, Styrofoam-like mass.

Deal's (2012) review of published laboratory experiments found that vesiculation or melting has been found to occur at temperatures as low as 700 - 760 °C, in the 815 - 875 °C range or not at all even above 900 °C, or at 1000 °C. Steffen (2005) showed that the tendency to vesiculate may vary among differing geological sources of obsidian, possibly due to intrinsic water content. Within the preserve, obsidian from the geological deposits at Cerro del Medio are less prone to vesiculation while those from the geological deposits at Rabbit Mountain are high vulnerable. Observation of fire effects at obsidian quarries after the Las Conchas Fire supported this distinction and demonstrated also that glasses at Cerro del Medio are highly prone to fire-fracture.

Figure 5-30. Right: extreme vesiculation in obsidian oven heated to 1472 °F (800 °C); sample also lost both weight and density. Left: Unheated obsidian from the same source (Deal 2012)

In addition to these potential macroscopic effects, obsidian also has a unique potential for dating, called obsidian hydration dating (OHD). The potential for fires to damage the OHD information value of obsidian artifacts has been well documented (e.g., Loyd et al. 2002, Steffen 2002, 2005, Trembour 1979) although the contexts that result in greater fire damage are not well understood. Temperature and duration of heat exposure are both relevant for OHD loss. Experimentation at the preserve during the Valle Toledo grassland prescribed burn demonstrated a surprising loss of 10 percent of hydration bands even in the light fuels and despite very rapid exposure (Civitello 2006). Nonetheless, it is clear that greater OHD information is lost (both due to higher likelihood of damage, and more artifacts affected) in fire conditions that include high temperature ground fires and long duration exposures (especially in root burnouts).

Cumulative Effects

The risk of adverse effects from uncharacteristic fire was demonstrated in the Las Conchas Fire of 2011. The Las Conchas Fire has created an irreparable gap in the nation's archaeological record. Over 150 documented sites (and probably more than 300 sites total) were within the burn perimeter on the preserve. We are only beginning to uncover and piece together the importance and the spatially and temporal extent of effects to quarry sites on at Cerro del Medio. The damage is especially regrettable when combined with the impacts to other related quarry sites from other severe fires (Cerro Grande 2000, Dome 1996, and La Mesa, 1977). While historic logging and road building in the area certainly impacted the archaeological resources in the fire area, uncharacteristic heat from the fire and the post fire erosion caused great obsidian damage through fire-fracture and unquestionably damaged dating information physically contained in the obsidian artifacts. More profound are the indirect and cumulative effects of erosion, most notable where past road building and timber harvesting (especially skid trails) combined with post-fire erosion to create gullies and fans. Surface erosion has also damaged

archaeological sites by stripping the cultural deposits and transporting artifacts. If burned area rehabilitation is not pursued, these effects will continue and compound through time and expand spatially.

The impacts to this quarry site have also affected what we can learn from the lithic resources that are ubiquitous across the landscape. The degree of this cumulative impact has not yet been quantified although monitoring projects are now under way at obsidian quarry sites on Cerro del Medio.

5.10.4 Environmental Consequences – Action Alternatives

There is a potential for minor, localized adverse effects to result from the action alternatives. Indirectly it is likely that implementation of the action alternative would benefit cultural resources in the landscape level.

Table 5-51. Environmental consequences summary table: action alternatives, cultural resources

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Wildland Fire Management	↓Direct	Project level	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Road Management	Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor	Likely
	↑Cumulative	Project Level	Minor	Likely
Riparian Restoration	↓Direct	Project Level	Negligible	Potential
	↑Indirect	Landscape level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Noxious Weed Management	↓Direct	Localized	Negligible	Likely
	↑Indirect	Project level	Negligible	Potential
	↑Cumulative	Project level	Negligible	Potential
Burn Area Rehabilitation	↓Direct	Project level	Negligible	Potential
	↑Indirect	Project level	Minor - moderate	Potential
	↑Cumulative	Project level	Minor - moderate	Potential

Direct Effects

Planned management actions are not anticipated to directly impact cultural resources. Performance requirements included in chapter 2, primarily discovering, recording and avoiding archaeological sites and TCPs are known to be effective at protecting cultural resources from being impacted from operations. Further, the proposed actions are far less intensive than the logging and road building that occurred prior to federal acquisition. However, it is possible that cultural sites could be missed by a pedestrian survey and thus be unprotected during operations. This has not been found during thinning activities the trust has implemented thus far.

Reducing fuels and concomitantly reducing the temperatures and duration of heat exposure during prescribed as well as unplanned ignitions will have a beneficial effect by reducing direct effects to cultural resources. It is possible that in spite of applied mitigations, localized areas of high severity or

intensity burning may occur during prescribed burning and could potentially impact cultural resources. Even where fuels loadings and overall fire intensity and severity are light, localized burning of heavier fuels could impact cultural resources (Rude and Jones 2012). Such impacts would be localized and limited to the specific feature affected and would not be expected to impact the state of knowledge or cultural resources at a landscape scale. Especially vulnerable are features with wood such as corrals and, aspen carvings, or wooden components that remain in fieldhouse ruins. Thorough and systematic documentation of historic resources, combined with focused evaluation of actual significance and development of relevant historic contexts, will be used to capture information to minimize potential information loss.

Indirect Effects

Indirectly the effects are expected to be moderate and beneficial at the regional scale due to the reduction in the potential intensity and severity of any future wildfires and the associated protection from impacts from high severity fires. Our ability to manage and protect cultural resources would also be improved as knowledge is gained through landscape scale survey and documentation of cultural resources. Minor localized, indirect, benefits would be realized from erosion control and road management activities by addressing localized sources of erosion.

Cumulative Effects

Cumulatively, all action alternatives would combine to protect the cultural resources of the preserve. The context and intensity of this impact parallels the effect described for soils under section 5.5 Watershed. Cumulatively, the inventory, survey and subsequent protection of cultural resources would improve our knowledge at the landscape and regional levels. Burned area rehabilitation activities would decrease long-term erosion damage to subsurface cultural deposits in the burn area and help retain this information for understanding the overall context of past human land-use in the caldera.

5.11 Recreation and Sensory Resources

5.11.1 Goals and Objectives

Goals and Objectives related to forest health and ecological condition also relate to the recreation values of the preserve.

5.11.2 Methods

Impacts to recreation and sensory resources are based on literature review and knowledge gained from implementing project level restoration activities and during and following the Las Conchas fire. While chapter 3 separates these resources we have combined the discussion of environmental consequences in order to avoid redundancy.

5.11.3 Environmental Consequences – No Action

Taking no action would not direct affect recreational values on the preserve. Indirectly there could be moderate mid-term effects to recreation from increasing potential for severe burning.

Table 5-52. Environmental consequences summary table: recreation - no action

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level	Moderate	Likely
	↓Cumulative	Landscape level	Moderate	Likely
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Moderate	Potential
	↓Cumulative	Landscape level	Moderate	Potential
No Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
No Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential

Forest Thinning and Wildland Fire Management

Direct and Indirect Effects

Not implementing forest management activities would not result in a direct impact to recreation values or activities. The current condition would continue to result in restricted uses of forested areas during extreme fire danger periods. Campfires would continue to per allowed only by permit and the issuing of permits would continue to be limited due to the current level of hazard.

Indirectly it is likely that a severe wildfire could result in moderate adverse impacts to recreation and these impacts could extend from short- to mid- term. Wildfire can affect recreational use by closing trails or other recreation areas for extended periods due to potential hazards from falling trees, erosion, flooding etc.; by destroying infrastructure, leading to full closure or reducing the capacity of recreational areas, by impacting fisheries and aquatic habitats, by affecting views, and closing roads and access to recreational areas.

Interestingly, wildfire does not seem to reduce the demand for recreational access. People are interested in seeing an area after a wildfire. A study prepared following the Cerro Grande fire found an increase in demand correlated with an increase in fire severity. The researchers had hypothesized that the amount

of fire damage would determine the amount of use, with more damage leading to less use of the area. The group distributed surveys at ten sites, eight of which had not burned in the last fifty years. One site had a fifty-year-old wildfire that burned 22,000 acres at mixed severity; the other was from a 20,000-acre fire in 2000 that had low severity. Those surveyed were asked to estimate their trips according to three pictures of fire damage. The first was for a recent high-severity fire, the second a recent low-severity fire and the third an old high-severity fire area in recovery. The survey returned 30 percent of the 1,302 handed out. This study used *Contingent Valuation Methodology and Travel Cost Methodology* to calculate their data. They also used regression analysis to evaluate the data. The study actually found that the interest of the people in visiting an area increased with fire intensity. The average numbers of visits for these people were 3.9 in 2001; with a high-intensity burn they found there would likely be 3.3 trips, 3.0 trips if a low-intensity fire, and 2.1 trips to the site of an old high-intensity fire. The researchers attributed this to the fact that curiosity of the devastation in a recent high-intensity burn are would draw more visitors.

Aside from initial curiosity, large areas impacted by severe fire in general have a lower scenic value Figure 5-31.

Figure 5-31. Severe burning leaves a denuded, unattractive and hazardous forest condition

Periods of full and partial closure of the preserve following the Las Conchas, made it difficult to relate visitation and no surveys were conducted, but recreation staffed indicated a spike in the number of visitors and reported that many visitors indicated that they were visiting the area in order to see the effects of the fire. Hunting generally improves following a fire as game is drawn to the new vegetative growth and hunters like the improved visibility. Fishing was negatively impacted due the loss of fish and impacts to water quality. Popular hiking trails were closed due to hazards (falling trees and holes). These trails may have to be closed periodically as trees continue to die and fall.

Road Management

Road management actions under this analysis focus on addressing localized repairs that are contributing to resource damage and degradation. Taking no action would not affect current recreational access. Routine maintenance and repair of roads used for recreation and trails can be addressed outside of this action.

Riparian Restoration

Recreation around the riparian areas focuses on catching non-native trout and enjoying the solitude and beauty of the preserve. These values would persist with or without riparian restoration. Some localized erosion could negatively impacts recreational enjoyment, but any such impact would be minor and localized.

Noxious Weed Control

There would be no direct impact to public access and enjoyment if proposed actions aimed at controlling and eradicating noxious weeds were not implemented. Indirectly, if new weeds were to go unchecked recreational values could be impacted and access could be restricted or controlled. Cumulatively, projected increases in recreation, coupled with unchecked weed populations could impact biodiversity and recreational values in the Valles Caldera and surrounding areas, especially in the event of a severe fire.

Burn Area Rehabilitation

Under the no action alternative, burned area rehabilitation would be limited to activities to mitigate safety hazards and some limited contour felling identified in the Burned Area Emergency Report but not yet completed. Rehabilitation aimed at reducing visual impacts and improving recreation quality would not be undertaken.

5.11.4 Environmental Consequences – Action Alternatives

Both action alternatives have to potential to create short-term, minor adverse impacts on the recreational opportunities, values and sensory resources including scenery, sounds and smell of the environment. Both alternatives would benefit these resources by improving the condition of the resources that attract visitors and by reducing potential impacts of wildfire.

Table 5-53. Environmental consequences summary table: action alternative, recreation and sensory resources

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↓Direct	Localized	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely
	↑Cumulative	Landscape level	Minor - moderate	Likely
Wildland Fire Management	↓Direct	Project level	Minor	Potential
	↑Indirect	Landscape level	Minor - moderate	Likely

Activity	Effects	Context	Intensity	Certainty
	↑Cumulative	Landscape level	Minor - moderate	Likely
Road Management	↓Direct	Localized	Minor	Potential
	↑Indirect	Project level	Minor	Likely
	↑Cumulative	Project Level	Minor	Likely
Riparian Restoration	↓Direct	Project Level	Negligible	Potential
	↑Indirect	Landscape level	Minor	Potential
	↑Cumulative	Landscape level	Minor	Potential
Noxious Weed Management	↓Direct	Localized	Negligible	Likely
	↑Indirect	Project level	Negligible	Potential
	↑Cumulative	Project level	Negligible	Potential
No Burn Area Rehabilitation	↓Direct	Project level	Negligible	Potential
	↑Indirect	Project level	Minor	Potential
	↑Cumulative	Project level	Minor	Potential

Direct effects of forest thinning include short term displacement of recreationist during implementation, temporary decrease in the quality of recreation settings due to the presence of slash, skid trails, log landings, construction and use of skid trails and temporary roads, and creation of dust and noise from thinning operations and biomass removal. Direct effects including the temporary loss of herbaceous cover, disorderly management activities and noise and dust, as well as lack of information, have been found to decrease the quality of recreation settings and user satisfaction(R. L. Ryan 2005).

Landing areas where equipment is staged, logs and firewood are carried to and decked are the most impacted. Figure 5-32 (right) below shows a landing area during active operations but preceding any rehabilitation. Ground disturbance and freshly masticated slash is apparent. Insect monitoring paraphernalia is visible in foreground. Biomass may also be processed for other uses or chipped or shredded at log landings. Processing would not affect recreation settings. Chipping or shredding and scattering the processed material has a short term effect on recreation settings. There would be some noise and dust resulting from chipping, shredding and spreading the slash in developed and dispersed recreation areas as shown in Figure 5-32 (left).

Figure 5-32. Right: Landing site during active operations, preceding rehabilitation. Left: Small logs being chipped into semi-truck at landing site.

The quantity of dust from operations, especially hauling chips or logs varies depending on the material of the road, moisture, and dispersion. The effects would be reduced by the application of mitigating measures from chapter 2 and localized within the preserve as routes exit onto paved roads. The exception is the exit from Sulphur Canyon, which leads through the Elk Valley subdivision. Access and egress through this gate would be an exception and would be coordinated with residents. Many users would find it unpleasant and disruptive if they are driving or recreating in the vicinity of haul routes. Temporary closures and providing visitor information about the locations of logging operations will assist visitors in making decisions about where they want to recreate. Scattered communities, homes and neighborhoods on private land outside of city centers may be adjacent to forest roads that will be used for transporting logs or processed slash. Noise and dust from the operations may be irritating and disruptive. Dust mitigation along main haul routes would help reduce dust and result in safer driving conditions especially during dry months.

Direct effects of pile burning, prescribed burning and fire line preparation have the potential for short term displacement of recreationists during implementation (trail closures are a good example), or visitor dissatisfaction (the visual impacts of active operations such as decked material, parked equipment, slash, or smoke from prescribed burning); however, these effects are expected to be of short duration and intensity.

Fire line preparation may include construction of cleared fire line (to bare soil surface), raked areas, and vegetation trampling from use of administrative motorized vehicles along portions of fire lines or creating of safe areas. Mitigation measures will close off fire line access points from roads and trails, and slash, rocks and pine needles will be used to disguise the first visible portion after implementation is complete.

The immediate effects of pile burning include small (less than one-tenth of an acre) bare, blackened areas that may persist in this condition until vegetation begins to move in or sprout usually within 1-3 years following burning. The immediate effects following prescribed burning include blackened ground, dead seedlings, scorched bark and needles, and some burned trees. The majority of these effects will persist for about a year until red needles fall, vegetation recovers and black fades. Burned trees will be evident for a longer period of time and create contrast with nearby green vegetation. Although some visitors may prefer to not see any signs of fire in the forest, or recreate in recently burned areas, the effects of low and some moderate severity fires are beginning to be accepted by the public as an integral part of a healthy forest landscape (Toman et al. 2011).

5.12 Socioeconomic

5.12.1 Goals and Objectives

Benefits to local communities and business are included as goals for management of the VCNP (U.S.C. 2000), and is a goal within the SWJML Restoration Strategy (Valles Caldera Trust, Santa Fe National Forest, 2010), and is included in the need for action from chapter 1. From chapter2 we have identified days of work as a measure along with labor and total income reported under the CFLR annual report.

5.12.2 Methods

Socioeconomic impacts are based on both qualitative and quantitative information. Quantitative information is at the county (Sandoval) level. Although other counties (Rio Arriba, Santa Fe, Los Alamos) have the potential to participate in economic opportunities and be affected by economic impacts, such impacts are simply not measurable when diluted in multiple counties. As noted in Chapter 4 – *Affected Environment*. The socioeconomic impacts are not measurable in the context of Sandoval County but may be meaningful to individuals or to small, family businesses.

Study Area

Two different study areas are defined in this section. The "local area" is defined as Sandoval County and serves as the base area for statistical analysis in the existing conditions. This is the area in close proximity to the SFNF and preserve. The development of new markets and identification of key partners would occur within this area. However, the "production area" consists of Sandoval, Rio Arriba, Santa Fe, Los Alamos and Bernalillo Counties. Identification of existing infrastructure and demand for small diameter woody products occurs within this area because they would be within a reasonable transportation distance and affect the total demand for products removed from the SFNF and preserve.

5.12.3 Environmental Consequences – No Action

By taking no action at this time we would not initiate any direct impacts to the socioeconomic environment. However, continuing the current trend in natural resource condition and fire behavior potential indirectly presents a potential for adverse impacts to this environment. The potential for wildfire is the key issue and focus of the no action impact analysis but we also look at the expected or potential impacts to socio economic environment including potential costs and losses of taking no action.

Table 5-54. Environmental consequences summary table: no action, socioeconomic

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	Direct	None	None	Certain
	↓Indirect	Landscape level to region	Minor	Potential
	↓Cumulative	Landscape level to region		Potential
Wildland Fire Management	Direct	None	None	Certain
	↓Indirect	Landscape level to region	Minor	Potential
	↓Cumulative	Landscape level to region	Minor	Potential
Road Management	Direct	None	None	None
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential
Riparian Restoration	Direct	None	None	Certain
	Indirect	Landscape level	Negligible	Potential
	↓Cumulative	Landscape level	Minor	Potential
Noxious Weed Management	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential

Activity	Effects	Context	Intensity	Certainty
Burn Area Rehabilitation	Direct	None	None	Certain
	↓Indirect	Landscape level	Minor	Potential
	↓Cumulative	Landscape level	Minor	Potential

Direct Effects – All Restoration Activities

There would be no direct effect to the socioeconomic condition at any local or regional scale if no restoration action were to occur.

Indirect Effects – Forest Thinning and Wildland Fire Management

Indirectly there is a potential for adverse impacts resulting from the ongoing threat of wildfire as described previously under *Wildland Fire Environment.* While the effects of large fires on small rural communities is not quantified with precision or certainty, we know that wildfires can have complex impacts on rural communities that are reliant on or surrounded by public lands. Wildfires can threaten homes, public health, and livelihoods. They burn timber, make recreation and tourism unappealing, and affect agricultural production. Yet suppression of large wildfires involves significant government spending and mobilization of considerable human resources and while wildfires themselves may displace normal economic activity, the process of suppression can create other types of economic activities. Further, these economic impacts are also intertwined with community social impacts in important ways (Davis, et al. 2011).

During the Las Conchas fire NM 4, the VCNP and NFS and NPS lands were closed or restricted to visitors in varying degrees due to the hazards presented by the fire and fire suppression operations. During active fire suppression the loss of tourism income was offset by the economic activity of the fire suppression organization. As the highway and forest reopened, there may have been a surge of increased visitation as people came to see the impacts of the fire first-hand.

Post fire hazards such as falling trees, unstable ground and flooding required many areas of the Las Conchas fire to remain closed and the quality of fishing on the preserve continues to be impacted well beyond the period of active suppression. Localized closures for public safety could remain in place for several years. While these impacts are localized, the media attention to the fire and post fire flooding may have created a perception of broader closures and devastated conditions that may further discourage visitation.

While socioeconomic impacts from the Las Conchas fire have not yet been quantified, studies in other areas suggest that large wildfires can affect a number of economic sectors in rural communities, producing both positive and negative impacts (Davis, et al. 2011, Carroll and Cohn 2007). These impacts although costly are expected to be short term, localized in the Jemez Valley and are not expected to change the structure of business or community and are therefore considered minor although they do not seem minor to those individuals affected, especially to those whose homes were destroyed.

Following fire suppression activities, BAER (Burned Area Emergency Rehabilitation) activities continue to bring economic activity similar to fire suppression operations, albeit at a smaller scale. Post fire impacts

to homes and businesses caused by fire and erosion can be as (if not more) destructive than the fire itself. An assessment of 27 large[41] fires in 2007 reported a total of $547 million dollars in suppression costs excluding indirect costs which amount to 34 percent of total costs nationwide (Blazer, et al. 2008).

The Western Forestry Leadership Council (WFLC) completed a case study (2010) and found that the true costs of wildfire extend beyond the area burned and the period of operational activity. Siting the potential impacts to communities including spikes in respiratory problems due to smoke and the other indirect effects already mentioned. This report looked at suppression costs, other direct costs, burned area rehabilitation costs, indirect costs and additional costs (costs of civilian life, physical and mental health impacts and effects to aesthetic and scenic beauty and overall "sense of place"). Of the six fires studied the total cost ranged from 1.9 to 29 times the cost of suppression (Table 5-55).

[41] The report identified "large" fires as those with suppression costs exceeding $10 million. NIFCC (National Interagency Fire Coordination Center) reports "significant fires" as fires that "are a minimum of 100 acres in timber fuel types or 300 acres in grass and brush fuel types, or are managed by a type 1 or 2 IMT (Incident Management Team).

Table 5-55. Summary of total wildfire cost information (Western Forestry Leadership Council 2010)

Costs ($) and Cost Category							Suppression costs relative to total costs	
Incident	**Suppression**	**Other Direct**	**Rehabilitation**	**Indirect**	**Additional**	**Total**	**Total/ Suppression**	**Suppression/Total**
Canyon Ferry Complex (MT 2000)	9,544,627	400,000	8,075,921	55,310	n/a	18,075,858	1.9	**53%**
Cerro Grande (NM 2000)	33,500,000	864,500	72,388	n/a	n/a	970,388,944	29.0	**3%**
Hayman (CO 2002)	42,279,000	93,269,834	39,930,000	2,691,601	29,529,614	207,700,049	4.9	**20%**
Missionary Ridge (CO 2002)	37,714,992	52,561,331	8,623,203	50,499,849	3,404,410	152,803,785	4.1	**25%**
Rodeo / Chediski (AZ 2002)	$46,500,000	$122,500,000	$139,000,000	$403,000	n/a	308,403,000	6.6	**15%**
Old Grand Prix (CA 2003)	$61,335,684	n/a	$534,593,425	$681,004,114	n/a	$1,276,933,224	20.8	**5%**

A study completed by Impact DataSource (2013) drew upon this work and created an estimate of total fire costs from recent large fires in New Mexico. The used the actual suppression costs and estimated costs using the lowest ratio and highest ratios from the previous study (Table 5-56). While suppression costs are reported consistently and are readily available, they represent only a small fraction of the costs of wildfires (Impact DataSource 2013, Western Forestry Leadership Council 2010).

Table 5-56. Total cost estimate based on reported suppression costs and range of indirect cost estimates (Impact DataSource 2013)

New Mexico Wildfire Full Costs Estimates: 2009-2012					
			Total Costs ($) Cost Estimate Factors		
Fire	**Year**	**Suppression costs ($)**	**Low (1.9)**	**Mid (12.7)**	**High (29)**
White Water-Baldy	2012	23,000,000	43,700,000	292,100,000	667,000,000
Little Bear	2012	19,400,000	36,860,000	246,380,000	562,600,000
Las Conchas	2011	48,385,000	91,931,500	614,489,500	1,403,165,000
Miller	2011	18,100,000	34,390,000	229,870,000	524,900,000
Donaldson	2011	5,700,000	10,830,000	72,390,000	165,300,000
Last Chance	2011	2,062,400	3,918.560	26,192,480	59,809,600
Enterprise	2011	37,000	70,300	469,900	1,073,000
Cata	2009	460,000	874,000	5,842,000	13,340,000
Pasco	2009	450,000	855,000	5,715,000	13,050,000
Total		**117,594,400**	**223,429,360**	**1,493,448,880**	**3,410,237,600**

The community of La Cueva and the subdivision of Sulphur Springs, along the western boundary of the preserve were not impacted by post fire flooding due to the buffer of unburned area between the fire and these communities. However, if the western half of the preserve burned with high severity impacts to these communities from post fire flooding could be severe from the post fire flooding and erosion as described under the watershed section. While these communities downslope and downwind may be spared loss from the fire they would be in the path of loss from post fire flooding and erosion.

Indirect Effects – Wetland Riparian Restoration/ Road Management

If proposed riparian restoration and closure, and road decommissioning repair and maintenance activities were not implemented there may be indirect effects as current impairments continue. However, no potential immanent event would be expected and overall the indirect effects would be negligible in the socioeconomic environment.

Indirect Effects – Noxious Weed Control

Management of existing populations of thistle would continue, thus reducing or eliminating indirect effects from the no action resulting from the existing thistles. Without treatment, the rangeland values of the preserve could indirectly be degraded by the possible the expansion of cheatgrass as well as any new invaders. The grazing program on the preserve provides a minor socioeconomic benefit that could be impacted by a lack of weed control.

Indirect Effects – Burned Area Rehabilitation

If no further burned are rehabilitation were to occur then current restrictions in access would persist. Indirectly restricted access could cause a loss of revenue to the preserve however, this impact would be negligible in the socioeconomic environment.

Cumulative Effects

A lack of forest management post fire could when combined with the public's perception of past management of public lands could and the skepticism about the "experimental" management of the preserve could lead to a decline in public support for the management of the preserve and public land in the Jemez. When a lack of management actions leads to increased fire danger, it is known to cumulatively impact people's community and social relations and relations with public lands and their management. A study following an exceptionally destructive wildfire season in the Shasta Trinity National Forest (Davis, et al. 2011) found that those interviewed, consistently blamed land managers for the condition of the forest that perpetuated the conflagrations. In their 2011 study, authors Martin, Martin, and Raish found that the public overwhelmingly blamed the US Forest Service for the present condition of the forests in New Mexico (Martin, Martin and Raish 2011). Cumulatively this could impact our relationship with the public and their trust in us in managing any aspect of the preserve. People's prior experience is a critical factor in the citizen-agency relationship and whether that relationship includes trust, overrides most other factors (Shindler and Brunson 2005).

Historic land use, present land use and potential future land use are very different however; they all rely on healthy and resilient ecosystems to support local communities and their relationship to the surrounding forest. The SWJML proposal notes that many individual restoration projects have been planned and implemented in the southwestern Jemez Mountains but they have been too small and too widespread to cumulatively benefit local communities. If the trust does not take action it will limit the potential socioeconomic benefits of future restoration on the surrounding NFS lands.

These impacts are locally important, however cumulatively we believe they would amount to minor impacts to the socioeconomic environment.

5.12.4 Environmental Consequences - Action Alternatives

The SWJML has been awarded $35 million dollars to implement a 10-year restoration plan. This funding is limited to expenditures for implementation and monitoring and is to be matched equally with other funds. The restoration activities, especially forest thinning and associated utilization, are likely to create meaningful economic stimulus and benefit local communities and businesses. However, this stimulus may not be significant when measured in the production area (multiple counties) over the 10-year planning period.

Cumulatively when combined with other potential restoration over the surrounding federal, state, private and tribal lands, forest restoration activities could bring about a moderate degree of stimulus to localized communities. The predicted impacts are summarized in Table 5-57 below; the summary is followed by a narrative description.

Table 5-57. Summary of environmental consequences – action alternatives, socioeconomic environment

Activity	Effects	Context	Intensity	Certainty
Forest Thinning	↑Direct	Landscape level to region	Minor – moderate	Likely
	↑Indirect	Landscape level to region	Minor – moderate	Likely
	↑Cumulative	Landscape level to region	Minor – moderate	Potential
Wildland Fire Management	↑Direct	Landscape level to region	Minor	Likely
	↑Indirect	Landscape level to region	Minor – moderate	Likely
	↑Cumulative	Landscape level to region	Minor - moderate	Likely
Road Management	↑Direct	Landscape level to region	Minor	Likely
	↑Indirect	Landscape level to region	Minor	Likely
	↑Cumulative	Landscape level to region	Minor	Likely
Riparian Restoration	↑Direct	Landscape level to region	Minor	Likely
	↑Indirect	Landscape level to region	Minor	Likely
	↑Cumulative	Landscape level to region	Minor	Likely
Noxious Weed Management	↑Direct	Landscape level to region	Minor	Likely
	↑Indirect	Landscape level to region	Minor	Likely
	↑Cumulative	Landscape level to region	Minor	Likely
Burn Area Rehabilitation	↑Direct	Landscape level to region	Minor	Likely
	↑Indirect	Landscape level to region	Minor	Likely
	↑Cumulative	Landscape level to region	Minor	Likely

Direct Effects

We expect forest thinning and the potential commercial utilization to have the greatest potential impact within the analysis area. As previously stated we extended the impact analysis to the SWJM landscape and regional area of impact. We look at the potential benefits to local communities, estimated employment and income as well as non-market benefits and contributions to social sustainability. The impacts described are expected to occur as direct socioeconomic impacts during the 10-year planning period.

Benefits to Local Economies

Benefits to local economies from well-constructed ecosystems restoration and woods products programs vary greatly. Benefits may be realized in both market and non-market forms. Market benefits include the jobs and income that are supported by activities that would occur under the restoration strategy. These benefits are measured quantitatively through an economic impact analysis. Non-market benefits include all those values that are not accounted for in the public market place. These include social values stemming from improved ecosystem health and wildlife habitat, recreational values, and scenic values. These are best addressed through a qualitative analysis. This report focuses on the rural economic development implications of the restoration strategy. Creating sustainable employment opportunities is an important component of benefiting rural economies. Those benefits are estimated in this section.

Employment and Income

The implementation of landscape-scale restoration includes a wide range of economic activities. Typically these activities can be categorized as: biomass utilization from implementation of the restoration treatments, transportation of logs and biomass to processing facilities, utilization of logs and biomass, shipping of byproducts of utilization, support activities (mechanical maintenance, fuel procurement, etc.), indirect activities (economic activities created in turn by direct activities, e.g. spare parts procurement, supply of fuel, etc.), induced economic activities (changes in spending from households as a result from incomes derived from all categories of activities). All of these activities require the integration of human labor and capital. IMPLAN provides a mechanism for modeling the production processes associated with the restoration strategy.

Removal of forest resources causes a production change in certain industries. IMPLAN tracks the supply chain events that occur as a result of a change in output of wood products. That output has a value that stimulates a chain of events that generates employment and income directly from the removal and processing of the products as well as indirectly through the inter-industry purchasing patterns of businesses and household consumption patterns of their employees. IMPLAN tracks economic activity according to the North American Industrial Classification System (NAICS). The Forest Service has developed a program called the Treatments for Restoration Economic Analysis Tool (TREAT). TREAT uses regional IMPLAN models to estimate the annual impact of activities that would occur under this proposal. The activities are allocated to the appropriate NAICS sectors, and response coefficients from the regional model are applied to estimate total jobs and labor income that would occur in one year. The model used for this project is for the entire Region 3 of the Forest Service, which includes Arizona, New Mexico, and parts of Oklahoma and Texas. TREAT averages the activities over the life of the strategy, therefore jobs are assumed to last for the 10-year period. However, if additional volume is harvested in the area it is likely that these jobs will continue beyond the 10-year strategy. IMPLAN reports employment simply as jobs, not full-time equivalents (FTEs). A person with more than one job would appear more than once in the data. Therefore we cannot make distinctions about fulltime employment or make comparisons to total populations. Table 5-58 reports the total annual employment and labor income that would be created by this restoration strategy. Impacts are broken down into three categories: commercial forest products, other project activities and Forest Service implementation and monitoring. A total of 575.5 jobs would be created, 407.2 of which would be due to the use of commercial forest products.

Table 5-58. Predicted employment and labor income impacts for the SWJM Restoration Strategy (Valles Caldera Trust, Santa Fe National Forest, 2010)

Types of Projects	Total part and full-time jobs	Total Labor Income (2009 $)
Commercial Forest Products	407.2	$15,794,877
Other Project Activities	135.5	$4,314,888
Forest Service Implementation and Monitoring	32.8	$1,971,194
Total Project Impacts	575.5	$22,080,960

Source: USDA Forest Service, TREAT

Table 5-59 below shows the jobs and income reported from activities in the SWJML in 2011.

Table 5-59. FY 2011 jobs created (CFLR and matching funding)

Type of Projects	Direct part and full-time jobs	Total part and full-time jobs	Direct Labor Income	Total Labor Income
Commercial Forest Product Activities			$0	$0
Other Project Activities	44.3	48.4	$979,790	$1,107,304
Total Project Impacts	44.3	48.4	$979,790	$1,107,304

Source: USDA Forest Service, TREAT

The impacts reported above would occur within Region 3 of the Forest Service. They do not provide an accurate estimate of employment and income impacts at the local level. At this point in the restoration effort there are not specific on the ground activities that can be modeled to accurately estimate the total impact to local jobs and income.

However, it is assumed that as restoration activities begin to be implemented that economic activity will occur based on the value of the output that is produced. The Walatowa Timber Industries which established in July of 2012 hired four full time positions in the first quarter of operations and turned 102 loads of finished product using small diameter material removed from the Valles Caldera and all size materials salvaged from Santa Clara Tribal lands (T.C. Company 2013)The majority of the direct activity associated with the restoration strategy will occur in the forestry and logging industry during removal, and the sawmills and wood products industry during processing. To that end, it is possible to model a certain level of activity in those sectors and estimate the resulting impact to employment and income at a smaller scale. Assumptions have to be made in regards to which NAICS sector will receive the activity. Once a detailed restoration strategy is developed and specific wood products are identified, IMPLAN models may be developed to accurately estimate the jobs and income that would be generated specific to that plan. That level of analysis is reserved for the NEPA phase. For the purposes of this proposal it is assumed that activity is evenly distributed across forestry, forest products and timber (IMPLAN sector 15) and commercial logging (IMPLAN sector 16). Those sectors combined are assumed to make up the forestry sector. Table 5-60 reports the jobs and labor income that would be created in the production area if a million dollars' worth of new activity were to occur in that sector. The production area consists of Sandoval, Rio Arriba, Santa Fe, Los Alamos and Bernalillo Counties. The figures reported in Table 5-60 are response coefficients; in other words, they report the total jobs and labor income that would be generated from a million dollars of activity in the forestry sector. Once activities are contracted out and a utilization strategy is developed, current prices and volumes of wood products may be used to estimate the total value of those activities in the forestry sector. That value may then be used with the response coefficients reported in Table 5-60 to estimate the total economic effect. The jobs and income estimated are generated through both direct and indirect activity and therefore represent a total effect. For every additional million dollars of activity in the forestry sector, 10 jobs and $200,000 of labor income are generated. As expected, the majority of jobs and income occur within businesses in the agriculture and forestry industry; however there are some impacts to other industries as a result of inter-industry and household purchasing patterns.

Table 5-60. Total jobs and labor income generated per million dollars of activity in forestry

Sector	# of Jobs	Labor Income
Agriculture, Forestry, Fishing and Hunting	7.83	119,012
Mining	0.56	13,736

Sector	# of Jobs	Labor Income
Utilities	0.00	257
Construction	0.03	1,199
Manufacturing	1.06	43,965
Wholesale Trade	0.01	265
Transportation and Warehousing	0.24	9,179
Retail trade	0.09	2,003
Information	0.27	7,397
Finance and Insurance	0.06	2,285
Real Estate and Rental	0.01	683
Professional Scientific and Technical Services	0.00	0
Total	**10.16**	**199,981**

Source: IMPLAN 2007

The State of New Mexico has a similar program called the Collaborative Forest Restoration Program (CFRP). Starbuck et al. (undated) estimated the total economic impact of CFRP. The economic impact for New Mexico is estimated at 569 jobs, $14,188,039 in labor income, and $27,096,053 in total output. The value added associated with this output is estimated at $16,150,079. Table 5-62 reports the estimated economic benefits per acre treated from this program. For every acre treated under CFRP it is estimated that 0.03 jobs and $731.57 of labor income are generated. Also, the total output and value added per acre are estimated to $1,397.14 and $832.14 respectively. Since CFRP and CFLRP are similar in terms of objectives, it is likely that economic benefits resulting from the two programs would also be similar.

The alternatives would be expected to produce similar outputs over the 10-year period covered in the plan using the benefit ratios established by Starbuck (undated) for the CFRP program. Alternative 2 shows a slightly greater benefit however, because the actual number of acres thinned is based on budget and capacity there may be little difference in what is accomplished over the 10-year period.

Table 5-61. Estimated cost for proposed thinning and prescribed burning

MECH Prescription	Acres		Cost/Acre ($)	Total Cost ($)	
	Alternative 2	Alternative 3		Alternative 2	Alternative 3
REST – Restoration	11095	11095	800	8,876,000	8,876,000
ASRE – Aspen Restoration	2020	9,677	950	1,919,000	9,193,150
FOHE – Forest Health	5480	0	700	3,836,000	0
HFRE - Hazardous Fuels	2900	522	600	1,740,000	313,200
Total	**21,495**	**21,295**		**16,371,000**	**18,383,150**
WFPF Type					
WFBD	21,495	23,498	150	3,224,250	3,524,700
WFPF - Grasslands	12,340	12,340	75	925,500	925,500
WFPF – Forest/Woodland	15,990	15,990	200	3,198,000	3,198,000
Total	**49,825**	**51,828**		**7,347,750**	**7,648,200**
Grand Total				**23,718,750**	**26,031,350**

Table 5-62. Economic benefits per acre treated for CFRP

	Benefit/acre	Alternative 2	Alternative 3
Acres Treated		21,495	21,295
Output per Acre Treated	$1,397.14	$30,031,524	$29,752,096
Total Value Added per Acre Treated	$832.74	$17,899,746	$17,733,198
Labor Income per Acre Treated	$731.57	$15,725,097	$15,578,783
Number of Jobs per Acre Treated	0.03	644.85	638.85

Source: (Starbuck, Prante and Berrens undated)

From a rural economic development perspective, the jobs and income reported above are only benefits if they occur in local communities. The activity reported in Table 5-58 would occur within the production area for the SWJM restoration strategy. However, those reported in Table 5-60 are based on Region 3 models; thus benefits to local communities may differ. During the collaboration process stakeholders expressed a concern for awarding contracts to local companies. Although no specific mechanism exists for limiting bidding to only local companies, in an October 16, 2009 letter from Ronald Hooper to Regional Foresters, Station Directors, Area Director, IITF Director and Deputy Chiefs it stated that when evaluating bids and proposals consideration may be given to local contractors “who provide employment and training for, dislocated and displaced workers in an economically disadvantaged rural community, including those historically timber-dependent areas that have been affected by reduced timber harvesting on Federal lands and other forest-dependent rural communities isolated from significant alternative employment opportunities.” Such contracts must be for projects that contribute to “hazardous fuels reduction, watershed or water quality monitoring or restoration, wildlife or fish population monitoring, or habitat restoration or management” (Hooper 2009).

Community involvement is an important component of CFLRP. Local stakeholders should be included throughout the restoration strategy. There are several opportunities to expand community involvement during on the ground operations to benefit local residents while meeting restoration objectives. Krasilovsky (2010) provides several recommendations for community involvement and outreach. Currently there is only one YCC crew on the Cuba RD. Additional YCC crews could be called upon to prep sites for prescription burning, pile or scatter slash as needed, collect vegetation data, or be mentored by agency professionals. Also, funding a part-time community outreach or education coordinator to perform outreach and collect feedback from interested parties within the greater Jemez Mountain region would help disseminate information to the public as well as educate agency officials of the potential local benefits of restoration efforts. Additionally, there could be opportunities to fund a small business technical assistance provider to help local operators scale up from the stand to the landscape scale project. Monitoring indicators should be developed to track community involvement and related economic benefits overtime. These would be in addition to those identified in chapter 2 and would address the SWJML.

WildEarth Guardians has been awarded funding for a Youth Conservation Corps crew on the VCNP in 2013. In addition, in 2012 Jemez Pueblo has entered into a joint venture agreement with a local operator, TC Company to operate a full service restoration and wood utilization business – Walatowa Timber Industries, LLC. The venture began operations with support from a CFRP grant. The trust collaborated in the CFRP proposal by providing the wood from ongoing project level thinning and restoration. In the first quarter of operations, the initiative supported three full time technicians (Figure 5-33) as well as a full time administrative assistant turning out over 100 loads of finished products (T.C. Company 2013). Figure 5-34 shows the range of products produced from projects where the maximum diameter of trees cut ranged from 14 – 16 in. diameter and most trees were in the 7-12 in. range.

Figure 5-33. Walatowa Timber Industries employed three full time technicians at its Jemez Pueblo worksite during its first quarter in operation

Indirect labor and income is also generated as material is hauled from the VCNP to the yard, or transported elsewhere for finishing (i.e. treated posts) and back to the wood yard or elsewhere for sale or consumption.

Figure 5-34. Products produced from small diameter trees form thinning projects on the VCNP. From top left, clockwise: Vigas, rough-cut lumber, posts, firewood, animal bedding, and landscaping mulch.

Non-market Benefits Contributing to Social Sustainability

During the collaborative workshop in Santa Fe, New Mexico issues regarding non-market benefits were the topic of many discussions. Throughout this workshop social values emerged as an important component of the restoration strategy. Several unquantifiable values were identified that would contribute benefits to society in addition to those specific to economics and wood utilization; for some

stakeholders, these values are the most important component of restoration efforts in the SWJM. This section qualitatively assesses those values and their implications for the lifestyles of local residents.

Non-market values associated with healthy ecosystems would enhance the benefits from the restoration strategy while greatly contributing to social sustainability. Many stakeholders are concerned with restoration from a community health standpoint and are less concerned with wood utilization and direct impacts to jobs and income. These stakeholders view CFLRP as an opportunity to collaboratively work towards restoration and social sustainability. First and foremost a healthy and fire resilient ecosystem is critical to the health of small communities in the SWJM. The potential losses associated with a catastrophic fire range from personal property values to spiritual and recreational values. Reducing the probability of such losses is a benefit to communities. The probably of such events is addressed in the cost savings section of this proposal.

Recreation supports social values for local residents as well as generates economic stimulus for businesses. Expenditures from visitors to the SWJM generate important revenues and taxes for small communities. These expenditures are what keep many businesses open because demand from local residents alone isn't sufficient to maintain a viable economic base for businesses in the recreation and tourism industry. Restoration efforts and reduced risks of catastrophic fire would help ensure that such economic activity would continue for years to come. Additionally, healthy ecosystems would support recreation values for many residents. The SWJM provides recreational opportunities for locals, many of whom can't afford to travel elsewhere for recreation. These opportunities support social values that contribute to community sustainability. Similarly, the SWJM support spiritual solace and traditional activities for many longtime residents. Healthy ecosystems are vital to the continuation and enhancement of cultural values, as well as spiritual retreat and renewal.

The restoration strategy would also improve conditions for wildlife, water quality, soil and native vegetation as described throughout this document; all of which affect social values. Improved wildlife habitat, soil and vegetation conditions would create additional recreational opportunities while contributing towards the objectives of many environmental groups. Improved water quality and supply would yield benefits for agriculture, community drinking water, and fire suppression. The corresponding changes in values that would occur as a result of restoration treatments are unquantifiable. However, they would contribute to community health and social sustainability. Restoration would also enhance scenic values of the landscape, which are known to affect property values and visitor experience.

CFLRP funding would also allow for continued and improved collaboration efforts between Forest Service representatives and stakeholders. Collaboration between landowners and public and private organizations keep people working towards common goals. And educational opportunities are important to help visitors understand the sensitivity of SWJM ecosystems and possibly transform current recreational and other forest uses into ones that are more environmentally friendly.

All of the topics addressed here affect social values and community stability. At one point during the collaborative workshop participants were asked to describe how the SWJM were special to them. Recreational, spiritual, ecological and industrial issues all emerged. These issues provided a reoccurring theme throughout the collaborative workshop (Valdez, 2010). Most discussions revolved around the notion that ecosystems restoration would benefit everyone, including timber industries. Industry has an important role in restoration because it generates demand for the byproducts; the sale of these

byproducts in a sense can help subsidize restoration activities. Therefore the theme of working together should be carried through the entire collaborative process for CFLRP as well as other projects.

Indirect Effects

As previous noted, studies find that people consistently blame land managers for degraded forest conditions and wildfires that burn in these conditions (Davis, et al. 2011; Martin, Martin and Raish 2011). While there is not research that quantifies improved relations following restoration actions, Martin, Martin, and Raish found that people view thinning small diameter trees as the most effective and preferred treatment option along with the thinning of diseased trees. Further their study found that people believed these treatments are best implemented over an entire landscape and preferred the prescribed fire be used *following* prescribed fire.

Trustworthiness is the most important factor in determining the agency-community relationship. The proposed action mirrors the action collaboratively developed at the collaborative workshops leading to the SWJML 10-year Restoration Strategy (Valdez, 2010). The alternative action varies somewhat with a greater emphasis on the restoration of aspen, but is still consistent with the strategy. We hope that upon seeing our adherence to collaboratively based goals, objectives, and actions will contribute to ongoing positive relations and continued public support for restoration activities.

Cumulative Effects

The proposed restoration plan could combine with past CFRP projects and other restoration actions and planned future restoration actions to encourage new start-ups for businesses that restore forests and utilize small wood. Increase capacity to perform work and utilize material could reduce future costs and bring long-term socio economic benefits.

5.13 Cumulative Impact Analysis

Cumulative impacts are examined as the cumulative effects of the proposed action in combination with each other as well as in combination with past present and reasonably foreseeable future actions.

The preceding sections considered the cumulative impacts of all activities proposed under the Stewardship Plan while this section presents a broader view of cumulative actions that may combine with the impacts of the proposed plan and create or contribute to impacts beyond the VCNP.

5.13.1 Cumulative Actions

Past Actions

Timber Harvest San Diego Land Grant; Pre 1962

The San Diego Land Grant included lands within the SWJML. The timber rights within the Land Grant were acquired by New Mexico Land and Timber. The ponderosa pine forests on Virgin, Holiday Stable and Schoolhouse Mesas were all intensively logged from the 1930's up until Federal acquisition of the land grant in 1962 (Glover 1990). This intensive logging contributes to the ecological departure and fire behavior potential at the landscape scale

Santa Fe National Forest Land and Resource Management Plan (Forest Plan); 1987, amended 2010

Establishes goals, objectives, standards and guidelines for the management of the Santa Fe National Forest.

East Fork of the Jemez River Designated as Wild and Scenic River; 1990

The East Fork of the Jemez River was so designated for possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. Rivers, or sections of rivers, so designated are preserved in their free-flowing condition and are not dammed or otherwise impeded.(National Wild and Scenic Rivers 2011)

Jemez National Recreation Area Established; 1993

The passage of Pub. L. 103-104 established the Jemez National Recreation Area (JNRA); the northwest boundary of the JNRA follows the southern end of the VCNP.

NM 4 is Designated as Scenic Byway; 1997

In 1997 the New Mexico Department of Transportation (NMDOT) designated NM 4 as a National Scenic Byway (MRCOG 2007)

Valles Caldera Preservation Act Signed in 2000

In 2000, President Clinton signed the Valles Caldera Preservation authorizing the acquisition of the Baca Ranch in north-central New Mexico and creating the Valles Caldera Trust, and the Valles Caldera National Preserve as an experimental management regime.

Santa Fe National Forest Plan Amended, East Fork of the Jemez, Wild and Scenic River Management Plan Incorporated; 2002

The plan adopted programmatic direction for the East Fork of the Jemez River. The area is managed as "semi-primitive, non-motorized recreation" (USDA - Forest Service 2002).

Santa Fe National Forest Plan Amended, JNRA Management Area Incorporated; 2003

On January 21, 2003 Forest Supervisor Gilbert Zepeda signed the FONSI and Decision to amend the Forest Plan by incorporating the JNRA Management Area and Plan. This placed a management emphasis on protecting and enhancing the recreational, cultural, and wildlife resources and values within the JNRA (USDA-Forest Service 2003).

Past Large Wildfires

Figure 5-35, below numerous large wildfires have burned in and around the preserve since the 1970's, both as a result of and contributing to the existing condition.

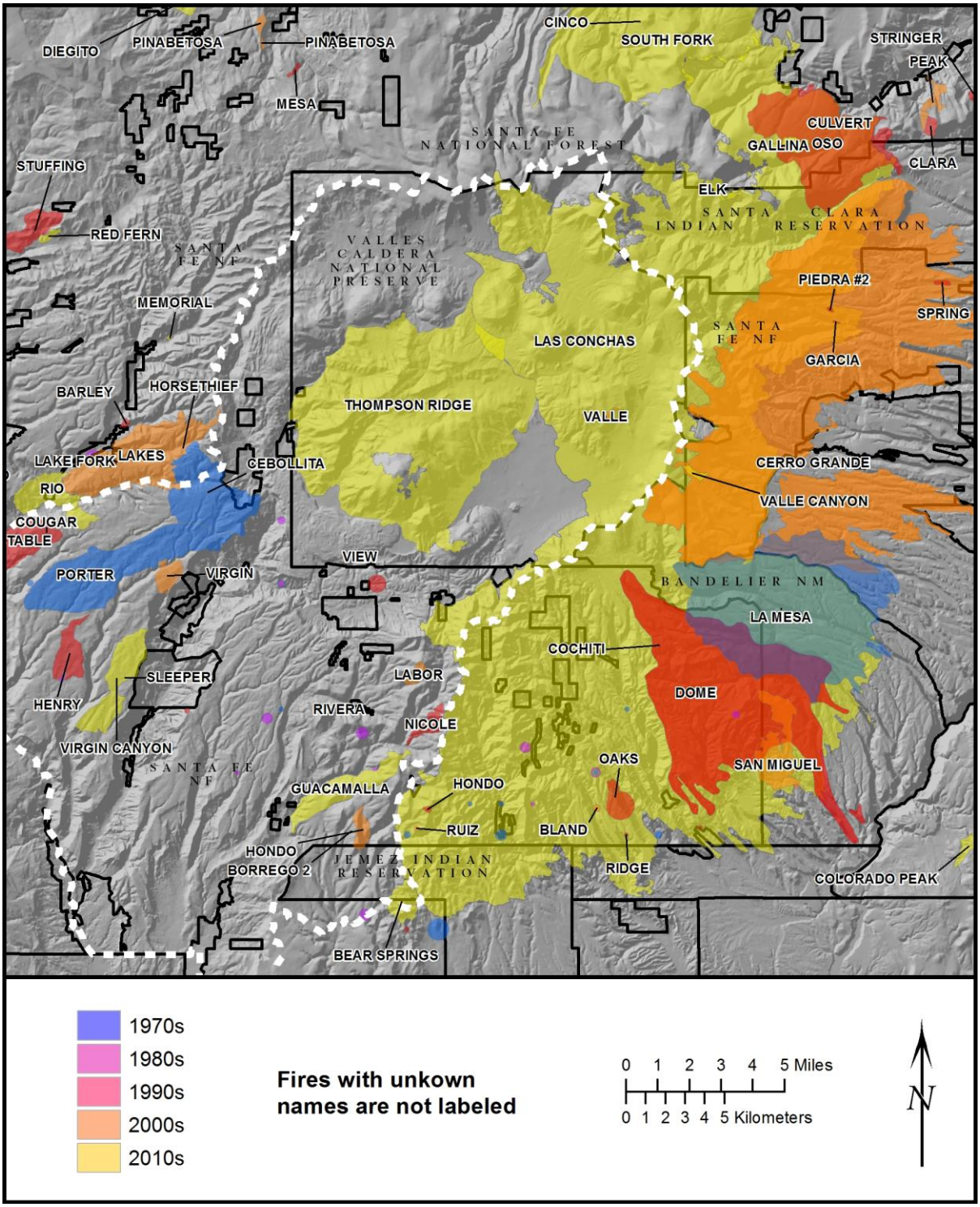


Figure 5-35. Large wildfires in and surrounding the VCNP

Present Actions

Paving NM 126

NM DOT is currently paving from the intersection of NM 4 to Cuba

SWJML Awarded Funding Under the CFLRP

Established a collaboratively developed strategy for forest restoration over a 10-year time frame on the preserve as proposed in this plan and on 110,000 acres of the SFNF.

SFNF Published FEIS/ROD for Travel Management on the Santa Fe National Forest; 2012

This plan proposes a significant change in motorized access and use on the forest including closing ~2,475 miles of open roads and adding 90 new motorized routes. Limits driving off of open routes and minimizes impacts of roads/trails on riparian zones and wet meadows. The SFNF plans to release the final EIS and ROD in 2012 (USDA - Forest Service 2010)

Sandoval County Express Provides Bus Service between Albuquerque, Jemez Springs, Cuba.

Bus service connects with rail runner transit system providing daily transportation from rail station and other stops in Bernalillo and Rio Rancho.

Bandelier establishes a shuttle system for public access.

Bandelier established a temporary shuttle serve to provide for public safety following the Las Conchas fire in 2011. They have now proposed to continue the shuttle service on a permanent basis.

Santa Fe National Forest Proposed Restoration Actions for the SWJML are under their jurisdiction.

The Santa Fe National Forest published a Notice of Intent proposing a suite of activities (forest thinning, harvesting, prescribed fire and riparian restoration across 110,000 acres south and west of the VCNP.

Valles Caldera Trust, published FEIS/ROD for the Public Access and Use Plan 2012

Valles Caldera Trust, signed a Record of Decision to construct a Visitor Center in the Valles Caldera National Preserve and use a shuttle system as the primary means for public access into the Valles Caldera National Preserve.

Reasonably Foreseeable Future Actions

Special Status Species

It is likely that Jemez Mountains Salamander, New Mexico meadow jumping mouse and Gunnison's prairie dog will become listed as threatened or endangered during the life of the Stewardship Plan.

Increased Visitation

Although the numbers may vary depending on the source all sources indicate an expected increase in stat population. The Mid Region Council of Governments predicted a 29 percent increase over 20 years in their 2006 assessment of the Jemez Corridor (MRCOG 2006). They also expect increase in recreational visitors to the Jemez Corridor. This prediction corresponds to a prediction of increased population leading to an increase in outdoor recreation cited in the SFNF EIS prepared for their proposed Travel Management Plan (USDA - Forest Service 2010)

Sandoval County Improvements to Amenities and Infrastructure

Plans for Sandoval County call for continued increase in mass transit and improvements including bike paths and walkways on NM 4 and 126, a realignment of NM through Jemez Pueblo, and building and zoning regulations of to protect water and view sheds (MRCOG 2006, MRCOG 2007). They also envision working more closely with state and local agencies to identify and publicize sites where increased tourism is feasible.

Landscape Restoration on the Santa Fe National Forest Proposed within the SWJML under USDA – Forest Service Jurisdiction

Activities similar to those proposed on the VCNP in this plan are being proposed across 110,000 acres of the SFNF (USDA - Forest Service 2013) to the southwest of the VCNP (Figure 5-36) including:

- Uneven-aged Thinning with Openings and Burning in Ponderosa Pine - 23,600 acres
- Stand Improvement Thinning and Burning in Ponderosa Pine - 1,500 acres
- Uneven-aged Thinning with Openings and Burning in Dry Mixed Conifer - 5,800 acres
- Stand Improvement Thinning and Burning in Dry and Wet Mixed Conifer - 80 acres
- Landscape Prescribed Burning - 76,900 acres
- Treatments in Wet Mixed Conifer - 1,400 acres
- Treatments to Maintain or Increase Aspen Cover - 1,800 acres
- Treatments in Piñon-Juniper - 1,000 acres
- Treatments in Mexican Spotted Owl Activity Centers - 2,800
- Treatments for Old Growth - 20% each of ponderosa pine and mixed conifer forest allocated for management as old growth, limited thinning, 24 in. diameter cap
- Treatments for Maintaining or Increasing Meadow Habitat - 5,500 acres (trees cut where encroaching on meadows)

- Treatments to enhance Seeps and Springs - 175 acres (remove conifers within 100 feet of seeps and springs)
- Treatments to Reduce Erosion Effects from Headcuts - Erosion control as needed
- Treatments to Enhance Native Riparian Vegetation and Restore Areas Damaged by Dispersed Recreation - 144 dispersed campsites (close damaged areas and rip compacted areas, seed or plant)
- Treatments to Restore Instream Habitats - Create pools and channels, replace culverts, and place or remove log and rock structures
- Nonnative Invasive Plants - Use non-chemical methods to control invasive plants
- Screen Water Sources from Human Disturbance - Plant trees around tanks and drinkers; construct exclosures
- Increase Water Sources for Wildlife - Construct earthen dams or trick tanks
- Create Snags - Kill trees greater than 16 in. diameter (by girdling or other methods)
- Cultural Site Protection - Remove trees and brush from up to 3,000 sites
- Road Maintenance - Build rolling dips, improve drainage structures, and replace gravel on roads used for operations
- Opening Closed Roads or Creating New Temporary Roads - Open approximately 17 miles of closed roads, construct 21 miles of new temporary roads
- Road Decommissioning - Close and decommission 150 miles of road
- Gravel Pits - Construct 5 new gravel pits, each less than 5 acres

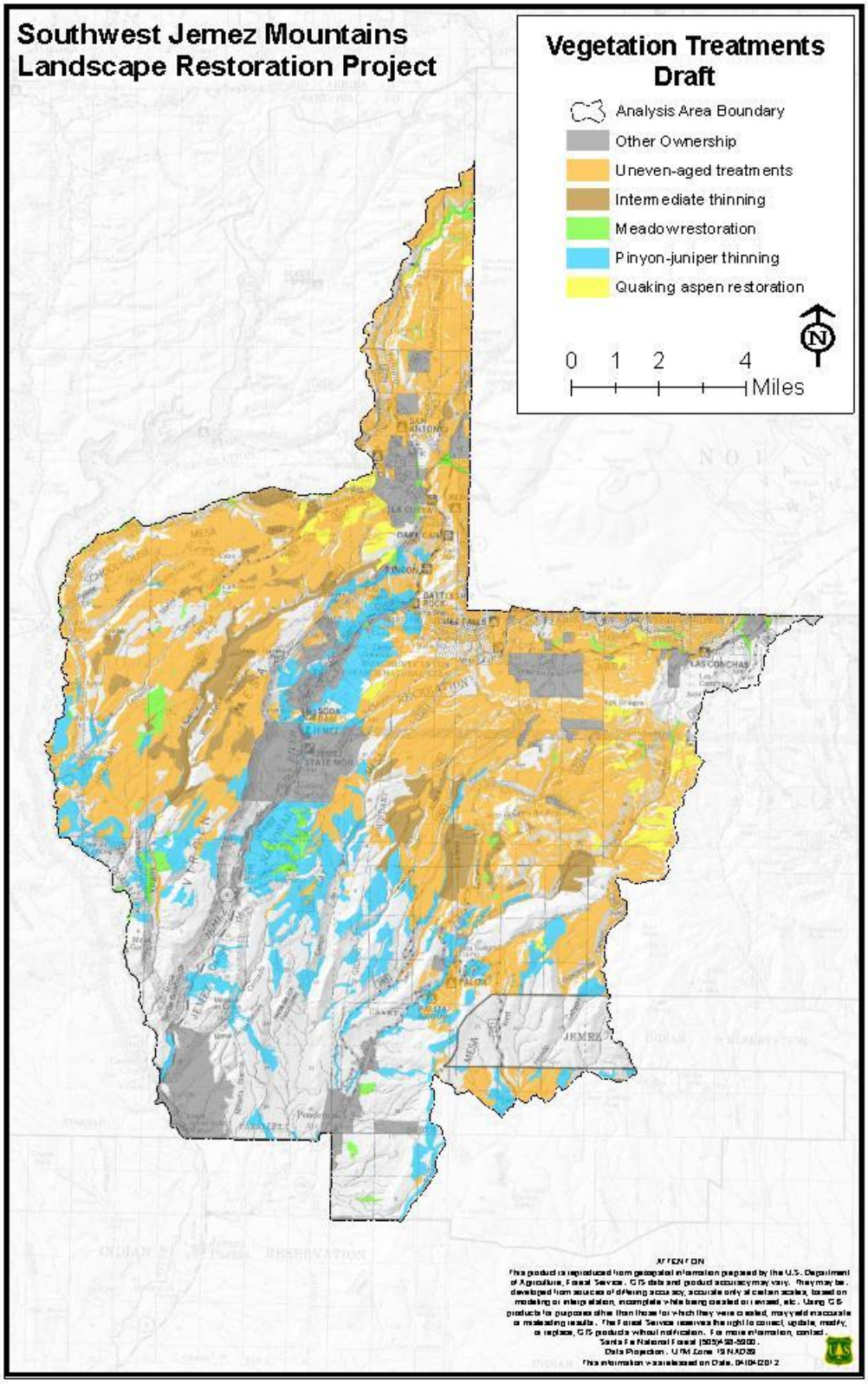


Figure 5-36. Restoration activities proposed by the Santa Fe National Forest (USDA - Forest Service, 2013)

5.13.2 Cumulative Effects – No Action

Increase in human caused fires as area population and visitation increases combine with the persistence of current levels of wildfire potential would be expected to result under the no action alternative. An increase in ignitions under the current forest condition would increase the burn probabilities over what is predicted under current and historic probabilities as described in chapter 4. A high severity fire on the preserve could spread to NFS land to the north and could impact water quality into the Jemez River, affecting the regional area.

The strategy for landscape restoration proposed in the SWJML includes restoration the interconnected biophysical settings contained within the landscape, on the NFS the emphasis is on the ponderosa pine forests and dry mixed conifer forests (FR I) that cover the mesas extending to the south and west of the caldera. Without the restoration actions on the preserve the strategy becomes more about hazard reduction and improving the condition of the ponderosa pine forest and less about the restoration of a landscape.

5.13.3 Cumulative Effects - Action Alternatives

Ecological Condition

The proposed stewardship plan if implemented under either action alternative is expected to combine with restoration on the surrounding NFS land to move the ecological condition in the SWJML towards the reference condition. The SWJML comprises much of the forested landscape within the Jemez River Watershed.

We are proposing to concentrate restoration activities within a watershed to concentrate the intensity of the benefits. By concentrating restoration activities, the VCC rating within the treated area, biophysical settings defined by vegetation would move from a highly departed state to a moderately departed state as we transition mid-age closed forests to mid-age open forests. With continued maintenance, these forests will eventually transition to late succession stages.

Socioeconomic

The proposed action when combined with reasonably foreseeable future restoration activities in the surrounding area could provide the basis for developing sustainable industries related to forest restoration especially small wood utilization. Besides utilization the combined long-term activities may attract workers skilled in the implementation and monitoring of restoration activities. This could ultimately increase the local capacity for performing restoration and utilizing small wood. An increase in local capacity could potentially reduce costs for restoration through increased competition and reduced transportation costs.

Increases in economic activity coupled with increased visitation could lead to a more diverse and sustainable local economy with over $30 million in total economic benefit predicted over 10 years.

Public Safety

The proposed action and foreseeable future actions would combine with past actions in and around local wildland urban interface communities to reduce direct and indirect losses from wildfire. However, increased traffic from restoration activities could combine with increased residential and visitor traffic and contribute to congestion. This impact would be somewhat mitigated in time and place as industrial traffic primarily occurs during the weekday and recreation traffic is concentrated on the weekend (J.F. Sato and Associates 2005).

Expected traffic or type of traffic would not be beyond the design level of NM 4, which has accommodated industrial traffic from past logging, pumice mining, and construction.

5.14 Unavoidable Adverse Impacts

As previous noted in this EIS, the actions being proposed are commonly implemented on public lands and when implemented in limited context and intensity have been shown to have no significant impact on the human environment (USDA - Forest Service 2010, Federal Register 2003, USDI - Bureau of Land Management 2008). These exclusions are called *Categorical Exclusions. Categorical exclusion* means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (§1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. (40 CFR 1508: Terminology and Index).

However, as discussed in this analysis there are localized adverse impacts that are likely to occur as a result of the proposed stewardship plan including: smoke from prescribed burning, increased localized traffic, dust, and noise from operations, localized noise and disturbance to wildlife, temporary closures and restrictions to public access, and/or temporary impacts to visual quality.

There are other localized adverse impacts that are less certain to occur but are possible and even probable including: isolated impacts to cultural resources, isolated losses of important biodiversity characteristics (down logs and snags), and/or localized areas of severe burning or soil disturbance.

These potential short-term, minor, and localized adverse impacts are identified for almost every resource area. Without exception they are offset by longer term minor to moderate beneficial outcomes that would occur at the project, landscape or regional level. Under the NEPA, the simple likelihood of an overall beneficial impact cannot be used to reduce the significance of adverse impacts. Therefore, we have identified guidelines in chapter 2 that are incorporated into the action alternatives and intended to minimize or avoid adverse impacts.

5.15 Short Term Benefits vs. Impacts to Long-term Productivity

The proposed action and alternative are aimed at protecting and improving long-term productivity. Mitigating measures proposed in chapter 2, especially limiting the circumstances under which large (>16

in. diameter) can be cut and protecting and preserving large down logs protect productivity now and into the future.

No permanent removal of productive wildland through the construction of roads or facilities is included in the proposed Stewardship Plan or alternative action.

Works Cited

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

Data is not information, information is not knowledge, knowledge is not understanding, understanding is not wisdom.

- *Clifford Stoll*

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Glossary

LANDSCAPE RESTORATION & STEWARDSHIP PLAN

"We shall never understand one another until we reduce the language down to seven words."

- *Khalil Gibran*

Glossary of Terms

Ecological Restoration – the process of assisting the recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged, or destroyed through human intervention by implementing *ecological restoration treatments*.

Best Available Science – disclosure of the relevant science that was considered to insure that science was appropriately interpreted and applied in the development of the *proposal*.

CFLR Fund - the Collaborative Forest Landscape Restoration Fund established by section 4003(f) of Title IV of the Omnibus Public Land Management Act of 2009.

CFLR Program - the Collaborative Forest Landscape Restoration Program established under section 4003(a) of Title IV of the Omnibus Public Land Management Act of 2009.

Composition – The mixture of species (plant or animal). Sometimes composition is measured as *species richness*, which is the number of species present, or as a *diversity index*, which all considers number of species and the relative amount of each species.

Designated Uses – The *reference condition* for water quality. All the benefits a body of water could serve for humans, wildlife, and ecosystem processes if it was of optimum quality.

Ecological departure – The difference between the *existing condition* and the *reference condition*. A measure of within 33 percent of the *reference condition* is considered similar or *Good;* a measure of 33-66 percent of the reference condition is a moderate departure or *Fair*; a measure greater than 66 percent of the reference condition is a significant departure or *Poor.*

Ecological restoration - the process of assisting the recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged, or destroyed.

Ecological restoration treatments – all treatments that help recover ecosystem resilience and adaptive capacity of ecosystems that have been degraded, damaged, or destroyed.

Ecosystem – a complex web of relationships among the biotic and abiotic components of an area. Ecosystems are interwoven at multiple scales such as a single tree or an entire forest and are often described by *structure*, *composition*, and *function*.

Ecosystem function – nature's basic processes and how they work. To help us work with nature's complexity, we can focus on four fundamental processes that operate in any ecosystem: water cycle, mineral cycle, energy flow, and succession

Ecotype - Ecotypes have no main taxonomic rank in modern biological classification. However some scientists consider them "taxonomically equivalent to subspecies". This is true in the sense that ecotypes can be sometimes classified as subspecies and the opposite.

Existing condition – Measures of the structure, composition and/or *function* of an ecosystem such as forest structure, species composition, *water quality*, habitat quality, *stream condition*.

Fire Regime – The natural frequency, intensity and severity of *wildland* fire in the *pre-suppression era.* The national, coarse-scale classification of fire regime groups commonly used includes five groups: I - frequent (0-35 years), low severity; II - frequent (0-35 years), stand replacement severity; III - 35-100+ years, mixed severity; IV - 35-100+ years, stand replacement severity; and V - 200+ years, stand replacement severity.

Forest land - Forested National Forest System (NFS) land is at least 10 percent stocked by forest trees of any size, including lands that formerly had such cover and will be naturally or artificially reforested.

Forest restoration by-products - forest products derived from *active ecological restoration* using tools such as commercial timber sales and permits, stewardship contracts, special forest products sales and permits, and through *woody biomass* utilization.

Forest stand – a delineated area of forest similar in *structure* and *composition*.

Forest structure – the age, size, and density of trees in a forest area, summarized as a *successional class*.

Forest thinning – tree cutting that focuses on removing smaller, less healthy trees; leaving larger, healthier trees. Forest thinning may be designed to reduce fire behavior potential, to improve habitat for wildlife (one or more species), to optimize the productivity of a site, to improve watershed function, or any combination thereof.

LANDFIRE - also known as the Landscape Fire and Resource Management Planning Tools Project, is a five-year, multi-partner project producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States. It is a shared project between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior. The project has four components: the LANDFIRE Prototype, LANDFIRE Rapid Assessment, LANDFIRE National, and Training/Technology Transfer.

LANDFIRE data products include layers of vegetation composition and structure, surface and canopy fuel characteristics, and historical fire regimes. LANDFIRE National methodologies are science-based and include extensive field-referenced data. LANDFIRE data products are designed to facilitate national- and regional-level strategic planning and reporting of wildland fire management activities. Data products are created at a 30-meter grid spatial resolution raster data set.

LANDFIRE National data products are produced at scales that may be useful for prioritizing and planning hazardous fuel reduction and ecosystem restoration projects; however, the applicability of data products varies by location and specific use, and products may need to be adjusted by local users. LANDFIRE meets agency and partner needs for data to support large landscape fire management planning and prioritization.

Large Tree Retention – vegetation treatment methods applicable to areas outside of identified old-growth stands to maximize the recruitment and retention of large trees in a manner that is appropriate for the forest type.

Mastication – grinding or shredding of trees or branches.

Old Growth – A forested area characterized by all components of mature forest from the *reference period*. These components include large, old trees, large snags, large down logs in various stages of decomposition, understory species and cover.

Prescribed Fire – planned ignition of wildland fire under "prescribed conditions" to achieve specific resource benefits.

Prescription – specified parameters for thinning (tree size, species, form or spacing) or prescribed fire (weather conditions, ignition pattern, fire behavior).

Pre-suppression Old Growth – a *reference condition* applicable within old growth stands that approximates the *composition* and *structure* of *forest stands* prior to the period of active fire suppression (circa 1900-1910).

Project decisions – includes decisions documented in a decision notice (as that term is used in the USDA Forest Service Handbook), implementing decision (as defined in the NEPA procedures of the Valles Caldera Trust) or a record of decision (as that term is used in applicable regulations of the Council on Environmental Quality).

Reference condition – the composition of landscape vegetation and disturbance attributes that, to the best of our collective expert knowledge, can sustain current native ecological systems and reduce future hazard to native diversity.Quantified, it provides a base line for measuring ecological *departure*. The value is often a modeled value estimating structure, composition or function of a particular *ecosystem*. The value is often +/- 33 percent, reflecting the range of variability inherent in natural systems.

Reference period - the time frame thought to support the *reference* condition. It is the prior to European settlement and the associated disturbances (fire suppression, grazing, logging and road building). Sometimes referred to as the *pre-suppression era* (circa 1900-1910) referencing when fire suppression began to effectively eliminate fire from most wildlands in the western United States, the *pre-settlement era*, a slightly earlier period referring when the exclusion of fire was resulting from fire suppression as well as grazing, road building, logging and settlement in general within the SWJML.

Land and Resource Management Plans - a land and resource management plan prepared for one or more units of land of the National Forest System described in Section 3(1)(A) under Section 6 of the Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 1604) or equivalent plans used by other Federal agencies.

Secretary – the Secretary of Agriculture, acting through the Chief of the Forest Service.

Stream condition – measures of stream bank morphology, water quality, benthic and vegetative diversity. The *reference* condition is summarized as *Proper Functioning Condition;* a moderate *ecological departure* is summarized as *Functioning at Risk; a* significant departure is summarized as *Not Properly Functioning.*

Stewardship action – A term unique to the NEPA procedures of the VCT meaning: Activity or group of activities consisting of at least one goal, objective, and performance requirement…that may

1. Guide or prescribe alternative uses of the VCNP upon which future implementing decisions will be based; or

2. Utilize or manage the resources of the VCNP.

Successional Class – stage of forest growth and development, abbreviated as s-class. Basic five forest s-classes include:

A: early-open; grass and seedlings

B: mid-closed; young forest, trees 5-16" d.b.h., canopy density >50 percent

C: mid-open; young forest, trees 5-16" d.b.h., canopy density < 50 percent

D: late-open; mature forest, trees +16" d.b.h., canopy density < 50 percent

E: late-closed; mature forest, trees +16" d.b.h., canopy density >50 percent

Title IV – Title IV of the Omnibus Public Land Management Act of 2009.

Uncharacteristic wildland fire - A wildland fire burning at a severity and intensity or size that would not have occurred during the pre-suppression era.

Vegetative Condition Class – A measure classified into three classes describing the relative degree of *departure* from historical *fire regimes*, possibly resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings. 1 - less than 33 percent departure, 2 - 33-66 percent departure, 3 - >66 percent departure.

Water quality – Water quality is the ability of a water body to support all appropriate ways or *designated uses* in which water is used by humans and wildlife; drinking water and fish habitat are two examples. If water supports a beneficial use, water quality is said to be good or unimpaired implying that harmful substances (pollutants) are absent from the water, and needed substances (oxygen, nutrients) are present. If water does not support a beneficial use, water quality is said to be poor or impaired. Designated uses are the *reference condition* or baseline for measuring *ecological departure.*

Watershed – A geographic landscape defined by a common point of drainage. The USGS delineates recognized Hydrologic Unit Codes (HUC) at the regional, sub-regional, basin, sub-basin, watershed, and sub-watershed levels. The regional level is a 1st code and the sub-watershed is the 6th code referring to the number of digits in the code. The Valles Caldera is within the Jemez River 4th code sub-basin, mostly within the East Fork of the Jemez 5th code watershed, and within several 6th code sub-watersheds.

Watershed condition – An informal term referring to the combined condition of a landscape related to the capture, storage and yield of water and water quality. There are various methods of quantifying watershed condition

Wildfire - unwanted wildland fires including unauthorized human caused fires, planned ignitions that exceed their boundaries or the prescribed conditions, or other wildland fires where the objective is to put the fire out.

Wildland fire – a non-structural fire burning through natural vegetation such as forests and rangelands. Current nomenclature refers to two types of wildland fire: Planned and unplanned ignitions.

Planned ignitions are ignited by land managers under prescribed conditions, with an intent to achieve specific resource objectives

Unplanned ignitions are unauthorized human caused fires or lightning caused fires.

Wildland fire behavior - Described by *intensity* (rate of spread, flame length, heat produced) and *severity (*the effects of the fires to *ecosystem structure*, *composition*, and *function*).

Wildland Fire Use - The application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in pre-defined designated areas outlined in Fire Management Plans. Operational management is described in the Wildland Fire Implementation Plan (WFIP). This term is not a part of current nomenclature.

Woody biomass - the by-product of management, restoration, and hazardous fuel reduction treatments, including trees and woody plants (i.e., limbs, tops, needles, leaves, and other woody parts) grown in a forest, woodland, or rangeland environment.