Vegetation

Introduction and Methodologies

This section evaluates and compares the existing and reference conditions of forest vegetation within the assessment area. Conditions are described in terms of the forest structural characteristics, species composition, and disturbance processes including fire, insects, diseases, and human activities.

Research and other reliable data sources used to illustrate the departure from reference conditions consisted of forest inventory data from National Forest databases such as Natural Resource Information System Field Sampled Vegetation (NRIS FSVeg; US Forest Service 2009b), Forest Service Activity Tracking System (FACTS), and Geographic Information System (GIS). Field reconnaissance in May and June of 2009 was used to help verify and update this information. Consideration was also given to information compiled in several past assessments completed for this area, plus monitoring results and environmental analysis documents completed in accordance with National Environmental Policy Act (NEPA). Vegetation on the National Forest has been mapped using aerial photo interpretation together with stand examinations and other field data collection methods. Stand exams have been conducted throughout the assessment area, and sampled stands were stratified to similar stands in the area using standard protocols. Most of the stand exam data on the National Forest is from the 1980s and 1990s, although additional stand exams were conducted in 2009, and most stand exam data on the Preserve was collected in 2008.

Factors Affecting Current Conditions

This assessment area is considered one of the most naturally diverse areas in the Southern Rocky Mountains Ecoregion (Muldavin and Tonne 2003). However, past land uses like logging, livestock grazing and wildfire suppression have caused a downward trend in the natural diversity of the ecosystems in this area. Table 13 summarizes the vegetative cover types in the assessment area. In the early 1900s, many of the desirable stands in the area, particularly ponderosa pine, were logged. Intensive railroad logging occurred throughout the Jemez Mountains from 1924 to 1941. Virgin, Holiday and Stable mesas were logged between 1934 and 1936. Selective logging of individual trees, particularly the largest trees, continued, until the Forest Service started to actively manage the forest vegetation, starting in the 1960s (Elliott 1997). These activities greatly reduced the amount of old growth forest. Ponderosa pine was the commercially favored species since the earliest logging, so other species such as Douglas-fir and white fir were often left in the stands.

In the past 20 to 30 years, the Forest Service emphasized thinning, firewood cutting and prescribed burning to reduce the abundance of smaller size trees and shade-tolerant fir species, increase the proportion of old growth, and help restore resilient and sustainable ecosystem conditions. In the Preserve, intensive logging continued under private ownership until 2000, when the land was acquired through Federal appropriations and conveyed into the national forest system under a unique system of management by a Board of Trustees (Valles Caldera Trust).

Climate, livestock grazing, and fire suppression also strongly influenced current conditions in the assessment area. The climate in the early 1900s yielded generally favorable moisture regimes in the Jemez Mountains that increased conifer tree regeneration. Historically, high numbers of sheep and cattle that grazed the Jemez Mountains reduced the amount of grasses available to carry a surface fire or to compete with tree seedlings. Over 100 years of active fire suppression added to the elements that allowed tree seedlings and saplings to thrive unchecked, without frequent fires to thin them out.

Major Ecosystems

Major ecosystems described in this report, also referred to as vegetation cover types, are defined by the dominant overstory vegetation. Table 13 and Figure 19 show the estimated vegetation cover type distribution in the assessment area based upon stand examination data and aerial photo interpretations.

Table 13. Vegetative cover type percentages

Vegetation cover type (ecosystem)	Percent of entire assessment area	Percent of National Forest land in the area
Ponderosa pine	38.0	49.5
Mixed conifer	22.3	15.3
Piñon-juniper	18.0	28.4
Grassland	7.9	1.3
Spruce-fir	6.3	2.7
Aspen	5.8	1.3
Non-vegetation	0.7	0.8
Riparian forest	0.5	0.0
Shrubland	0.4	0.7

Source: National Forest GIS database 2009

Ponderosa Pine Ecosystem

Currently, ponderosa pine (Pinus ponderosa) is the dominant forest type, comprising 38 percent of the assessment area and 50 percent of the National Forest lands. Ponderosa pine stands range from lower elevation, dry sites where they are transitional with piñon-juniper woodlands, to higher elevation, moist sites where ponderosa pine grades into mixed conifer. Between the extremes, ponderosa pine is the climax tree (mature, end-point species) on some sites and the seral tree (early pioneer species) on the mixed conifer sites where Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) become more dominant.

Species and structural composition has been significantly altered in most of the historic ponderosa pine stands in the Jemez Mountains. The proportion of shade-tolerant fir species has increased due to the amount of logging of ponderosa pine and the lack of surface fires (Taylor and Skinner 2003). Fire suppression reduced the evolutionary advantage of ponderosa pine, which is better able to survive low to moderate intensity surface fires than the shade-tolerant tree species. Historically, ponderosa pine forests were maintained as open stands with a grassy surface fuel bed by frequent 2 to 40-year fire return intervals.

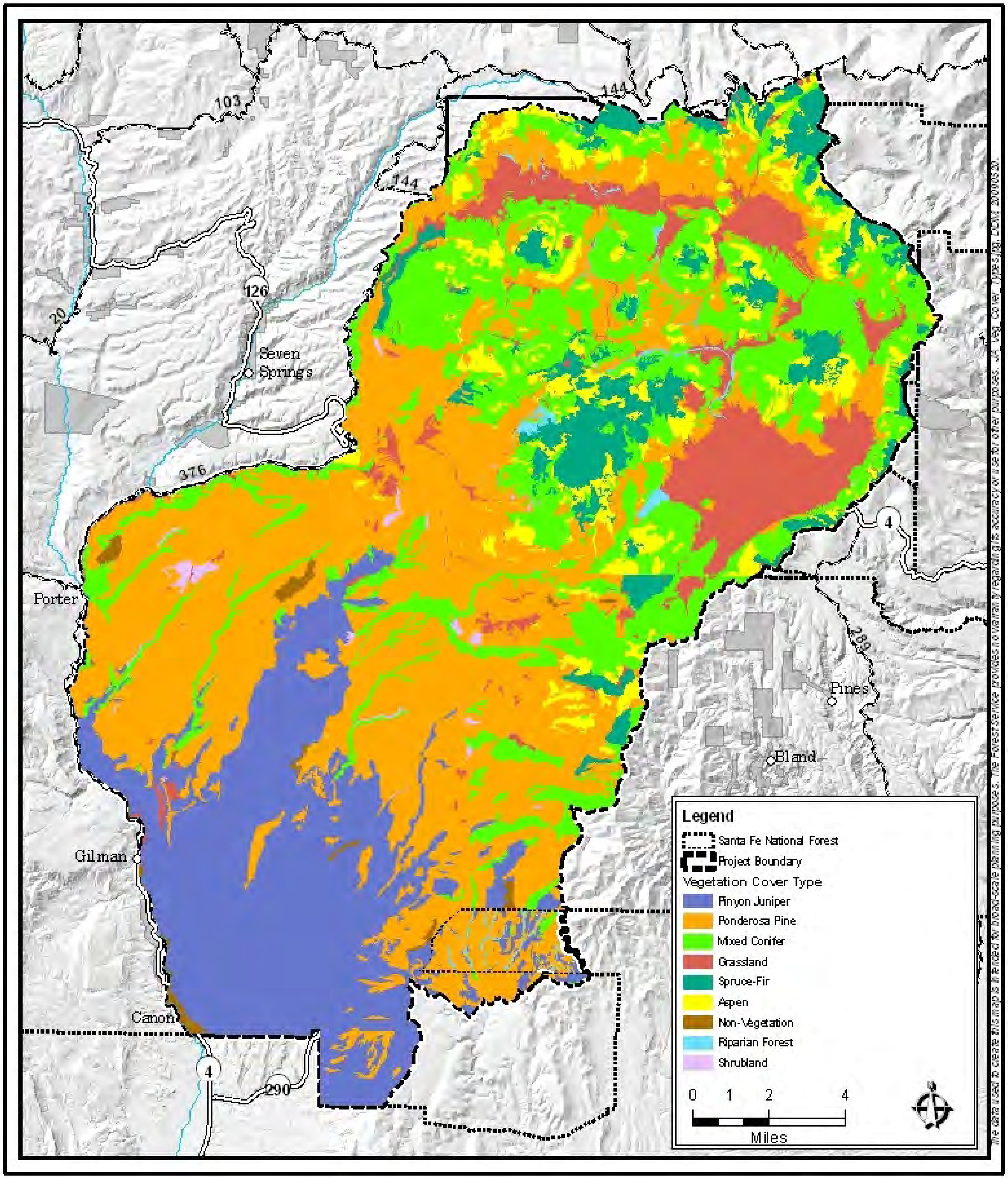

Figure 19. Vegetation cover types based on dominant overstory trees

As a result of human-caused alterations in natural fire regimes, many ponderosa pine dominated stands have shifted to become mixed conifer stands. Johnson (1993) documented an 81 percent increase in mixed conifer dominated stands across Arizona and New Mexico from 1962 to 1986. In addition, ponderosa pine stands typically form a dense and continuous blanket of pole-size trees, having lost their natural clumpiness and age-class diversity. Herbaceous plant cover in most stands has decreased (Covington and Moore 1994b); replaced by heavy accumulation of conifer needles. Without periodic fires to thin out the smaller trees, the number of trees has become unnaturally high. The excessive number of trees has greatly increased the competition between trees for light, moisture and nutrients, which has resulted in reduced tree growth and vigor. This has lowered the ponderosa pine forest's resilience, or its ability to survive fires or outbreaks of insects or diseases.

Thus, the representation of different vegetation structural stages (VSS classes) has become less diverse. Vegetation structural stage is a generalized description of forest growth and aging stages based on the size class of trees comprising the majority of basal area in the stand. Forest Plan guidelines call for managing for diverse VSS class distributions in ponderosa pine ecosystems based on guidelines for managing northern goshawk habitat in the Southwestern U.S. (Reynolds et al. 1992). Those management guidelines are based on the dominant VSS classes within clumps and patches, totaled across large watershed-size areas. Table 14 shows the target or reference condition VSS class distribution in comparison with the existing VSS class distribution for ponderosa pine stands in the assessment area.

Table 14. Vegetative structural stage (VSS) and canopy cover for ponderosa pine stands on the National Forest lands

VSS Class	Existing VSS	Reference VSS	Existing Canopy Cover	Reference Canopy Cover
VSS 1 (< 1") grass/forb/shrub	6%	10%	NA	NA
VSS 2 (1-4.9") Seedling/sapling	8%	10%	NA	NA
VSS 3 (5-11.9") Young forest	51%	20%	NA	NA
VSS 4 (12-17.9") Mid-age forest	21%	20%	48%	40%
VSS 5 (18-23.9") Mature forest	11%	20%	46%	40%
VSS 6 (>= 24") Old forest	3%	20%	45%	40%

Existing condition source: Forest RMRIS database 2009 and Forest Vegetation Simulator

As shown in the table, there is currently a significant excess of mid-age, pole-size trees in the 5 to 12-inch diameter class. There is a significant deficit of larger, older trees (VSS 5 and 6, or over 18 inches in diameter). The number of large snags (dead standing trees) is slightly below the Forest Plan standard, although it has been increasing over the past decade due to mortality from fires, insects and diseases. There is an average of about 1.7 snags per acre that are at least 12-inches DBH (diameter at breast height) and 15 feet tall. Approximately 41 percent of those snags are at least 18-inch DBH and 30 feet tall, which is the reference size according to the Forest Plan and northern goshawk guidelines. Most of this data was collected in the 1980s and 1990s, so the current number of snags is likely a little higher due to the increase in insect and disease mortality in the mid-2000s (US Forest Service 2007a).

Historical reference conditions of the Southwestern ponderosa pine ecosystem have been thoroughly studied. Covington and Moore (1994a) evaluated numerous studies that found pre-settlement ponderosa pine densities typically ranged from 15 to 56 trees per acre in Arizona and New Mexico, including 26 to 47 trees per acre on the Carson National Forest, adjacent to the Santa Fe National Forest.

Table 15 shows the current basal area per acre (square feet of wood volume per acre) within the ponderosa pine type in the assessment area, along with the density in terms of number of trees per acre (TPA), in trees over 1 inch and over 5 inches in diameter. There is an increased stand density and canopy cover relative to historical reference conditions in the ponderosa pine type.

Although canopy cover within clumps or groups may be similar to historic conditions, the openings between the clumps or groups are fewer and narrower than what historically occurred in ponderosa pine. Historically, ponderosa pine stands were horizontally diverse, with scattered openings and even-age clumps of trees. Clumps ranged from a few trees to clumps of about 0.75 acre in size (Covington and Moore 1994a). Historically, average canopy cover across the variable-density landscape was generally less than 30 percent though canopy cover at the clump level was much denser (Pearson 1923). Frequent low-intensity surface fires promoted an abundance of grasses and forbs while reducing the numbers of tree seedlings and saplings.

Table 15. Basal area (BA), quadratic mean diameter (QMD), and trees per acre (TPA) for ponderosa pine stands on National Forest Land

Ponderosa Pine	Minimum Stand Average	Maximum Stand Average	Assessment Area Average
BA 5”+	20	250	92
QMD 5”+	7.3	25.1	10.0
TPA 1”+	6	2224	537
TPA 5”+	6	438	178

Source: RMRIS database, Santa Fe National Forest

Mixed Conifer Ecosystem

The mixed conifer forest type comprises only 15 percent of the National Forest land within the assessment area. It consists of a variety of species including Douglas-fir, white fir, ponderosa pine, blue spruce, aspen, southwestern white pine (*Pinus strobiformis*), limber pine (*Pinus flexilis*) and minor amounts of Rocky Mountain juniper (*Juniperus scopulorum*), Engelmann spruce (*Picea engelmanii*) and corkbark fir (*Abies lasiocarpa var. arizonica*). Mixed conifer is a transitional forest type that ranges from warm, dry to cool, moist. For consistency with wildlife habitat analysis, the definition of mixed conifer according to the Mexican spotted owl recovery plan is used in this report (USDI 1995). This definition includes stands within Douglas-fir, white fir, limber pine and blue spruce series, except those (1) considered “pure” for a species other than

Douglas-fir, white fire, limber pine, southwestern white pine or blue spruce, or (2) stands with more than 50 percent of the basal area in quaking aspen.

Warm, dry mixed conifer is associated with the lower elevations and dryer southerly aspects within the Douglas-fir and white fir ranges. Many stands that are currently classified as dry mixed conifer stands were historically open-canopy ponderosa pine-dominated stands (Allen et al. 2002). Due to the lack of frequent fires and other influences, the warm, dry mixed conifer today often has a dense and dominant understory of shade-tolerant white fir (Taylor and Skinner 2003). There are still typically larger ponderosa pine and Douglas-fir in the overstory. Other species are minor components. Historically, the dry mixed conifer stands were more open than they are today and supported high frequency, low severity fire regimes. As such, the understory of grass and other non-woody vegetation was more productive and diverse than current times.

Cool, moist mixed conifer is found between the warm, dry mixed conifer at the lower elevations and subalpine types at the higher elevations. This moist mixed conifer type has less ponderosa pine than dry mixed conifer. Douglas-fir and white fir are the predominant species, and blue spruce may be common, especially in drainages and riparian areas. Aspen may be a major or minor seral component. Fires are less frequent than in ponderosa pine, and fire severity is mixed, with stand replacing crown fire usually occurring in patches (Touchan et al. 1996). The composition of these stands has not changed drastically from historic conditions. However, the mixed conifer forest structure is typically denser and less diverse than it was (Muldavin and Tonne 2003), similar to the altered conditions described for the ponderosa pine ecosystem.

Currently, the mixed conifer type in the assessment area includes both even-aged and uneven-aged stands. Historically, these stands were all-aged due to disturbance. Heavy regeneration events, periodic harvesting, and reduced natural fire disturbances have created stand conditions in many cases dominated by one or two age classes. Species composition has been altered as well. Aspen, ponderosa pine and other shade intolerant tree species were historically maintained in mixed conifer forests through disturbances such as fires. The lack of fire occurrence has resulted in an over-representation of shade tolerant trees within mixed conifer stands, and a decline in patches of young aspen (Touchan and Swetnam 1995).

For most mixed conifer stands on National Forest land in the assessment area, average basal area ranges from 80 to 250 square feet, with a mean of 150. The average density of trees is 600 trees per acre, with tree density ranging from 250 to 1600 trees per acre (trees larger than 1 inch DBH). Regionally, historical basal areas were 40 to 45 percent of current levels and trees per acre 20 to 25 percent of current numbers (Smith 2006). Table 16 illustrates average basal area, average diameter, and average trees per acre for mixed conifer in the assessment area based on stand exam data collected in the 1980s and 1990s. This same data was used to evaluate the occurrence of snags in mixed conifer stands. Based on dead trees sampled during stand inventories, approximately 7.4 snags per acre at least 12 inch DBH and 15 feet tall are scattered in mixed conifer stands in the assessment area. Only 24 percent of those snags are at least 18 inches DBH and 30 feet tall, due to the overall lack of large trees in the area. The Douglas-fir bark beetle mortality that peaked in the mid-2000s likely increased the amount of large snags. Ongoing data collection will provide a more accurate representation in the near future.

Table 16. Basal area (BA), quadratic mean diameter (QMD), and trees per acre (TPA) for mixed conifer stands on National Forest Land

Mixed Conifer	Minimum Stand Average	Maximum Stand Average	Assessment Area Average
BA 5”+	70	240	135
QMD 5”+	8.2	16.3	10.6
TPA 1”+	254	1690	622
TPA 5”+	95	450	226

Source: RMRIS database, Santa Fe National Forest

Piñon-Juniper Woodland Ecosystem

Piñon-juniper woodlands are one of the most prominent vegetation types, covering 18 percent of the total land and 28 percent of National Forest land in the assessment area, all of it in the southern portion. It is a diverse type that ranges from open savannas to dense-canopy woodlands, influenced by many factors including biogeophysical factors, climate, as well as past and current land use. Three piñon-juniper types can be found in this area (Romme et al. 2007). The distribution of these three types is not quantified for the assessment area.

1. On lower elevations with deeper soils and gentle topography, piñon-juniper savannas maintain sparse canopy cover and relatively continuous grass cover. The grass cover historically supported frequent, low-severity fires. Some of these savannas were previously grasslands, but have successfully seeded in with juniper and/or piñon trees as a result of changes in climate, disturbance of fire regime, and/or effects of grazing. Similarly, many of the historic savannas have experienced ingrowth of piñon and/or juniper better described as open woodland. The continuous grasses are the key feature for this savanna classification.

2. Shrub woodlands have a successional character that is dominated by shrubs but supports a density of tree cover that fluctuates with climate and disturbance. These areas expand and contract over time. Surface cover is highly variable as typical sites range from deep valley-bottom soils to shallow rocky soils on steep slopes.

3. Persistent woodlands are found on shallow upland soils that favor piñon and juniper over grasses and other non-woody vegetation. Canopy cover varies depending on site. Understory can include grasses, forbs, and/or shrubs, but is not continuous and often displays bare ground. Fire likely was infrequent, though stand replacing. Other environmental factors, such as the Ips beetle epidemic a few years ago, play a significant role in stand dynamics.

The density of piñon-juniper woodlands has increased in much of its range over the past century or more. The range of piñon-juniper woodlands has likely increased as well, with expansion into grasslands. However, large-scale, natural decreases in piñon-juniper have occurred in recent times also. A combination of environmental factors—drought, insects, and high temperatures—killed millions of piñon trees in New Mexico, including portions of the assessment area, in the early 2000s (Romme et al. 2007).

Spruce-Fir Ecosystem

The spruce-fir cover type comprises 6 percent of the assessment area and less than 3 percent of the National Forest land portion. This forest type is predominantly composed of Engelmann spruce and corkbark fir with smaller components of white fir, Douglas-fir, Colorado blue spruce and aspen. Spruce-fir forests are typically dense and uneven-aged, dominated by Engelmann spruce in the overstory and corkbark fir in the understory. Aspen may be a major seral species, but diminishes after a century or more without disturbance. Spruce-fir forests are found at high elevations (often above 10,000 feet) where conditions can be severe. Growing seasons are short, snow loads are high, and average temperatures are low. Stand dynamics rely on disturbance for regeneration, such as fire, insects (spruce beetle), windthrow, avalanche, etc. Fire occurrence is low frequency and high severity, with fire return intervals of 150 years or more (Dahms and Geils 1997). Most of the spruce-fir forest on the National Forest land in the assessment area is on the high peaks north of the Preserve.

On the Preserve, most of the forests including spruce-fir stands were clearcut or selectively logged using jammer-logging techniques, which required construction of over 1,200 miles of roads. At that time, the Preserve was a private ranch, and loggers there were not required to burn the slash or plant new trees. As a result, the present day forests on the Preserve consist largely of second-growth “dog hair” thickets of young ponderosa pine and white fir, averaging over 1600 trees per acre. On the National Forest portion of the assessment area, little or no logging was done before 1950 (US Forest Service 1997), and there are very few spruce-fir stands in these lower elevation area. Unmanaged spruce-fir stands on the National Forest portion of the assessment area are similar to what existed prior to European settlement in a forest type perpetuated by both high-intensity, low-frequency, large-scale events and frequent patch-scale disturbance.

Aspen Ecosystem

The aspen cover type comprises only 6 percent of the assessment area and 1 percent of the National Forest land in the assessment area. It is found in small stands associated with disturbance as well as a component of many mixed conifer stands. Some of the aspen stands in the assessment area are young, dating to wildfires in the 1970s. However, due to lack of periodic fires that historically regenerated patches of aspen, most of the aspen is mature or over-mature. Conifer trees are taking over the aspen patches due to the lack of natural fire disturbances, resulting in a gradual reduction in the extent of aspen stands throughout the area and conversion from aspen to mixed conifer stands.

Thus, the acreage of aspen in the Southwest Jemez Mountains assessment area is on a downward trend due to the absence of large scale disturbance. This is the case across much of the West. In fact, over the last 30 years, the acreage of aspen in the Southwest is estimated to have declined by almost one-half (US Forest Service 1993a).

Aspen stands are generally even-aged and have conifer trees in both the overstory and the understory. Average diameters run between 8 to 10 inches DBH, although stands originating in the 1970s average 5 to 6 inches DBH. For mature aspen stands in the assessment area, the average basal area ranges from 110 to 240 square feet per acre. Table 17 illustrates average basal area, average diameter, and average number of trees per acre for aspen in the analysis area, based on stand exam collected in the 1980s and 1990s.

Table 17. Basal area (BA), quadratic mean diameter (QMD), and trees per acre (TPA) for aspen stands on the National Forest land

Aspen	Minimum Stand Average	Maximum Stand Average	Assessment Area Average
BA 5"+	112	238	175
QMD 5"+	8.4	10.3	9.3
TPA 1"+	408	1162	702
TPA 5"+	237	510	374

Source: RMRIS database, Santa Fe National Forest

Grassland and Meadow Ecosystems

Southwestern grassland and meadow ecosystems are being invaded by trees because of the absence of fire and past and continued grazing (Allen 1989). Research by Allen shows a decrease in open grassland area of 55 percent since 1935 in the southeast portion of the Jemez Mountains. On Cerro Grande in Bandelier National Monument grasslands have decreased by 85 percent since 1935. Field reconnaissance in the assessment area revealed meadows that were disappearing as trees encroached. Heavy grazing pressure in moist grasslands is favoring the establishment of the exotic Kentucky blue grass (Figure 20) and encouraging the disappearance of the native bunch grasses. Kentucky blue grass is almost impossible to burn, where the native bunch grasses create an excellent fuel bed for surface fire. Maintaining grasslands with fire where Kentucky blue grass is dominant is not an option.

Figure 20. Remnant native bunch grasses on left, Kentucky blue grass on right

Threatened, Endangered and Sensitive Plants

There are no federally listed threatened, endangered, proposed or candidate plant species that have potential to occur in the assessment area.

There are 11 plant species on the Forest Service's sensitive plant species list (US Forest Service 2008). Of those, only four were determined to have potential to occur in the assessment area based on their physical and biological habitat requirements. The four sensitive plant species with potential to occur in this area are:

- Yellow lady's slipper *Cypripedium parviflorum var. pubescens*
- Robust larkspur *Delphinium robustum*
- Wood lily *Lilium philadelphicum*
- Springer's blazing star *Mentzelia springeri*

The wood lily has documented occurrence in several locations. There are no known records of occurrence for the yellow lady's slipper, robust larkspur, or Springer's blazing star on the Jemez District. The Forest Service regional botanist has noted that yellow lady's slipper occur in Bandelier National Monument, so could occur on the Jemez District (personal communication with Charlie McDonald, Sept. 14, 2009).

The Forest Plan designated a botanical special interest area within this Jemez Mountains assessment area. This botanical special interest area was designated in order to protect a unique bunchberry dogwood plant population.

Invasive Plants

Invasive/exotic plants (also known as noxious weeds), are aggressive species that displace native plant species. Where invasive plant populations occur in the assessment area, they are gradually out-competing native plants for moisture and nutrients, and taking over native plant communities. They are turning diverse native plant communities into monocultures, and disrupting natural ecosystem processes. By reducing native plant populations and altering natural ecosystem functions, they are also reducing the abundance and diversity of native wildlife species and microorganisms in those ecosystems. Table 18 and Figure 21 show the types and amount of known invasive plant populations within the entire assessment area.

Table 18. Invasive plant acreages on the National Forest and private land

Plant Name	Acres
Siberian elm	1,678
Russian olive	1,634
Tamarisk	1,634
Bull thistle	1,623
Nodding plumeless thistle	40
Hardheads	16
Poison hemlock	12
Whitetop	10
Canadian thistle	5
Field bindweed	4

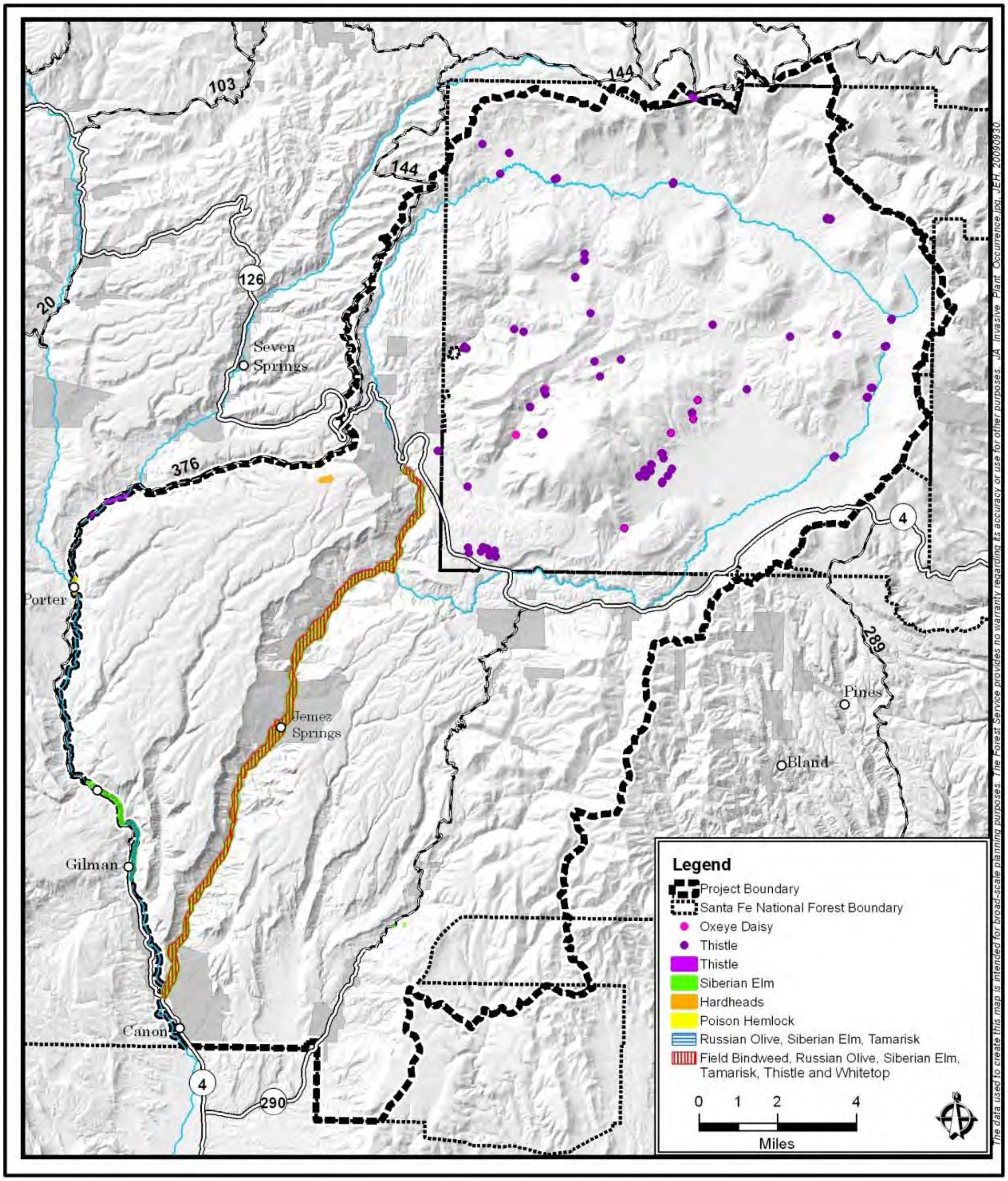

Figure 21. Invasive plant species and distribution

There are approximately 6,700 acres of inventoried invasive plant populations scattered throughout the assessment area, distributed by land ownership as follows:

- National Forest: 3,360 acres
- Private: 3,290 acres
- Preserve: 50 acres

Surveys for invasive plants on the National Forest land have been quite limited, due to funding constraints. It is estimated there are considerably more populations that have not been found. Existing populations are spreading annually.

Concentrations of invasive plants are most noticeable along the riparian areas, as well as along roads where the soil has been disturbed and bare soil exposed.

Species of invasive plants that are the most dominant on the National Forest and private land in the area are tamarisk, Russian olive and Siberian elm, which occur along the Jemez River and other lower elevation streams. On the Preserve, botanical surveys have been extensive and invasive plant control treatments have been occurring annually in recent years. Thus, the extent of invasive plants is significantly lower there. The Preserve has approximately 50 small occurrences, primarily thistles, and some oxeye daisy and bindweed, mostly along roadsides. The National Forest and Jemez Pueblo conducted limited riparian restoration treatments along the lower Jemez River to control tamarisk, Russian olive, and other invasive species, although additional control measures are needed.

A forest-wide Final Environmental Impact Statement that evaluates proposed invasive plant control alternatives was completed and the associated decision appealed. The appeal reviewing officer remanded it back to the Forest, recommending additional analysis. A supplemental (revised) EIS is expected to be completed by December 2010.

Insect and Disease Pests

Insects and diseases are a natural and common occurrence in all forest types in the Jemez Mountains. With a change of species and structural composition due to reasons cited above, an increase of competition between trees for light, moisture and nutrients has resulted in reduced tree growth and vigor. This has lowered the forest's resiliency from outbreaks of insects or diseases. Bark beetles, defoliators, dwarf mistletoes, root diseases, and white pine blister rust have widespread impacts on the forest and within the analysis area.

True mistletoes (*Phoradendron* species) and/or dwarf mistletoes *(Arceuthobium* species) infect every coniferous species in the assessment area. Dwarf mistletoe infection is typically patchy within stands and across the landscape. Infections spread short distances to adjacent trees, so changes in occurrence on a landscape must be measured on a long-term scale, rather than annually (US Forest Service 2008a).

Though not as widespread as juniper infections, dwarf mistletoe infects over one-third of the ponderosa pine acreage and about one-half of mixed conifer acreage in New Mexico and Arizona. The effects of dwarf mistletoe infection on growth and vigor of these commercially important species are significant: an estimated 25 million cubic feet of annual timber production is lost to reduced growth and increased mortality on Forest Service land in New Mexico and Arizona.

Some infection centers are small and manageable, even with uneven-aged silviculture systems. Other infection centers are larger and managing dwarf mistletoe may not be a suitable objective.

Root diseases are another common pathogen, but one which is not readily visible. The most abundant root diseases in this area are likely armillaria (*Armillaria spp.)* and annosus (*Heterobasidion annosum*) root diseases. They are most common in mixed conifer forests, but can infect many species, both coniferous and deciduous. Individuals infected with root disease suffer increased susceptibility to insect attacks as well as higher probability of windthrow, which is often when a root disease is identified. Root diseases spread slowly and survive as decayers on dead woody material. As such, it is a chronic condition that remains on site and can be exacerbated by harvesting.

Unlike mistletoes and root diseases, insect-caused impacts are typically visible in short time frames, making them easier to monitor and evaluate. The Forest Service Southwestern Region forest health staff completes annual insect and disease aerial detection surveys, which are mapped and sampled for accuracy. That source is the most reliable and quantitative source available for displaying the impacts of insects and pathogens in the assessment area. Table 19 shows data for the past 10 years of detection surveys over the entire assessment area (US Forest Service 2007a, 2008a).

Table 19. Acres of defoliation and mortality in forested cover types

Primary Host Species	**Ponderosa pine**	**Douglas -fir and white fir**	**Spruce and corkbark fir**	**True fir**	**True fir, Douglas -fir, spruce**	**Aspen**	**Aspen**	**Total Acres**
Primary Damage Type	bark beetle mortality	bark beetle mortality	bark beetle mortality	bark beetle mortality	defoliation	defoliation	mortality	
Report Year								
1998	29.6	22.7	151.5	22.7	1,092.5	124.9		**5,470**
1999	0.0	13.5	0.3	13.5	108.7			**122**
2000	70.8	23.2	51.3	23.2	1,939.8	2072.2		**4,320**
2001	141.5	130.7	17.5	57.4	14,365.8	620.6		**15,276**
2002	840.3	0.2	21.8	0.2	439.7	1904.0		**3,206**
2003	448.5	479.8	21.4	0.7	10.3	78.4		**1,038**
2004	134.6	1,802.3	39.0		5,307.3	399.8		**7683**
2005	18.8	2,030.9		322.9	7,559.6	683.8		**10,293**
2006	120.2	340.3		34.1	3,949.0	395.8		**4,805**
2007	628.1	274.9		8.4	19,875.0	819.4	727.4	**22,325**
2008	239.8	36.7	21.3	21.3	11,826.7	597.3	684.3	**13,406**
Total Acres Mapped	**2,672**	**5,155**	**324**	**484**	**66,475**	**7,696**	**1,412**	**87,946**
Total Ground Area Affected	**2,552**	**4,660**	**303**	**246**	**40,683**	**6,952**	**1,393**	**60,618**

Source: R3 Forest Health GIS data 2009

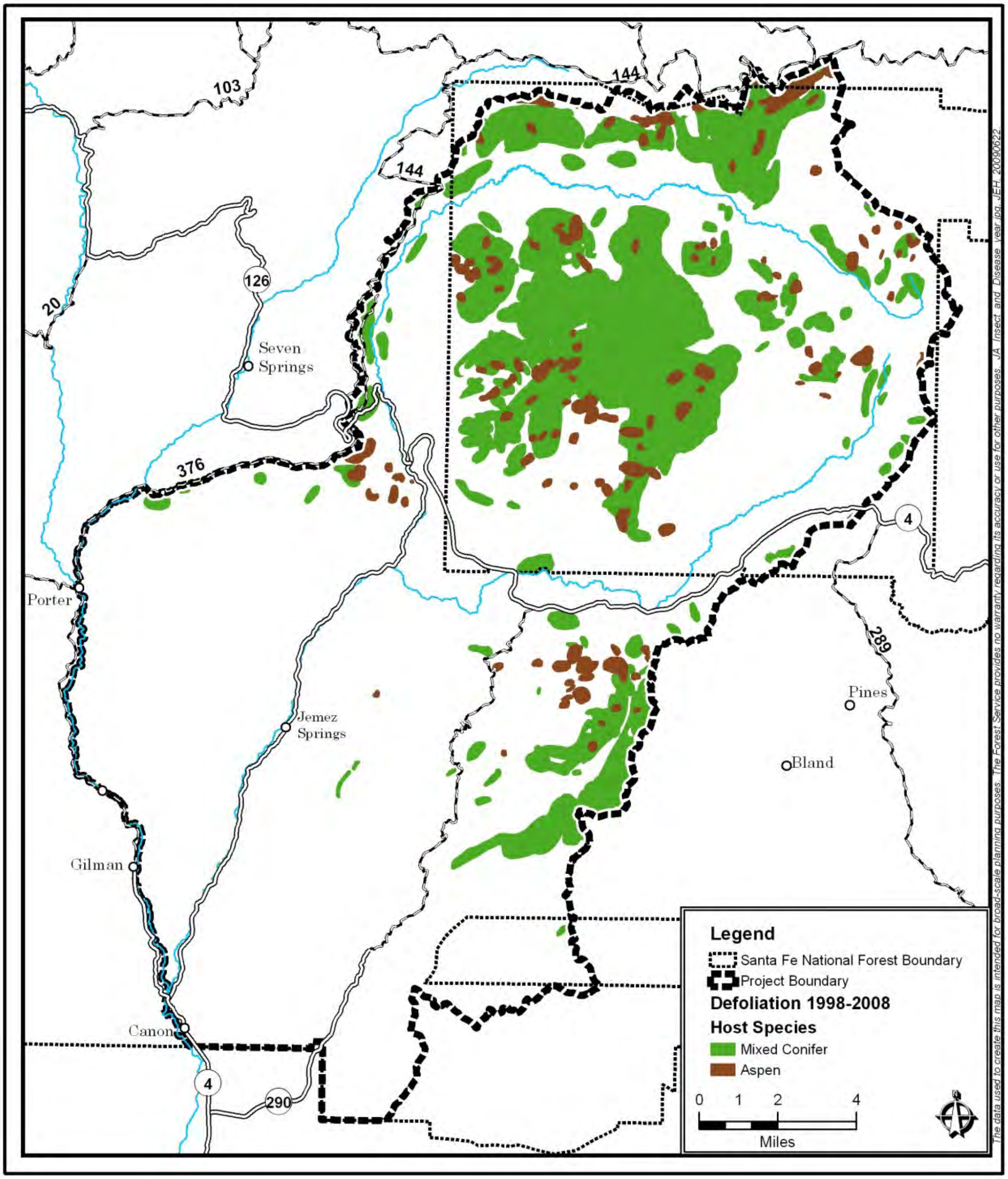

Figure 22. Tree defoliation from insects and disease, 1998-2008

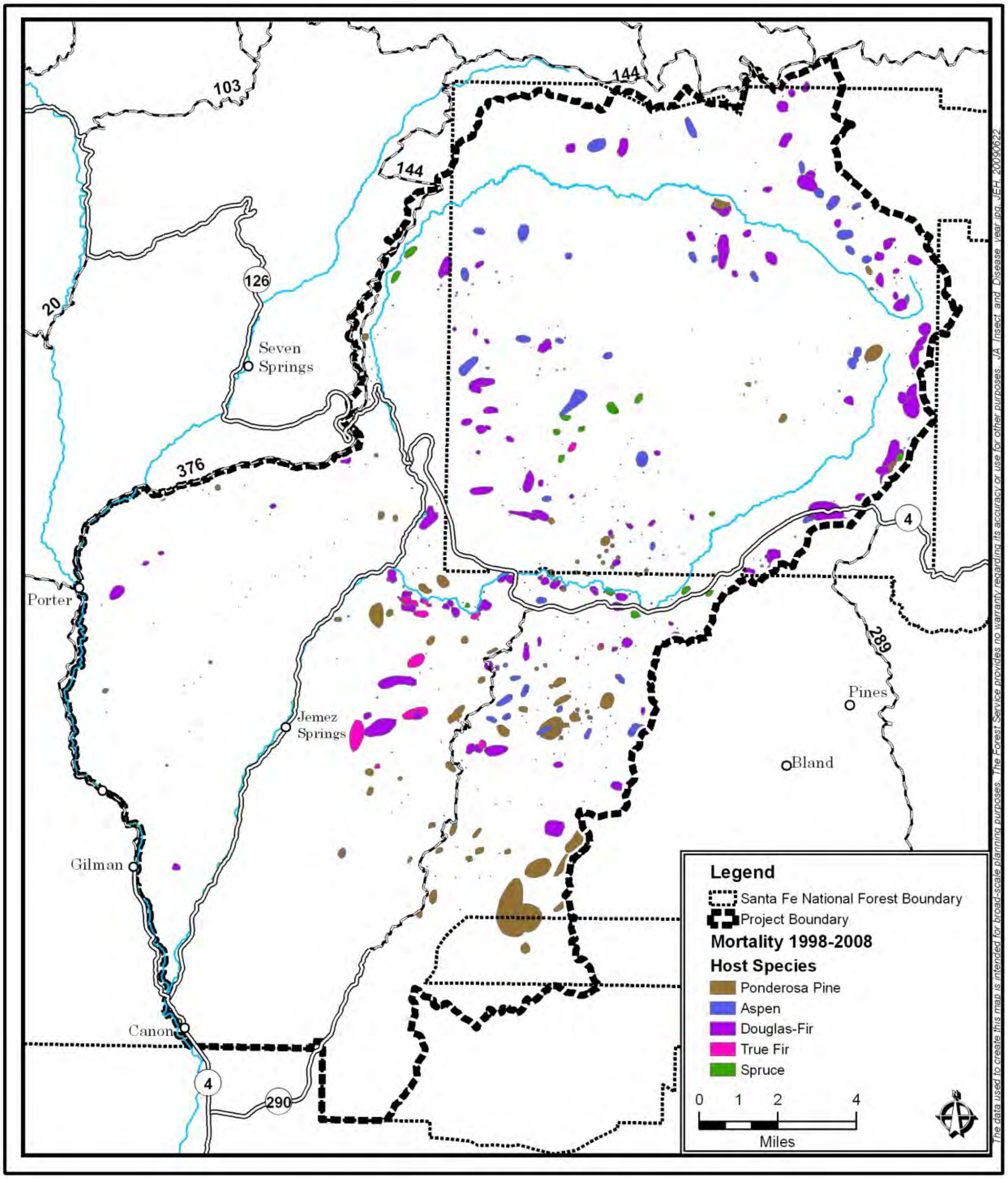

Figure 23. Tree mortality from insects and disease, 1998-2008

In terms of land area affected, **western spruce budworm** (*Choristoneura occidentalis*) has been the most widespread and chronic pest in the assessment area. Spruce budworm defoliates host trees from the top down. Host species include true firs, Douglas-fir and spruce, with white fir seemingly preferred. Multi-storied stands are typical and provide favorable conditions for the larvae to feed upon. Repeated defoliation has occurred in much of the affected area.

Some mortality of larger trees is attributed to repeated defoliation either directly to western spruce budworm or indirectly where bark beetles have attacked weakened individuals. During the survey years 1998 to 2008, approximately 66,500 acres have been mapped with western spruce budworm defoliation, with 2007 and 2008 displaying two of the three largest defoliation years. The affected area on the ground is approximately 40,700 acres. The difference in the two figures indicates repeated defoliation in some areas. Most of the spruce budworm activity has occurred in the Preserve, though much of Paliza Canyon has seen repeated defoliation.

Piñon ips beetles (*Ips confusus*) reached epidemic proportions in New Mexico in the early 2000s as a result of ongoing drought and high temperatures. When the epidemic peaked in 2002 to 2004, there was widespread mortality of piñon, especially on lower quality sites. The impact to piñon trees in the assessment area is not well known because the surveys did not consistently include the piñon-juniper types.

Western pine beetles (*Dendroctonus brevicomis*) and **Ips engraver beetles** (*Ips* spp) are the primary mortality agents in ponderosa pine trees. Western pine beetles typically attack mature, low-vigor trees, while engraver beetles prefer smaller-diameter slash and damaged trees. During past droughts, however, Ips engravers commonly attacked low-vigor smaller tree stems and larger tree crowns, causing mortality in both size classes. Throughout the drought years surveyed, ponderosa pine mortality impacted small pockets and scattered individuals; it never approached epidemic proportions as the piñon did. Mortality increased after 2000, and has fluctuated from almost none to more than 800 acres annually within the assessment area.

Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) and **fir engraver beetle** (*Scolytus ventralis*) activity was minimal before 2003 and peaked in 2005, as the effects of drought gradually moved into the higher elevation forests. Mortality was typically confined to small pockets of only a few trees. Douglas-fir mortality was more prevalent in mature and old trees, while white fir mortality occurred in young to mature trees.

Spruce beetle (*Dendroctonus rufipennis*) activity has not been reported in the last four years of detection surveys. Prior to that, approximately 300 acres of mortality were mapped. It was relatively evenly divided between high-elevation spruce-fir forest type and blue spruce in or near drainages in mixed conifer stands. Some mortality of corkbark fir from western balsam bark beetle was recorded in 2008 and was also found intermixed in the earlier spruce mortality when ground-checked.

Western tent caterpillars (*Malacosoma californicum*) are endemic to the area and feed on several species, but are most visible in aspen. Larvae feed on aspen leaves and large populations can completely defoliate stands of aspen. Repeated defoliation appears to be limited within the assessment area. However, aspen decline (mortality) has been mapped in recent years and may be attributed to western tent caterpillars.

White pine blister rust is caused by the fungus *Cronartium ribicola*, introduced from Asia around 1900. As the name implies, it infects white pines, including southwestern white pine and limber pine (*Pinus flexilis*). Although the Santa Fe National Forest supports the largest population of white pines in the Southwestern Region, there is currently very little blister rust. The first, and currently the only, white pine blister rust infection center known on the forest was discovered in the assessment area in 2007 (Conklin et al 2009). It is expected to spread over time, with intensity and severity dependent on site suitability. No management options currently exist to mitigate the impacts of this disease on host species. Conservation of white pines is the most likely means of ensuring future viability of southwestern white and limber pines.

Old Growth

Old growth (also called late successional stage or climax) forest is a unique component of all healthy, functioning forest ecosystems. Old growth forest is critical to maintaining the biological diversity and abundance of many species of native plants and animals. There has been a long-term decline in the abundance of old growth forests in this area and throughout the Southwest, which has contributed to the decline of some old growth associated wildlife species. For example, the proportion of open-canopy old growth ponderosa pine forest is only about 3 percent compared to a historic range of 30 to 75 percent (based on fire regime condition class analysis using LANDFIRE).

Monument Canyon Research Natural Area is located in a 160-acre section of the assessment area. It is used to research old growth ponderosa pine ecosystems and its response to various types of restoration treatments. Research on old growth in the RNA is ongoing by scientists from Rocky Mountain Research Station and University of Arizona.

Over the past 10 to 20 years, vegetation management practices included maintaining or enhancing development of old growth forest within the assessment area in accordance with Forest Plan direction, as well as agency requirements in the Healthy Forest Restoration Act (HFRA). Section 102(e)(2) of HFRA provides direction to “fully maintain, or contribute toward the restoration of, the structure and composition of old-growth stands according to the pre-fire suppression old-growth conditions characteristic of the forest type, taking into account the contribution of the stand to landscape fire adaptation and watershed health, and retaining the large trees contributing to old-growth structure."

Based on Forest Plan direction, old growth on the National Forest is managed using a minimum 40-acre stand size. Within Ecosystem Management Areas, at least 20 percent of each forest type should be allocated to maintaining or improving old growth. Table 20 displays the minimum criteria for defining old growth, common to Forest Plans throughout the Southwestern Region. Stands meeting these criteria are considered old growth, but stands are not required to meet these criteria to be managed for old growth.

Forest Plan direction says to *…develop or retain old growth function on at least 20 percent of the naturally forested area by forest type in any landscape*. Further direction is provided to allocate those percentages at the ecosystem management area (EMA) level. The assessment area includes portions of nine EMAs: Polvadera, Cañones, San Antonio, L.A., Canyon, Cebollita, San Juan, Paliza, and Borrego and has not been fully inventoried for old growth. Areas with the greatest likelihood to currently meet old growth criteria include steep slopes, unlogged drainages, and reserved areas such as Mexican spotted owl protected activity centers and northern goshawk post-fledgling and nest areas. Productive soil types have the best potential for achieving old growth conditions in the future.

Table 20 Minimum criteria for old growth structural attributes (Forest Plan)

Forest Cover Type	Piñon-Juniper		Ponderosa Pine		Aspen	Mixed-Conifer		Spruce- Fir	
Site Capability	Low	High	Low	High	All	Low	High	Low	High
Live Trees in Main Canopy:									
Trees/Acre	12	30	20	20	20	12	16	20	30
DBH/DRC	9"	12"	14"	18"	14"	18"	20"	10"	14"
Age (Years)	150	200	180	180	100	150	150	140/ 170	140/ 170
Dead Trees Standing									
Trees/Acre	0.5*	1	1	1	ND	2.5	2.5	3	4
Size DBH/DRC	9"	10"	14"	14"	10"	14"	16"	12"	16"
Height (Feet)	8'	10'	15'	25'	ND	20'	25'	20'	30'
Dead Trees Down									
Pieces/Acre	2	2**	2	2	ND	4	4	5	5
Size (Diameter)	9"	10"	12"	12"	ND	12"	12"	12"	12"
Length (Feet)	8'	10'	15'	15'	ND	16'	16'	16'	16'
Number of Tree Canopies	SS/ MS	SS/ MS	SS/ MS	SS/ MS	SS	SS/ MS	SS/ MS	SS/ MS	SS/ MS
Total BA, Square Feet/Acre	6	24	70	90	ND	80	100	120	140
Total Canopy Cover, Percent	20	35	40	50	50	50	60	60	70

Source: Santa Fe National Forest Plan

Where stand exam data exists, 14 stands were classified as VSS 5 or VSS 6 conditions at time of inventory. They range in size from 7 to 140 acres each. These stands may exhibit old growth character. They represent 5 percent of the sampled stands, and only 2 percent of the sampled acres. In evaluating VSS 5 and 6 at the plot or clump level, the VSS 5 and 6 clumps represent 14 percent of the ponderosa pine cover type. This is well below historic reference conditions.

In ponderosa pine, the forest plan requires managing for a wide range of VSS classes, distributed in small clumps with openings in between clumps. In ponderosa pine systems, approximately 20 to 40 percent of the clumps should be in VSS 5 or 6, or in a mature to old growth condition. In ponderosa pine under a natural fire regime, it is unlikely that old growth would exist in 40-acre or larger patches, but would instead be peppered throughout the landscape. In mixed conifer stands with a mixed-severity fire regime, old growth may exist in 40-acre and larger patches due to the typical fire disturbance pattern. In spruce-fir forests, old growth may exist in larger, more contiguous areas, as disturbances tend to occur less frequently but over a larger area. In aspen patches, old growth is rare as aspen is an early development ecosystem that is over-taken by various fir and spruce trees over time, and is historically regenerated by a fire or insect epidemic.

Vegetation Management

As previously mentioned, past management activities have contributed to changes in forest conditions. Treatment-specific records of activities occurring before the 1990s are quite limited. The level of detail in treatment records has greatly improved over the past decade, and currently, Geographic Information System (GIS) databases enable the National Forest to maintain accurate records of treatment locations.

Most of the vegetation management activities in the area over the past 30 to 40 years have been intermediate treatments—thinning the smaller trees for a variety of resource objectives. Approximately 2,100 acres of commercial thinnings have been carried out on National Forest land in the assessment area, including sanitation and salvage harvests to remove dead or dying trees, as well as thousands of acres of precommercial thinning. Spacing of saplings and poles after precommercial thinning remained close (8 to 10 feet apart) with the anticipation of a future pulpwood harvest which never came to be. Consequently, many of these areas have received additional non-commercial thinning since the 1990s, while others remain densely stocked.

Approximately 900 acres of regeneration harvests have occurred in the assessment area, mostly in the ponderosa pine forest in the late 1980s and early 1990s. Most were shelterwood prescriptions. The shelterwood harvests removed the understory trees and retained an open canopy of large ponderosa pine trees to provide a seed source for regeneration. Although removal of the overstory was planned for a later date, it never occurred for most of the shelterwood units. In a few stands, shelterwood final removals or other overstory removals were used where there was sufficient pine seedling regeneration, to allow for better growth of the seedlings. Group selection harvests or removals of small patches less than 4 acres in size were also used in some forest stands. No clearcut harvests were conducted in the assessment area.

Reforestation (tree planting) occurred on approximately 1100 acres in the assessment area, mostly in larger wildfire burn areas where seed sources were lacking. Stands were typically planted with 300 trees per acre or more, and with the lack of subsequent fire or thinning, many remain uncharacteristically dense.

Table 21 and Figure 24 summarize the forest and fuels management projects with NEPA analysis and decision documents that were completed over the past 20 years. Several of these projects have not yet been fully implemented. The activities are listed by project area name, in chronological order from the most recent to the oldest, per existing records. Treatments in the Preserve are noted, and all others are on the National Forest. Activity type acronyms used in the table are as follows: IH=Intermediate Harvest (thinned); RH= Regeneration Harvest; B=Burn (burned without mechanical thinning).

Table 21. Vegetation management projects with NEPA decisions completed, 1989-2009

NEPA Decision Date	NEPA Project Name & *Implementation Name*	NEPA Doc. Acres or *GIS map acres*	Activity Types
2007-09-12	**Jemez Collaborative Forest Restoration Program** *Redondo (3 units), East Fork (3 units), and a Mistletoe unit*	203, 47, 142	IH, B
2007-09-12	***Jemez Collaborative Forest Restoration Program: (on Preserve)****t*	*165*	*IH, B*
2006-02-02	**Paliza Burn**	2,100	B
2005-09-21	***Preserve: Valle Toledo RxFire***	*1961*	*B*
2005-08-02	**San Antonio Ck Riparian Thin**	4 miles	IH, B
2005-01-27	**Oak-Pony-Hay Meadow Restoration**	250	IH, B
2004-11-24	**LosConchas Meadow Restoration**	70	B
2004-09	**Cajete Blowdown**	12	RH
2004-08-31	**Monument Canyon Research Natural Area Ecological Restoration Project**	234	IH, B
2004-04-15	**F.Road 10 Thinning (12 mi. road)**	45	IH, B
2003-09-30 amended 2007-01-17	**Forest Health- Stand Improvement (Thinning) Jemez Ranger District Campgrounds** *Jemez Falls-150 acres, San Antonio-20 acres, Redondo- 100 acres,Paliza Family-75 acres, Paliza Group-20 acres*	365	IH, B
2003-08-08	***Preserv: Fuels & Veg Project***	*607*	*IH, B*
2003-08-06	**Lakes Fire Timber Salvage,** *portion within assessment area*	*4,887*	RH
2003-06-10 2002-DN appealed; 2007 clarifctn	**Jemez Wildland Urban Interface Hazard Reduction Project:** *Sierra Los Pinos and Thompson Ridge (portions within assessment area)*	1,948-*2,270*	IH,B
2001-09-17	**Sierra los Piños 2** Fuels Reduction	483-*467*	IH, B
1999-11-22	**Jemez Corridor Fuelbreak**; Forest Rds 607, 1610	970	IH, B
1999-09-28	**EastFork Thinning Fuelbreak**	260	IH, B
1998-01-06	**Thompson Ridge Fuelbreak**	130-*194*	IH, B
1997-09	**Vallecitos Fuelbreak**	500	IH, B
1997-07-09	**San Juan Mesa Burn**	7150	B
1997-03-27	**Monument Cyn Fuelbreak**	50	IH, B
1996-05-31	**Stable Mesa Burn**	6200	B
1995-08-04	**Dollar Fuelwood**	110	IH, B
1995-	**Nicole Fire Salvage**	*288*	IH
1994-	**Cat Mesa Burn**	*1381*	B
1994-09 1995-06-05 DN-Suppl.	**Paliza Vegetation Mgt.:** *GrpSel- 354 ac; Thin-1372 ac; ThinPJ- 20 ac; SpCuts-194 ac; Shltrwd-40 ac; Burn only-4,520 ac.*	6500 total: IH/RH,B: 1980 Burn only: 4520	IH/RH, B

Table 21. Vegetation management projects with NEPA decisions completed, 1989-2009

NEPA Decision Date	**NEPA Project Name & *Implementation Name***	**NEPA Doc. Acres or *GIS map acres***	**Activity Types**
1989-	**Bonito Diversity Unit:** *Bonito, Banco and Bench timber sales*	*7037 (analysis area acres)*	RH, IH, B

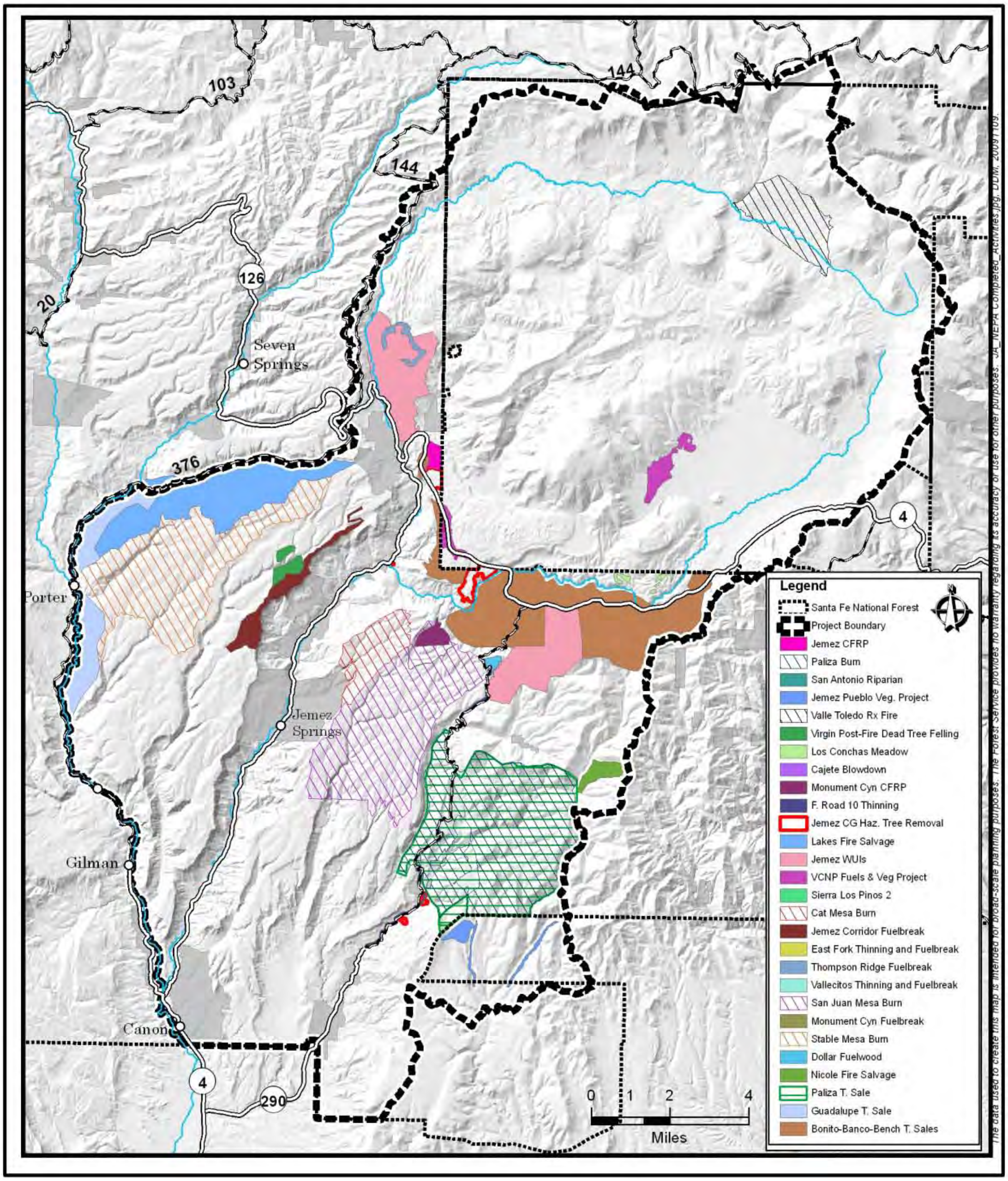

Figure 24. Vegetation management projects with NEPA decisions completed

Fuels and Fire

Introduction and Methodologies

This section evaluates and compares the existing and reference conditions of forest fire and fuels within the assessment area. Reference conditions or management standards come from the 1995 Federal Wildland and Prescribed Fire Policy, the Forest's fire management units (FMUs) and associated objectives. The FMUs identify which wildland fire use strategy is typically preferred based on conditions within a specific geographic area. FMUs also indicate the prescribed fire objectives that apply to a given area (fire management plan section D). Conditions are described in terms of fire regimes (including frequency, extent and intensity of fires), and potential fire behavior, such as the potential for high-intensity crown fire behavior. Definitions of the terminology used in this section can be found in the Glossary.

Some of the modeling tools used in this analysis included:

- Historic fire weather was analyzed to determine winds and fuel moisture conditions during the fire season using FireFamilyPlus (USDA 2002). Adjustments were made based on weather conditions data from the Jemez RAWS station. Wind speed and direction were inputs into fire behavior calculations, using Wind Wizard (Butler et al. 2006) to model variability of wind speed and direction due to topography across the landscape.
- Research on fire history conducted in the Jemez Mountains and other reliable scientific research publications were used to illustrate the departure from reference conditions for each of the ecosystems in the SWJM landscape area.
- The PROBACRE computer program was used to estimate the probability of a single large fire event (over 4,000 acres) occurring within the next 20 years, or a combination of wildfires occurring that exceeds a certain number of acres (Wiitala 2008).
- The latest version of FlamMap/FBAT was used in conjunction with LANDFIRE vegetation and fuels data, as a spatial (mapping) fire behavior risk model. It uses LANDFIRE data (Stratton 2009; www.landfire.gov) to model fire behavior at a single point in time. Fuels and forestry specialists from the National Forest, Preserve, Forest Service Fire Sciences Lab and Washington Office critiqued and corrected LANDFIRE data for this specific landscape, using field verified forest and fuels condition data and walk-thru surveys to adjust the LANDFIRE satellite imagery data to better reflect actual conditions.
- The Forest Vegetation Simulation (FVS) model was used to calculate site specific values for trees per acre, crown density and crown-to-base height, based on inputs of field reconnaissance data, that share common vegetation and fuel characteristics due to past disturbances (wildfire), management activities (harvesting, thinning, burning), biological and physical characteristics (soils, aspect). Potential fire behavior was modeled with FVS to compare with the outputs from FlamMap/FBAT.

Wildfire History

Historic reference condition (pre-1900) fire regimes in ponderosa pine forests of the Jemez Mountains were characterized by high frequency, low intensity low severity fires (Touchan and Swetnam 1995). The Jemez Mountains experience one of the highest levels of lightning activity in the western United States (Reap 1986) resulting in a high frequency of lightning caused fires (Barrows 1978). Figure 25 shows lightning-caused fire ignitions in the area since 1970.

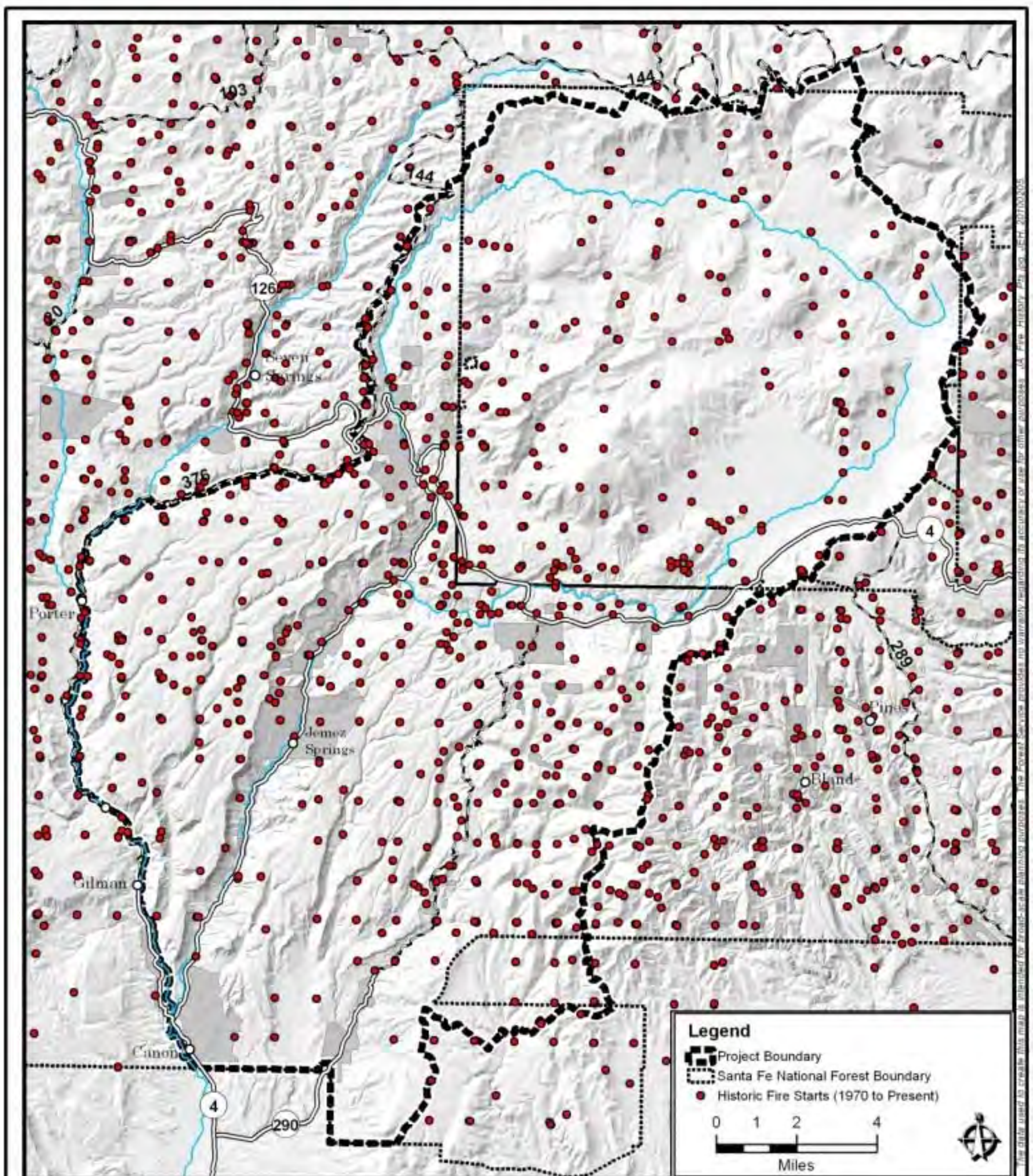

Figure 25. Past fire ignition points, 1970 to 2009

There have been seven large wildfires (over 300 acres) within the assessment boundary in the past 20 years. All of them, with the exception of the Stable, exhibited crown fire behavior, and all of them burned in the direction of the prevailing south-southwest winds that predominate during fire season. The Porter and Cebollita fires burned 8,000 acres in the early to mid 1970s. Just to the east of the assessment area, La Mesa, Dome and Cerro Grande fires burned a combined 80,000 acres, much of them with crown fire. Table 22 and Figure 26 display the recent past wildfires over 200 acres in size that burned in this area.

Table 22. Large fires in the assessment area, 1989 - 2009

Fire Name	Size (Acres)	Cause	Fire Date
Virgin	406	Human Caused	June/2003
Henry	800	Lightning	June/1991
Stable	1246	Human Caused	Oct/1999
Lakes	4095	Human Caused	Aug/2002
Hondo	445	Lightning	Aug/2000
Nicole	400	Lightning	June/1996
Labor	200	Human Caused	August/2002

(Source: Forest GIS database 2009)

Fire Disturbance Regimes

Fire regimes in the mixed conifer forests were characterized by somewhat lower fire frequencies and higher severity than in the ponderosa pine forest (Allen 1984). Prior to 1893, the mean fire return interval (MFI) for the ponderosa pine stands in the Monument Canyon area was 5 years (Swetnam 1995). The MFI for the mixed conifer stands at the Los Griegos Mountain site was 15 years (Swetnam 1995). Patchy crown fires also occurred during some years in the mixed-conifer forests which encouraged the establishment of aspen. Data collected by Swetnam in the Canada Bonito area above Los Alamos indicates a pulse of aspen regeneration in the 1890s, which suggests crown fire occurrence across much of those mixed conifer forest slopes (Allen 1984, Swetnam 1988).

A great deal of variability in past fire regimes existed in the pine and mixed conifer forests of the Southwest. On a local scale, fire behavior and growth are heavily influenced by slope, elevation and aspect as fire patterns tend to follow topographic landforms (Graham 2003, Graham and McGaffrey 2004).

On a regional scale, a change in the climate conditions after 1875 played an important role in the decline of fire occurrence after the late 1800s. Touchan and Swetnam's (1995) climate reconstruction for the Southwest indicates a very wet period occurred from 1875 to 1930. There was a cessation in widespread fire occurrence in the Jemez after 1893 (Allen 1989, Allen 1984), principally because of intensive wide spread grazing. By 1900, intensive livestock grazing had reduced the continuity of the grassy surface fuels and hence the ability of surface fires to spread. Trails created by the herding of animals also disrupted fuel continuity and fire spread patterns. Land use changes have continued to alter the ignition and spread patterns of historical fires (Figure 25). Prior to European settlement fires that ignited in the low elevation grasslands gained access to adjacent forest lands. Now the continuity of fine fuels across these non-forested lands has been reduced or eliminated because of human land use such as development, road construction, and agriculture.

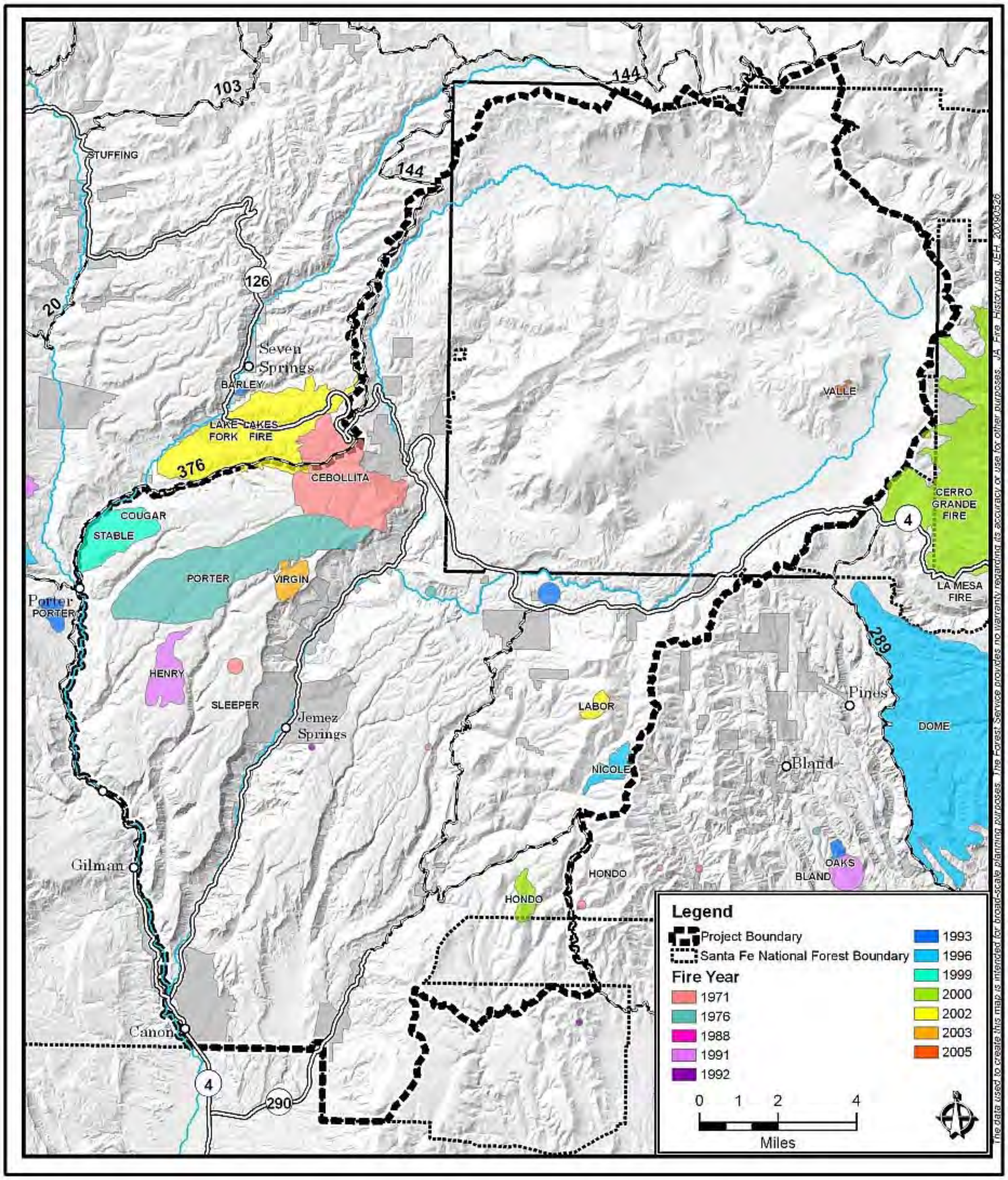

Figure 26. Past wildfires, 1971 to 2009

Fire detection and aggressive suppression programs began in this area in the 1920s, marking the beginning of the era (nearly a century) of fire exclusion. It appears that only a small fraction of the pre-1900 annual average fire acreage is being burned today in the Southwest (Gruell 1985). Gruell estimated that throughout the Rocky Mountain Region, modern fires burn less than one-fourth of the land that burned prior to 1890. Not all ecosystems or plant communities in the Southwest have experienced the impacts of fire exclusion as yet. In some ecosystems such as alpine or desert scrub, fires were important, but their rate of occurrence was low and they have not been as severely altered as the ponderosa pine forests by the relatively short period of fire suppression. Despite these exceptions the Southwestern landscape is not burning at the pre-1900 rate (Covington et al 1994).

Fire suppression (exclusion) has resulted in the most devastating impact on this landscape, in part because the long-term impacts of fire suppression are manifest in nearly every portion of the landscape rather than localized to small areas (Keane 2002). Fire plays a critical role in sustaining forest ecosystems. It recycles nutrients, regulates succession by selecting and regenerating plants, maintains diversity, reduces biomass, controls insect and disease populations, regulates interaction between vegetation and animals, and maintains biological processes (Agee 1993).

Past harvesting and silvicultural practices, such as overstory removal of ponderosa pine, favoring white fir and Douglas fir as the replacement stand, and logging with no follow up slash disposal compounded the effects of fire exclusion. The most documented and studied effect of fire exclusion is the change in stand composition and structure in historic ponderosa pine forest ecosystems. Fire exclusion resulted in dramatic increases in shade-tolerant late seral species such as white fir, and increasing tree densities regardless of site (Figure 27). Increases in tree densities result in increased accumulations of woody surface and canopy fuels. Crown fuels increase because late seral, shade tolerant species tend to have more biomass in the forest canopy due to their leaf areas, and the needles tend to be well distributed over the height of the trees. Shade tolerant species generally have longer needle retention times, and because of their shade-tolerance, they rapidly generate an overabundance of seedlings and saplings in the understory. They also have thinner bark and lower branches than ponderosa pine trees, which makes them more susceptible to mortality in surface fires. Forest composition has gone from shade-intolerant tree species like ponderosa pine to shade intolerant species such as white fir, with stand structure shifts from single-layer canopies to multiple-layer canopies (Keene et al 2002). The combination of greater crown leaf mass distributed along greater parts of the

Figure 27. Old growth ponderosa pine forest invaded by white fir

bole and high seedling and sapling densities create ladder fuels that allow flames from surface fires to climb into the canopy and result in crown fires.

Figure 28 shows an old growth stand of ponderosa pine that was invaded by shade-tolerant Douglas fir and white fir trees as a result of fire exclusion. Under a natural fire regime, a low to moderate intensity surface fire would have killed the fir trees when they were seedlings or young saplings, the large pine trees would have survived, and pine seedlings would have grown into the sunlit openings. The photo was taken north of the East Fork of the Jemez River along the Preserve boundary. The ponderosa pine tree in the foreground is over 400 years old, and there are other large pines in the left margin of the photo. The Douglas fir and white fir trees in the background are 80 to 90 years old.

Figure 28. Typical dense ponderosa pine stand in the area

Stand exam data collected in dry ponderosa pine forest stands show tree densities of 800 to 1,000 ponderosa pine trees per acre, which is much higher than what occurred under historic fire regimes. A sample ponderosa pine stand in the Monument Canyon Research Natural Area was a dense thicket of over 8,700 trees per acre, consisting of mostly saplings and small pole-size trees and about 40 stems/acre of large mature ponderosa pine, prior to being thinned in 2007.

Because of the dry climate, productivity exceeds decomposition and woody surface fuels tend to increase in the absence of fire (Keene et. al.2002). Long periods between fires means dead fuels have more time to accumulate on the ground. Fire suppression/exclusion has allowed for development of highly unnatural stand structures and dead woody fuel accumulations in the ponderosa pine. Accumulations of pine needles and other organic matter have increased in some places by up to 200 percent (Fulè et al 1997). Grass and non-woody plants have dramatically disappeared from the forest floor as the dense tree canopy shaded them out.

Grazing and fire exclusion have resulted in changes to surface fuels, with corresponding changes in surface fire intensities and rates of spread. Prior to intensive grazing and fire suppression, surface fuels that were responsible for carrying fire were grasses intermixed with dead plant material (Figure 29). Note in Figure 28 above, the absence of grass or any vegetation under the dense canopy of ponderosa pine. Under the same weather conditions, a fire burning in grass will spread at 2300 feet per hour and generate flame heights of six feet where a fire burning through pine needles will spread at 528 feet per hour and generate flame lengths of two and a half feet. A surface fire burning through compact fir needles will spread at 100 feet per hour and generate flame lengths of only one foot. The difference in intensities between fuels beds is because the "fluffier" the fuel the more oxygen there is available for the fire to burn, tightly packed fuels burn slower with less intensities than loosely packed fuels.

Figure 29. Herbaceous understory recovery after thinning and burning

Historically surface fires in the forest were probably more intense and faster moving than surface fires are today. However, the accumulations of large diameter woody fuel and litter and duff layers have probably increased the severity of today's fires. Large logs and heavy duff burn and smolder for extended periods of time known as residence time. Increased residence times promote the formation of water-repellant layers at or near the soil surface, and loss of soil structural stability. The results are increased run-off and soil particle detachment by water and increased transport off-site (erosion). Generally, there is a close correlation between soil properties and the amount of heat experienced by the soil as well as the residence time of the heat in contact with the soil.

Fire Regime Condition Class

Fire Regime Condition Class (FRCC) measures the degree of departure (gap) between existing conditions and reference conditions[1]. Causes of this departure in this area include fire suppression, livestock grazing, and timber harvesting, as just discussed (Schmidt et al 2002). FRCC represents the current ecological trend in forest structure, composition, and processes. FRCC is commonly reported in three classes:

- FRCC 1: No or low departure
- FRCC 2: Moderate departure
- FRCC 3: High departure

FRCC was measured using the Standard Landscape Mapping Method (Hann et al. 2008), using the FRCC Mapping Tool (FRCCmt) version 2.2.0, was applied to geospatially assess FRCC departure metrics for the project area. The FRCCmt produces consistent, objective, and spatially specific output data for multiple scales. The FRCCmt requires geospatial data on biophysical setting (BpS), succession class (S-Class), and landscape units, plus the tabular dataset of reference conditions.

The BioPhysical Setting (BpS) layer was downloaded from the LANDFIRE products. Biophysical settings are the primary environmental descriptors used for determining a landscape's natural fire regimes[2], vegetation characteristics, and resultant FRCC departure metrics. Biophysical settings use dominant vegetation types and their associated fire regimes. Map units are classified using NatureServe's Ecological Systems classification and represent the natural plant communities that may have been dominant on the landscape during the reference period and are based on both the current biophysical environment and an approximation of the historical disturbance regime.

Each BpS is associated with a vegetation dynamics model, which is used to quantitatively assess information about the rates and pathways of vegetation succession and the frequency and effects of disturbances during the reference condition period. Each model is created through a series of expert workshops and a review process that engages regional experts from around the country and is based on expert knowledge and published literature. Each model includes comprehensive documentation that describes the vegetation, geography, biophysical characteristics, succession stages, and disturbance regimes of the BpS. Figure 30 displays a map of the major (largest, grouped) biophysical settings in the assessment area.

[1] 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" (Hann and others 2008).

[2] 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).

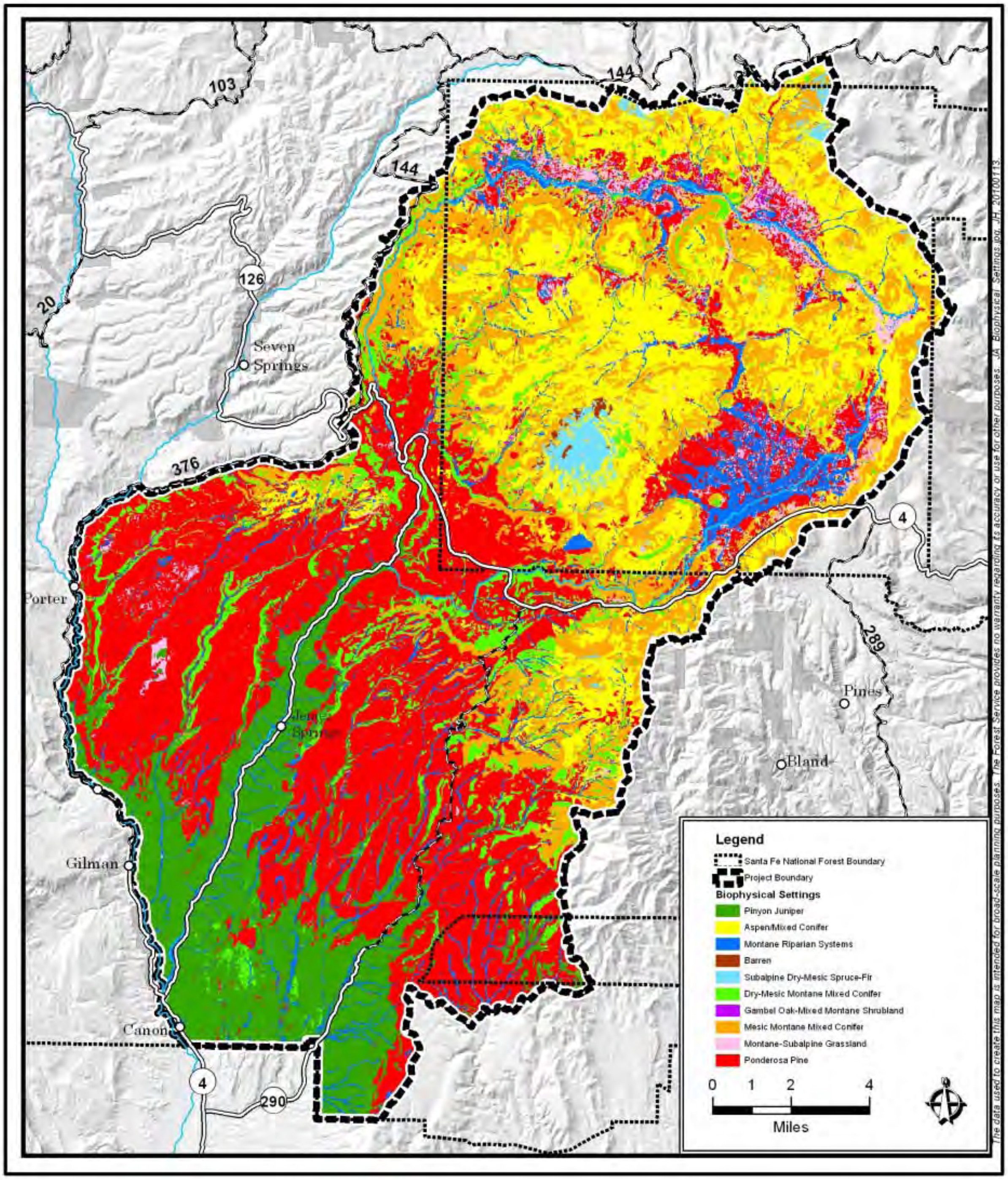

Figure 30. Major biophysical settings (ecosystem types)

Succession classes (S-classes) are characterized by the structural traits for each BpS vegetation type. For any given stand, only one S-Class can occur at a time. However, multiple succession classes can occur in different stands across a given BpS. While there are five standard S-classes in forest ecosystems, grasslands may have only one to three S-classes (Hann et al 2004).

Figure 31 is a map displaying the distribution of S-classes across this landscape area. The area is clearly dominated by mid-stage closed canopy forest, in nearly all forested ecosystems. This differs from the more structurally diverse and more open canopy conditions that historically dominated the ponderosa pine forest, woodlands, and dry mixed conifer forests covering most of this landscape. Figure 32 shows photos and dynamic flows of S-classes for a forest ecosystem (Agee and Skinner 2005).

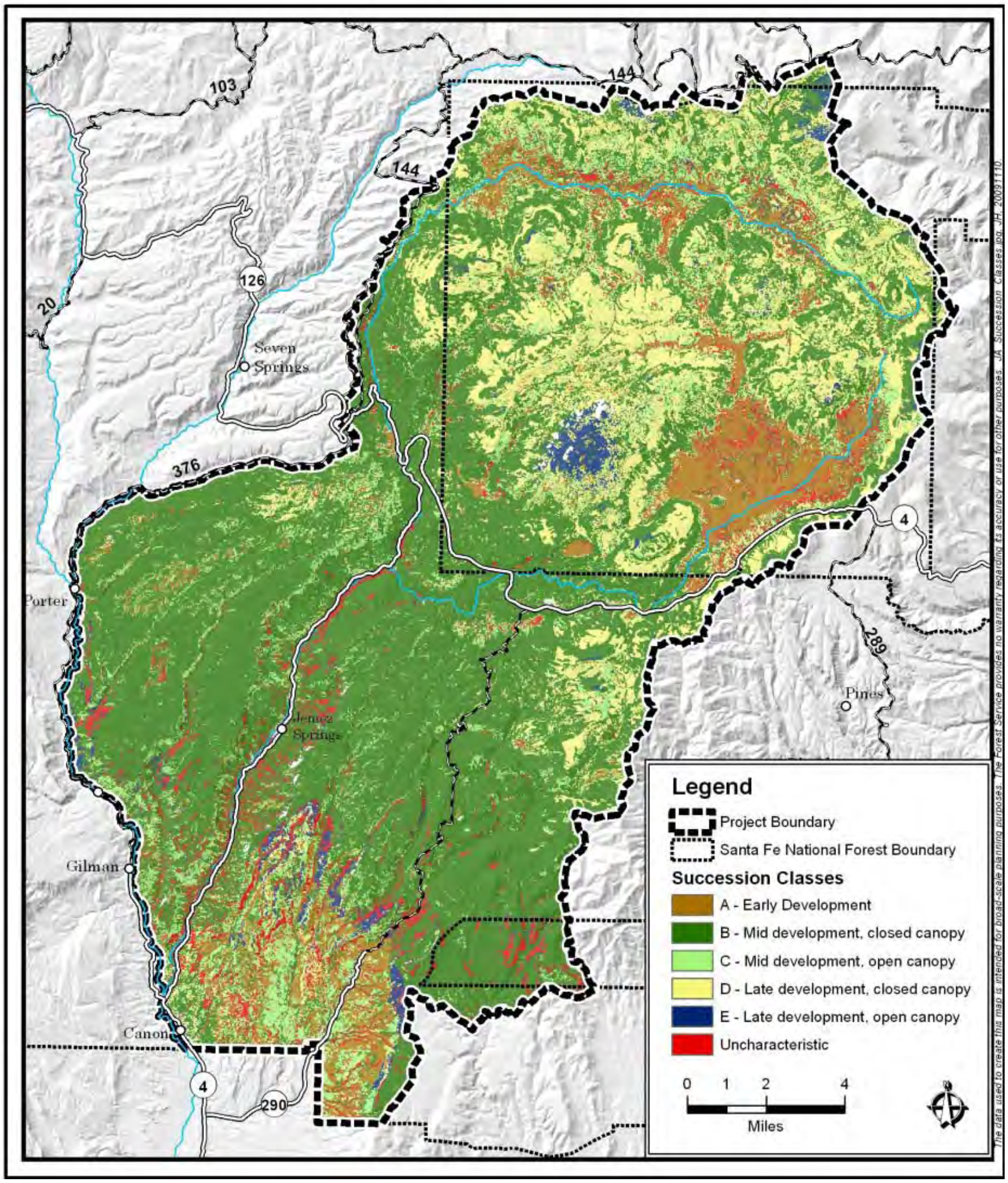

Figure 31. Forest succession classes (structural stage and canopy closure)

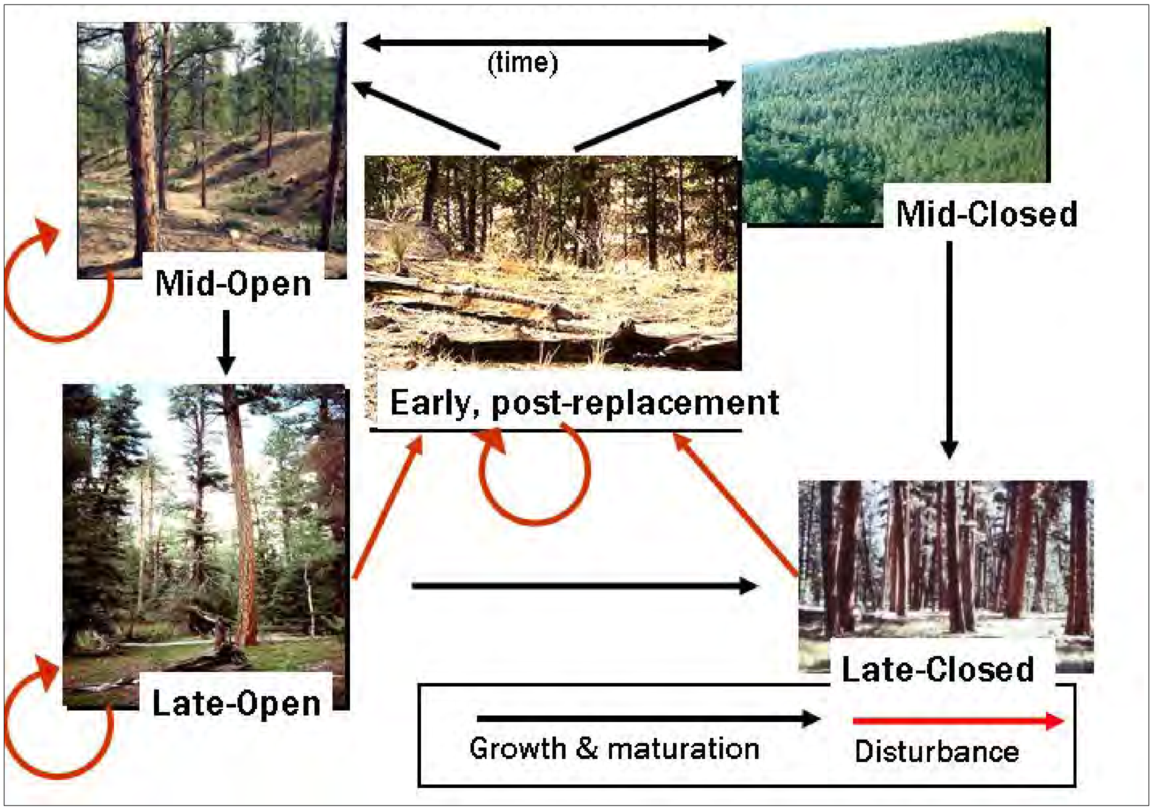

Figure 32. Succession class dynamics, early-open to late-closed forest

FRCC analysis involves the following data assumptions and limitations:

- The BpS layer represents an ecosystem's reference condition based on an estimated historic range of variation and disturbance regimes.
- The historical range of variation may portray climatic conditions that are not representative of current and future conditions. The reference conditions used in this analysis represent conditions that are considered to be resilient and capable of supporting future biodiversity at the landscape scale.
- FRCC departure estimates are sensitive to the S-Class layer mapped by LANDFIRE, which is assumed to represent the current distribution of vegetation composition and structure.

Results from the FRCC analysis found that 94 percent of the assessment area is departed from reference conditions, with 53 percent being moderately departed and 41 percent highly departed. Thus most of the ecosystems in the area are in FRCC 2 or 3, which makes them highly susceptible to uncharacteristic wildfires.

Table 23 shows the S-class reference conditions for major biophysical settings within the assessment area; for biophysical settings totaling over 2,500 acres within the entire assessment area. They are listed in order of abundance in the area. Some LANDFIRE map units were corrected based on more accurate data regarding the biophysical settings known to occur in certain geographic locations in the area. For example, LANDFIRE map units originally identified as madrean encinal, big sagebrush shrubland, and juniper woodland were found to be located within and correlated with the Southern Rocky Mountain piñon-juniper woodland biophysical setting. Other corrections included changing LANDFIRE's agriculture map unit to grasslands, and a few other minor corrections.

Table 23. Reference condition successional class distribution among the major biophysical settings

Biophysical Setting	Percent of Area	Successional Classes				
		Early	Mid Closed	Mid Open	Late Open	Late Closed
Southern Rocky Mountain Ponderosa Pine	35%	10	10	25	40	15
Inter-Mountain Basins Aspen-Mixed Conifer (Rocky Mountain Aspen)	19%	25 (5)	40 (35)	5 (60)	30 (0)	0 (0)
Southern Rocky Mountain Mesic Montane Mixed Conifer	15%	10	40	25	10	15
Colorado Plateau/Southern Rocky Mountain Pinyon-Juniper Woodlands	14%	5	20	30	35	10
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer	7%	15	15	10	50	10
Rocky Mountain Montane Riparian	7%	65	35	0	0	0
Southern Rocky Mountain Montane-Subalpine Grassland	2%	20	30	50	0	0
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir	2%	15	20	15	20	30

The successional class layer from LANDFIRE for current vegetation. FRCCmt compares current successional classes and their historical reference conditions to assess departure of vegetation characteristics within a landscape. The fire regime, size of the landscape, and amount and extent of the BpS should be taken into account when interpreting FRCC analysis results. The size of the landscape used to assess FRCC is based on the dominant fire regime of each BpS. The FRCC guidebook recommends using relatively small watersheds, 6th level HUCs- 10,000 to 40,000 acres, where small patchy fires in regime class I or II dominated historically (Hann et al 2004). Where variable-sized, mixed-severity fires dominated, mid-scale 5th-level watersheds- 40,000 to 250,000 acres are recommended. In areas dominated by large, replacement-severity fires, subbasins at the 4th level HUC- approximately 450,000 acres are recommended.

Three fire regime groups are associated with the biophysical settings within the area. Table 24 shows the natural fire regimes within the assessment area and the scale at which each was assessed.

Table 24. Natural fire regimes: frequency, severity, and typical watershed size

Fire Regime	Frequency (years)	Severity	Severity Description	HUC Level
I	0 – 35	Low/mixed	Generally low severity fires replacing less than 25% of the dominant overstory vegetation. Can include mixed severity fires that replace up to 75% of the overstory.	6th
III	35 – 200	Mixed/low	Generally mixed severity, can also include low severity.	5th
IV	35 - 200	Replacement	High severity, replacing more than 75% of the overstory vegetation.	4th

Other FRCC-based metrics useful for evaluating the need for ecosystem restoration include:

- **BpS departure**: overall departure across all succession classes within a particular BpS
- **S-class departure**: succession classes that are departed within a given BpS and landscape
- **S-Class relative amount**: amount of an S-class that is deficient or excessive relative to the reference condition: Trace, Under-represented, Similar, Over-represented, or Abundant.

Table 25 shows the S-class relative amount and FRCC for the two dominant biophysical settings in the assessment area. Other tables comparing reference to current conditions are in the project record.

Table 25. S-class relative amounts for the two dominant biophysical settings

BpS Name	S-Class	Reference %	Current %	Acre Difference	S-Class Rel. Amt.
Mesic Montane Mixed Conifer	A-early	10	0.8	-2522	trace
Mesic Montane Mixed Conifer	B-mid closed	40	92.8	14539.9	over rep
Mesic Montane Mixed Conifer	C-mid open	25	4.6	-5631.6	trace
Mesic Montane Mixed Conifer	D-late closed	10	0	-2755.1	
Mesic Montane Mixed Conifer	E-late open	15	0.2	-4089.9	trace
Mesic Montane Mixed Conifer	U- unchar	0	1.7	458.8	abundant
Ponderosa Pine	A	10	10.2	43.8	similar
Ponderosa Pine	B	10	72.1	14757.6	abundant
Ponderosa Pine	C	25	10.5	-3445.2	under rep
Ponderosa Pine	D	40	0.7	-9335.7	trace
Ponderosa Pine	E	15	1.1	-3293.8	trace
Ponderosa Pine	U	0	5.4	1273.2	abundant

The mixed conifer and ponderosa pine biophysical settings that comprise at least 50 percent of the area are significantly departed from reference conditions. The ponderosa pine forest is highly departed from reference in all S-classes. Both biophysical settings show an excess of acres in the mid-development, closed canopy S-class and a deficit in the older structural classes and more open canopy structures. These results suggest a need to thin smaller trees within the dense mid-stage closed canopied stands (mechanically or with prescribed fire). This would still leave a shortage of late-development, open and closed canopy stands that only time and succession can mitigate but may have the additional benefit of reducing crown fire potential by reducing canopy bulk densities and raising canopy base heights.

Approximately 94 percent of the assessment area is in FRCC 2 to 3; moderately to highly departed from ecological reference conditions. Only 6 percent of the assessment area (excluding rock and waterbodies) was estimated with no significant departure (FRCC 1). Those FRCC 1 areas are located primarily in the moist meadows, riparian areas, and ridgetop grasslands (see Figure 33). Nearly all forested ecosystem areas are in FRCC 3, and the remaining are in FRCC 2. Ponderosa pine accounts for 74 percent of the FRCC 3, and the mesic (moist) mixed conifer 17 percent. About 75 percent of the FRCC 2 is from the aspen-mixed conifer (35 percent), mesic (moist) mixed conifer (29 percent), and piñon-juniper (11 percent). The mid-successional closed-canopied acreages are clearly over-represented throughout most of the assessment area. The late-successional open and closed classes are the most under-represented, compared to reference conditions. Figure 33 shows the distribution of FRCC classes in the area.

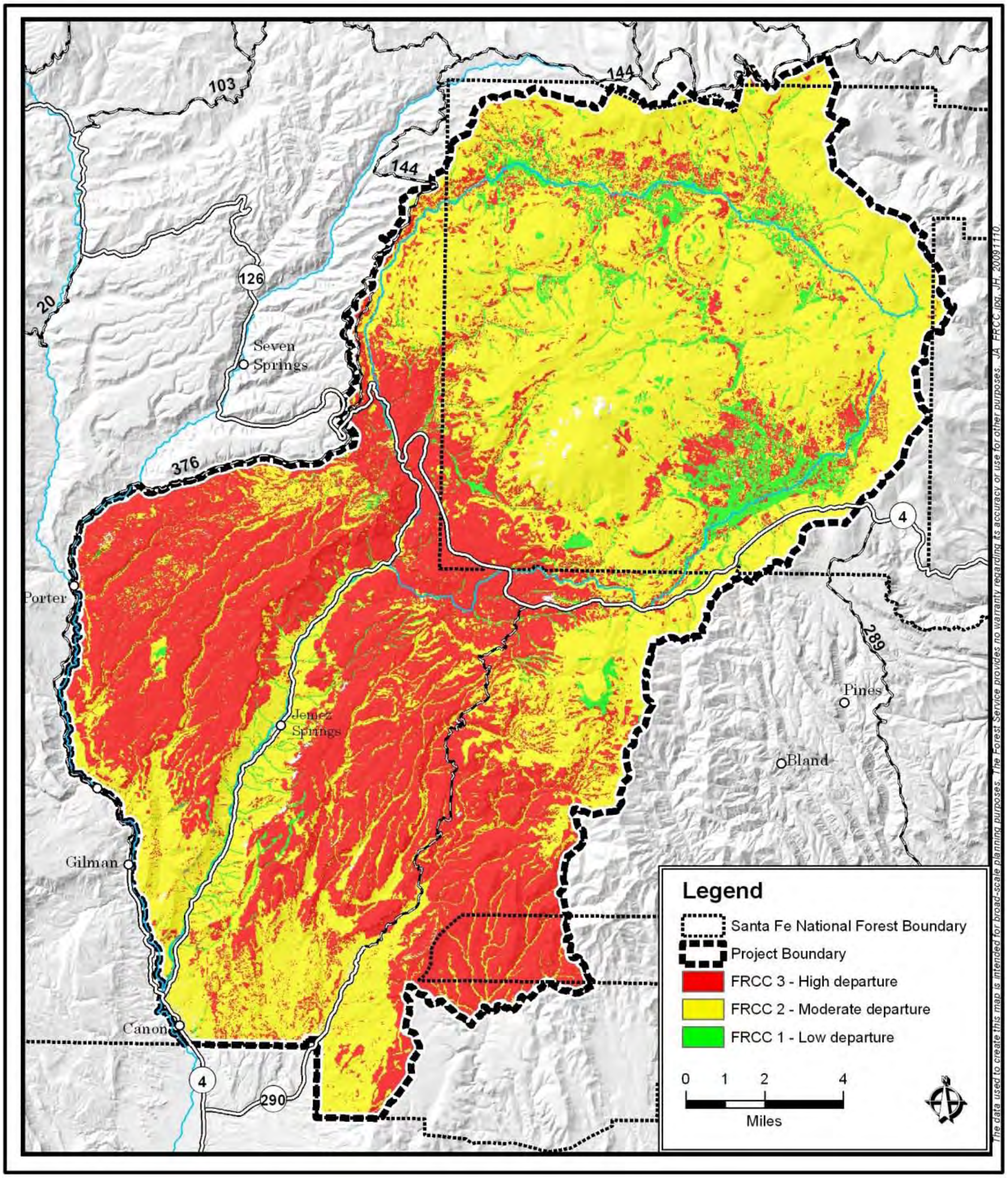

Figure 33. Fire regime condition class distribution across the landscape

Table 26. FRCC departures for major biophysical settings

Biophysical Setting	HUC Level	FRCC	Acres	Difference from reference condition
Ponderosa Pine	5th	3	67,438	74% of the FRCC 3 in the project area Surplus of mid-development closed canopy stands Deficit of open canopy and late-development closed
Aspen-Mixed Conifer	6th	2	38,644	Surplus of late-development open and closed canopy stands Deficit of early development and mid-development closed stands
Mesic Montane Mixed Conifer	5th	2	32,209	Over 90% in mid-development closed canopy No late-development open canopy stands were mapped in the area Only trace amounts of the other succession classes
Pinyon-Juniper Woodland	5th	2	15,904	Surplus of mid-development closed canopy stands Deficit of all other succession classes Uncharacteristic vegetation high (>20%)
Dry-Mesic Montane Mixed Conifer	6th	3	14,952	17% of the FRCC 3 in the area Surplus of mid-development closed canopy stands Deficit of early development and late-development open and closed Mid-development open canopy stands highly variable
Montane Riparian Systems	5th	1 & 2	13,942	Upper Jemez River 5th level HUC has similar percentages of early and mid-development succession classes Uncharacteristic vegetation accounts for 16% in Upper Jemez River Other 5th level HUCs have over-representation of mid-development Uncharacteristic vegetation accounts for up to 17%

Fire Behavior

Historical fire weather analysis utilized Remote Automated Weather Stations (RAWS) weather data 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. Table 27 summarizes the length of data and some station information. The Jemez station data was determined to best represent the assessment area while the Tower data was used for landscape calibration using FARSITE.

Table 27. RAWS station information in the Jemez Mountains

Station Name	Station Number	Record Period	Elevation (ft)
Jemez	290702	1966 - 2009	8,000
Tower	290801	1964 - 2009	6,500

Historic fire weather was analyzed to determine winds and fuel moisture conditions during the fire season using FireFamilyPlus (US Forest Service 2002b). 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. FlamMap adjusts fuel moisture for each pixel of the landscape to account for aspect, elevation, slope and canopy cover. Adjustments are based on weather conditions data from the Jemez RAWS station. Wind speed and direction are inputs into fire behavior calculations. Wind Wizard (Butler et al. 2006) was used to model variability of wind speed and direction due to topography across the landscape.

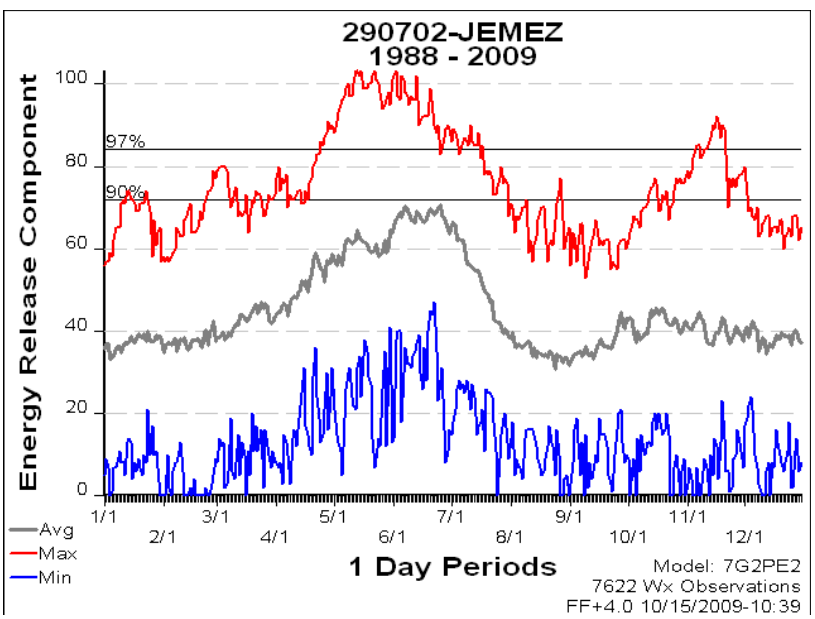

Figure 34. Graph of energy release component from the Jemez RAWS station, for year round data, 1989 – 2009

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

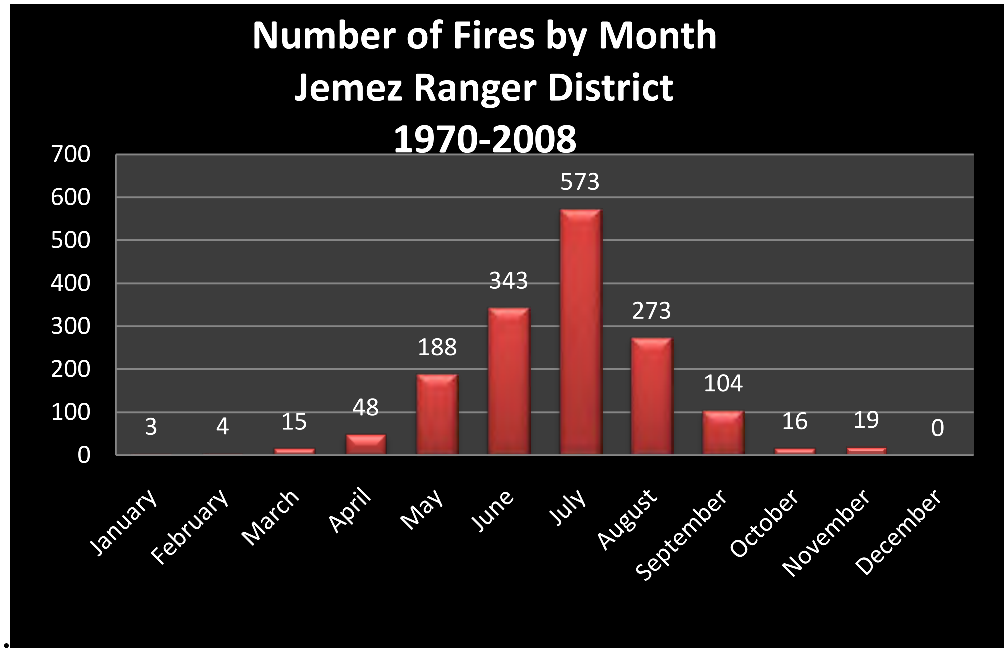

Figure 35. Fire occurrence 1970 to 2008 on the Jemez Ranger District, Santa Fe National Forest

The PROBACRE Model for Computing Aggregate Burned Acreage Probabilities for Wildfire Risk Analyses (Wiitala 2008) was used for assessing the probability of crown fire behavior in the area. Inputs included historical fire size and annual occurrence over the past 20 years, such as: four 400-acre fires with an annual occurrence of 0.20, one 800-acre fire with annual occurrence of 0.05 and one 4,000-acre fire with an annual occurrence of 0.05. All probabilities were computed from information on the annual fire frequency data by size class. Burned acreage probability estimates were made on the assumption that the number of fire events in any period follows a Poisson probability model. PROBACRE assumes that the frequency and distribution of fire sizes will remain constant over any assessment time frame.

PROBACRE determined an annual probability of **not** having a fire of at least 4,000 acres to be 36 percent over the next 20 years. There is equal probability of having one 4,000-acre fire every year over the next 20 years, and an 18 percent chance of having two 4000-acre fires a year over the next 20 years. It estimated a 65 percent probability of wildfires exceeding 4,000 burned acres.

Table 28. Probability of fire occurrences, per PROBACRE model results

Size Class (Ac)	Annual Fire Frequency	Probability of Number of Fires Per Period					
		None	1 fire/year	2 fires/year	3 fires/year	4 fires/year	>4 fires/year
400	0.2	0.02	0.07	0.15	0.19	0.19	0.37
800	0.05	0.37	0.37	0.18	0.06	0.01	0.003
4000	0.05	0.36	0.36	0.18	0.06	0.01	0.003

Probability of exceeding 4,000 threshold in 20 years is 0.654; Probability of exceeding 20,000 threshold in 20 years is 0.004 (Wiitala 2008)

The FlamMap modeling system (Finney 2006) was used to assess distribution of potential fire behavior characteristics in the assessment area. Specific characteristics assessed were fireline intensity expressed as flame length, rate of spread, and type of crown fire activity. FlamMap was used to estimate burn probability, 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.

To model fire behavior in FlamMap, fuel moistures and conditioning periods were selected to represent 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 (respectively to represent Dome and Cerro Grande fire weather). 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 with a modal value of 2 percent. For dry conditions, one-hour fuel moistures ranged from 2 to 9 percent across the landscape with a modal value of 4 percent.

Live 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 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 to 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 (1,000 to 2,000 hours) are somewhat variable, but are predominantly out of the southwest to west. Wind gusts of 30 to 40 miles per hour are fairly common. Winds of 30 mph from the southwest were used for analysis. Figure 36 graphically shows the 1000 to 2000-hour wind speeds, April through October, from the past 10 years of recordings at the Jemez Springs climate station.

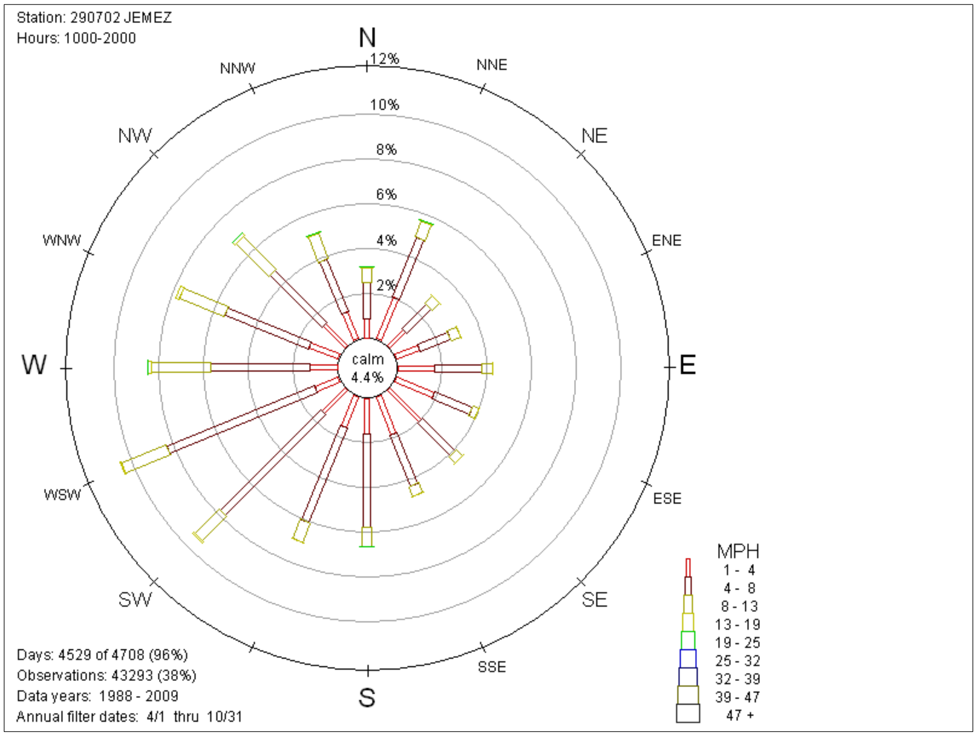

Figure 36. Wind speeds at Jemez RAWS Station, Apr-Oct. 1988 – 2009

Fuel models were inputs to the FlamMap model, to help predict surface fire behavior and transition to crown fire. The original fuel models from LANDFIRE data were refined based on field verified data from specific locations in the area. There are approximately 15 different fuel models identified in the area.

About 40 to 52 percent of the assessment area is mapped as fire behavior fuel model timber-understory 5 (TU5) and timber understory 1(TU1). The primary carrier of fire in timber understory is grass, shrub, litter, and small tree understory. About 20 to 33 percent of the area is mapped with a timber litter (TL) fuel model. The primary carrier of fire in the timber litter fuel models is dead and down woody fuel. Live fuel, if present has little effect on fire behavior. The remainder of the area is mapped as grass, grass-shrub or shrub. Fire behavior characteristics are directly related to fuel models, but vary with fuel moisture and wind. Table 29 shows the fuel models in the assessment area and their relative amount, in acres and percent of the entire area.

Table 29. Fuel models and acreages

Fuel Model	Fuel Model Descriptor	Forest		Preserve	
		Acres	Percent of Total	Acres	Percent of Total
TU5	Very high load, dry climate timber-shrub	61,733	29	33,924	39
TL8	Long needle litter	51,201	24	5,246	6
TU1	Low load dry climate timber-grass-shrub	20,251	10	10,902	13
TL3	Moderate load conifer litter	17,654	8	12,050	14
SH1	Low load, dry climate shrub	14,524	7	9	<1
GR2	Low load, dry climate grass	13,413	6	10,279	12
Custom	Moderate load, dry climate wetland	6,991	3	6,602	8
GS1	Low load, dry climate grass-shrub	6,026	3	851	1
GS2	Moderate load, dry climate grass-shrub	5,359	3	1,884	2
GR4	Moderate load, dry climate grass	4,043	2	3,321	4
GR1	Short, sparse dry climate grass	3,347	2	261	<1
SH2	Moderate load, dry climate shrub	2,534	1		
SH7	Very high load, dry climate shrub	745	<1	167	<1
TL1	Low load, compact conifer litter	724	<1	251	<1
SH5	High load, dry climate shrub	57	<1		

Fires are likely to exhibit a wide range of flame lengths and rates of spread and are likely to be crown fires in forests where there are sufficient surface fuels in association with low canopy bases to support crown fire. The FlamMap/LANDFIRE analysis resulted in comprehensive data tables of the predicted crown and surface fire behavior, including flame length, fire size, rate of spread, and other attributes, within each fuel model (available in fire and fuels specialist report and project record). While dry conditions have fewer acres of active crown fire and lower flame lengths and rates of spread, the patterns across fuel models are similar. Under maximum and dry conditions, flame lengths range from less than 1 foot to several hundred feet in forests where there are sufficient surface fuels in association with low canopy bases to support crown fire. The dominant TU5 fuel model will have the most potential for crown fires. Rates of spread range from less than one to several hundred chains per hour. Generally fire behavior will be dominated by active surface fire in the grass, shrub, and forest communities with little live surface fuels and crown fire in forests represented by timber understory fuel models.

On the Preserve, a higher proportion of the landscape is predicted to experience crown fire due to the higher percentage of the landscape being represented as timber with heavy understory fuels. Wet meadows in the south 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 are expected to experience fire behavior similar to the moderate load, dry climate grass (GR4).

The entire assessment area has vegetation and fuel conditions that support fire, and most of the area supports crown fire behavior. The probability of fire burning on the landscape is greatly related to the arrangement of fuels on the landscape, which determines how fires move across a landscape (Figure 37). The forested slopes in the Preserve have the highest probability of burning within the assessment area, and a fire could reasonably be foreseeable to burn into Los Alamos, the National Lab complex, Santa Clara Pueblo and Bandelier National Monument. Under maximum conditions, forests in the southern portion of the assessment area have the highest burn probabilities, along with areas north and east of the assessment area (Figure 37). Flame length includes flame length when crown fire is predicted Figure 43 displays the predicted distribution of crown fire, both active and passive crown fire, likely to occur on this landscape, under extreme fire weather conditions. Extreme fire weather conditions occur at some point nearly every fire season. The remaining areas are more likely to burn as surface fire. In order to treat the assessment area to disrupt the growth of large crown fires, fuel treatments would need to be arranged in an optimal pattern over at least 1 to 2percent of the landscape each year (Finney et al 2007).

Fuels and Fire Hazard by Geographic Area

Geographic subdivisions of the assessment area were mapped based on areas that share common biological and physical characteristics (soils, aspect), or vegetation and fuel characteristics due to past disturbances (wildfire) and management activities (harvesting, thinning, burning). Each geographic area has a distinguishing set of fuel conditions that influence the need and opportunity for restoring natural fire regimes. Data on fuel quantity and arrangement, crown to base heights, species composition, tree density and arrangement was gathered in each block, along with photo point data, in representative locations. The data is not statistically robust but provides a basis for the characterization of forest conditions. The data was input into the Forest Vegetation Simulation Model (FVS) to calculate site specific values for trees per acre, crown density and crown-to-base height. Potential fire behavior was modeled with FVS for the sample plots to compare with the outputs from FlamMap/FBAT. Figure 38 is a map showing these distinct geographic areas.

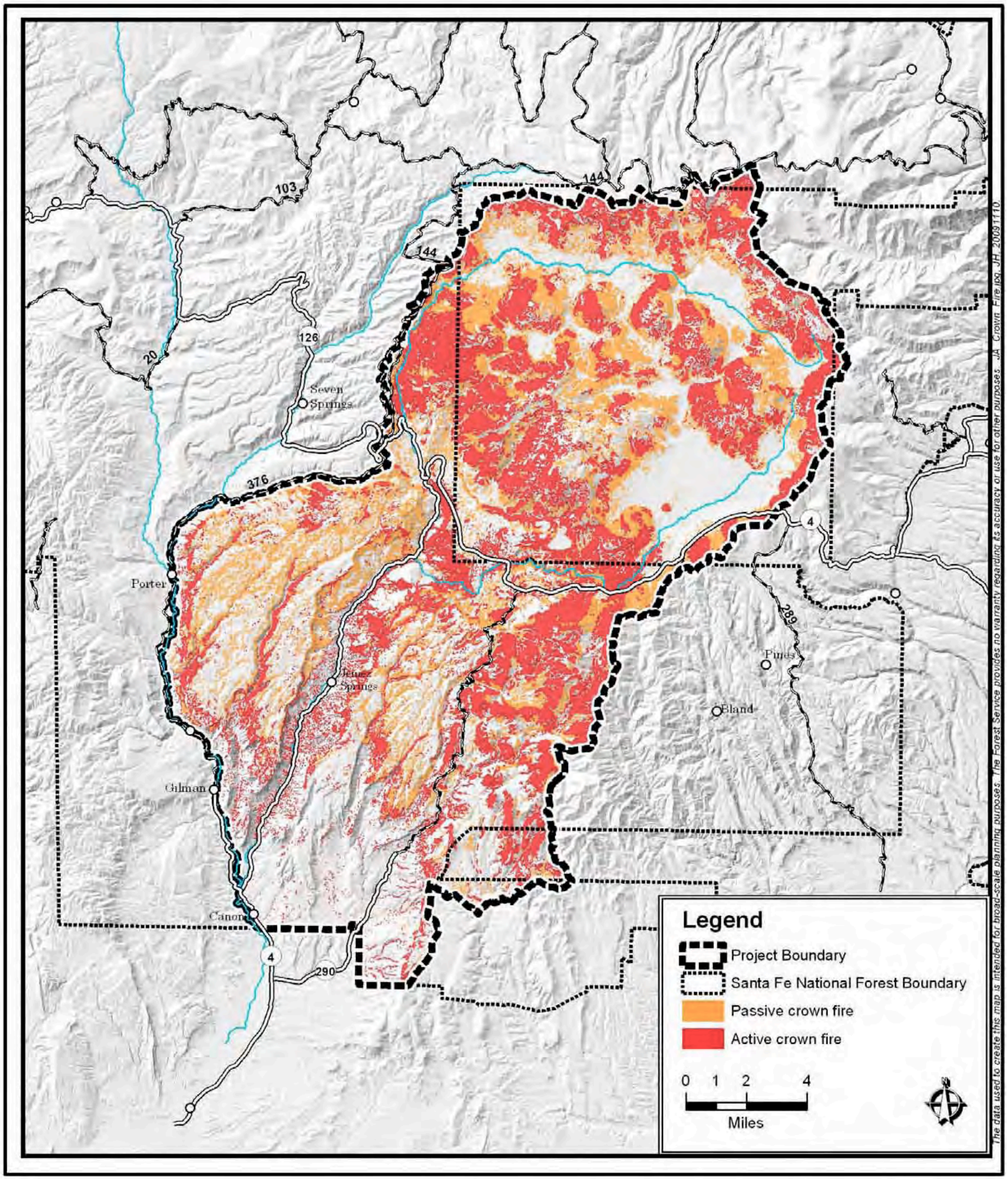

Figure 37. Crown fire risk under extreme fire weather conditions

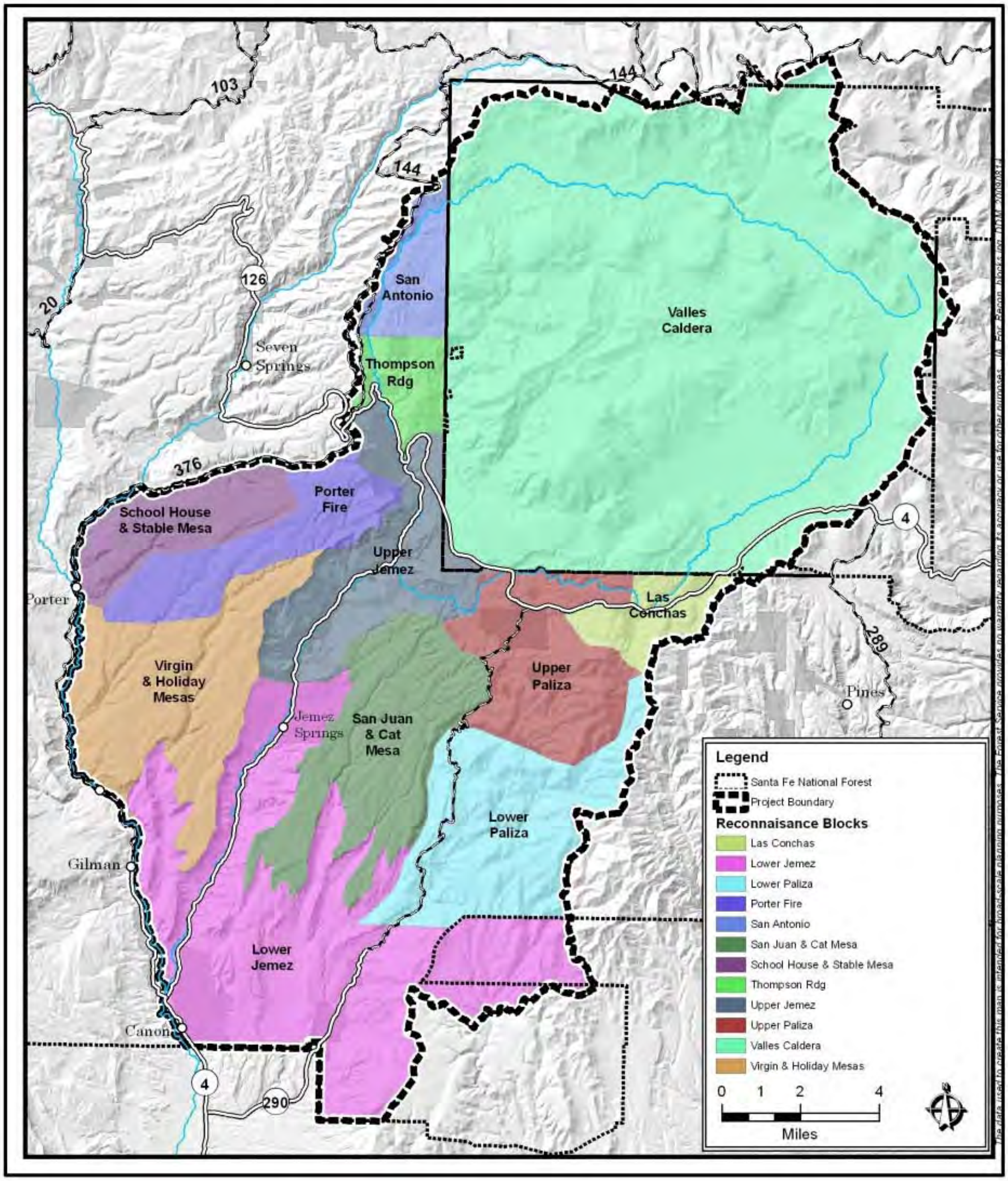

Figure 38. Geographic areas with similar physical characteristics

For each geographic area, the FlamMap model was used to predict crown fire hazard. Crown fire hazard includes six ratings: low, moderate, high, very high, severe, and extreme. They are based on the relationship between torching and crowning indices. These indices indicate the relative susceptibility to crown fire behavior. Torching index (TI) and crowning index (CI) quantify the amount of wind required to initiate crown fire (torching of the tree crown) and spread (Scott and Reinhardt 2001). The lower the index value, the higher the potential for initiating crown fire. In a dense, multi-storied stand, lower wind speeds (low TI and CI) can initiate extreme crown fire behavior. In a more open stand, higher wind speeds (high TI and CI) are needed to initiate and spread a crown fire. Thus, fuel conditions that yield lower torching and crowning indices have higher crown fire hazard ratings. Wind speeds used in the fire modeling assume a 20-foot open wind speed. The following table shows the relationship between TI, CI and crown fire hazard ratings used in this assessment.

Table 30. Relationship between torching index (TI) and crowning index (CI) and crown fire hazard ratings

	Low TI 0 -16 mph	**Moderate TI 16 -40 mph**	**High TI 40+ mph**
Low CI 0 -16 mph	Extreme	Severe	Very High
Moderate CI 16 -40 mph	Severe	High	Moderate
High CI 40+ mph	High	Moderate	Low

Source: US Forest Service, Paul Langowski and Eric Twombley

The following table shows the potential fire behavior and related characteristics under severe fire weather, for each geographic area. It shows the current average trees per acre and diameter (at breast height), as well as the crown base height (distance from ground to bottom of tree branches or crown), and crown bulk density, although these average attributes vary widely within these large blocks. It also shows the expected surface fire flame length and crown fire hazard rating, predicted by the model.

Table 31. Potential fire behavior under severe weather, by geographic area

Geographic Area	Trees per Acre	Average Diameter (in)	Crown Base Height (ft)	Crown Bulk Density (kg/m3)	Surface Flame Length (ft)	Crown Fire Hazard Rating*
Thompson Ridge/San Antonio Canyon	798	5.7	13	0.350	3.7	High
Cebollita and Porter	539	5.7	8	0.048	2	Low
School House Mesa Area	799	5.5	6	0.063	3.4	High
South aspect of unnamed canyon in School House Mesa Area	56	18	53	0.30	4.6	Low

Table 31. Potential fire behavior under severe weather, by geographic area

Geographic Area	Trees per Acre	Average Diameter (in)	Crown Base Height (ft)	Crown Bulk Density (kg/m3)	Surface Flame Length (ft)	Crown Fire Hazard Rating*
Virgin and Holiday Mesas	1,044	5.6	2	0.135	2.3	Severe
San Juan/Cat Mesas, excluding Monument Canyon	232	9.8	24	0.068	3.1	Moderate
Upper Jemez Canyon	944	5.8	9	0.350	2.1	Severe
ponderosa pine in Paliza Canyon area	2,487	3.1	4	0.072	3	High

Thompson Ridge/ San Antonio

San Antonio Creek runs north south through a canyon that splits the block. The canyon is a cold air drainage, which favors blue spruce along the bottom. The largest spruce trees are 80 to 100 years old, suggesting they became established right after heavy sheep grazing stopped and fire exclusion began. Larger diameter ponderosa pine and Douglas fir are mixed with a dense shade-tolerant conifer understory. The larger ponderosa and Douglas fir are over 300 years old. The combination of extensive ladder and surface fuels (over 20 tons per acre), canyon alignment with south winds, and steep slopes make this area highly susceptible to crown fire under extreme fire weather. On the east side of the canyon below and south of the Thompson Ridge community is a stand of large old growth ponderosa pine with an understory of over 800 saplings per acre.

Figure 39. Larger ponderosa pine and Douglas fir trees are scattered in the younger white fir understory, above San Antonio Creek

There is currently a 500-acre contract to thin and pile the sapling understory for burning in the winter. Within the 500 acres is a section of private land and several houses. There have been no Firewise measures taken by these residents. County Rd 106 is the only road access into Thompson Ridge. A contract was completed in 2008 for thinning and masticating the slash for 300 acres along Rd 106, with the intent of securing an evacuation route for the community in the case of wildfire. These 300 acres are scheduled to be prescribed burned in 2009. The area north of Thompson Ridge and east of San Antonio Creek is an extensive mixed conifer stand with a short needle surface fuel bed typical of a mixed severity fire regime (see Table 31).

Porter and Cebollita Fire

The Porter and Cebollita Fires on Holiday and Stable Mesas burned 8300 acres in the 1970's. At that time, the timber production objective following forest fires drove the cutting of all trees exhibiting any degree of crown scorch (many would have survived). The Porter and Cebollita fire areas were planted with ponderosa pine seedlings according to guidelines that maximized timber production.

Figure 40. Planted Cebollita Fire area, with suppressed pole-size trees and no herbaceous understory vegetation

Planted areas seeded in with more ponderosa pine and Douglas-fir seedlings. Scattered patches of pole size trees are present but not extensive. Aspen regenerated extensively throughout the burns. It forms a mosaic, interrupting crown fuel continuity and reducing the potential for crown fire initiation and spread. Surface fuels are sparce and compact. The area is heavily grazed and Kentucky blue grass is dominant on moist sites (see Table 31).

Figure 41. Young aspen in the Cebollita Fire area

School House Mesa

The School House Mesa Area sits between the 2005 Lakes Fire and the Porter Fire. There are no recently cut stumps-only stumps from harvesting in the early 1900s. The majority of the mesa top is covered with ponderosa pine pole and sapling stands, thinned in the 1970s. Tree density is still high, averaging 799 tree per acre. Stand structure is homogeneous (uniform) with few trees over 16 inches in diameter. The largest tree measured in the reconnaissance plots was 13 inches in diameter.

The mesa was burned with a low intensity prescribed fire after the thinning. The fire consumed most of the slash, but had little effect on the residual stand. Surface fuels are light accumulations of pine needles. There are almost no herbaceous plants on the forest floor. The sparse surface fuels, absence of ladder fuels and high crown to base heights make it very difficult to carry a prescribed burn in this area to modify stand structure. Thinning would have to be done mechanically first, in order for fire to remain on the surface.

Figure 42. Pine stands in school house Mesa area where thinning occurred

Several canyons intersect School House Mesa including School House, Stable and several unnamed canyons. The canyons still have scattered large trees to provide some structural diversity. The canyons do not have signs of being burned with prescribed fire. Surface fuel beds have more large logs and a thicker accumulation of pine needles than the mesa top. The deep litter depth may be why grasses and non-woody plants are scarce.

Virgin Mesa, Holiday Mesa

The 1970s Porter Fire burned the northern portion of Holliday Mesa, then the 1991 Henry Fire burned 800 acres in the southern portion of Holiday Mesa. The Henry Fire was a crown fire that burned through dense thickets of young ponderosa pine trees. The burned area was not planted and has grown back in patchy oak and grass. The forest south of the Henry Fire is extremely dense, like stands on Virgin Mesa. Surface fuels are pine needles, logs, and branches.

Virgin Mesa parallels Holiday Mesa on the south side of Virgin Canyon. The 2003 Virgin Fire burned 400 acres as a crown fire at the north end of the mesa. Scattered large pole and small saw timber ponderosa pine survived the fire. Scattered pine seedlings are present in the burn area. The majority of the burned area has come back into bunch grasses that are being grazed heavily. Approximately 120 acres of ponderosa pine were thinned south of the Virgin Fire, and a narrow strip along the Jemez Canyon rim north of the fire has been thinned. Thinning was done according to uniform tree-spacing guidelines, creating uniform stands similar to those on School House Mesa. The thinning slash remains. South of the Virgin Fire and the recently thinned area, forest conditions become a dense thicket of saplings and poles. Historic logging removed the large, straight ponderosa pine and left poorly formed large

Figure 43. Dense forest with low branches, on Virgin Mesa

pine trees scattered throughout the stands.

The southern two thirds of Virgin Mesa and the southern third of Holiday Mesa are the last large contiguous blocks of unthinned forest and hazardous fuels west of the Jemez Canyon rim. The rest of this area has seen the dense fuel continuity broken up by past fires that burned approximately 15,000 acres (Stable, Porter, Cebollita, Henry, Virgin and Lakes) and extensive thinning and prescribed burning, creating a network of areas with lower crown fire hazards.

A fire starting on the south end of Virgin or Holiday Mesas during the fire season would be in alignment with burning uphill on a south slope pushed by the prevailing SW winds. Given the forest and fuel conditions and a “severe” crown fire rating, there is a high degree of certainty that an ignition in this area during fire season will initiate a crown fire. Virgin Canyon with its southwest orientation would compound the situation as prevailing winds would funnel rapidly up the canyon. The danger of a fire in this area is from the transport of embers by the wind and fire column that would start more fires downwind. Downwind includes the Village of Jemez Springs and the dense forests and residential properties in upper Jemez Canyon.

Lower Jemez Canyon

The dominate forest type in the Lower Jemez Canyon Area is piñon-juniper woodland. Surface fuels are sparse and tree crown continuity discontinuous. Wildfire spread in this woodlands type and rocky terrain would be limited by both fuels and topography. Prescribed fire is not an option because of the lack of surface fuels. No additional reconnaissance plot data was collected.

San Juan/Cat Mesa

The San Juan and Cat Mesas lie to the south and in alignment with the community of Vallecitos. Monument Canyon Research Natural Area (RNA) is at the north end of Cat Mesa. The RNA is selected to represent a remnant old growth ponderosa pine stand. Portions of the area (323 acres) were thinned in 2006, removing the majority of the sapling and pole understory. The remaining northern third of San Juan Mesa was thinned within the past 20 years to a uniform tree spacing. The mesa, with the exception of the RNA, was prescribed burned twice since 2000. Surface fuels are pine needles. Non-woody vegetation on the forest floor is sparse. The past prescribed burns were low intensity and did little to alter the ponderosa pine overstory. In many cases the past burns did not even kill or thin out dense thickets of small seedlings that were established in openings. Crown to base heights however were raised from the fire scorch. The sparse surface fuels, absence of ladder fuels and high crown to base heights make it very difficult to use prescribed fire to thin and modify stand structure. As the Mesa slopes gently to the south, density of ponderosa pine stands

Figure 44. Thinned stand on San Juan Mesa has high branches, uniform spacing, and lack of ground vegetation

decrease and the site becomes rocky and surface fuels discontinuous. At the southern end of the mesa, the vegetation transitions to piñon-juniper, and surface fuels are sparse and discontinuous, interspersed with bare soil.

The northern third of this block has seen a ponderosa pine regeneration event within the past 3 years. Openings in the tree canopy filled in with dense ponderosa pine seedlings, averaging 10,000 seedlings per acre in the RNA (Figure 45).

Figure 45. Ponderosa pine seedlings that regenerated in the larger canopy openings

Upper Jemez Canyon

The Upper Jemez Canyon block begins just north of Jemez Springs where the piñon-juniper transitions into mixed conifer on the north aspect and into ponderosa pine on the south aspect. The canyon is in alignment with the southwest winds. The canyon sides are steep and interspersed with rocky cliffs, so access is difficult. Crown fuels are continuous vertically and horizontally. The north aspects have a buildup of heavy fuels, including large recently beetle-killed trees that are falling down.

Figure 46. North-facing slopes of Upper Jemez Canyon show ladder fuels

Potential ignition sources are along State Highway 4, with subdivisions on both sides of the highway, a summer music camp, several dispersed recreation areas and Battleship Rock Campground. Wildfire in this block would also endanger the communities of La Cueva, Vallecitos de los Indios and Thompson Ridge, which are in alignment with a fire burning up canyon. Redondo and Jemez Falls Campgrounds would be in the fires path. A severe fire in the canyon would devastate the economy of the nearby Jemez communities. Flooding in the aftermath of a severe fire would endanger property and agricultural fields in the Jemez River floodplain along with State Highway 4.

There has been past thinning along the north rim of the canyon in the Banco Bonito area. Adjacent to Banco Bonito, over 200 acres were thinned and masticated in the southwest corner of the Preserve. Thinning is being done in the Jemez Falls Campground, but too few trees are being cut and the area is too small for the treatment to have any effect on wildfire behavior.

Upper and Lower Paliza Canyon

Figure 47. 1996 Hondo Fire area showing lack of forest recovery

The Paliza Canyon area is dominated by a series of canyons, including Paliza and San Juan Canyons, which are in alignment with the southwest winds. The community of Vallecitos de los Indios sits to the north, in the path of any wildfire burning up the canyons. Topography, slope and aspect are varied and broken with corresponding variability in vegetation and fuels. Cerro del Pino, Cerro Pelado, and Los Griegos are peaks in the area and are above 9,000 feet. The southern portion of the Paliza area includes National Forest land and a portion of the Jemez Pueblo tribal land. Jemez Pueblo has thinned the ponderosa pine stands on their land, although they did not burn the thinning-generated slash. Prescribed burning on adjacent National Forest lands is therefore difficult because of this surface fuel hazard. Vegetation and fuel is continuous vertically and horizontally across the area. The only openings are a scattering of pumice mines and the scars of three crown fires that burned in the last 15 years. Surface fuels are long and short needle cast. Aspen is not a major component.

Figure 48. Dense ponderosa pine saplings in the Paliza area

Large trees were selectively harvested from ponderosa pine stands, but some large trees remain. Dense sapling and pole-sized stands with scattered large pine trees dominate dry sites. Moist sites contain mostly white fir seedlings under a pine and mixed conifer tree overstory. The area has been logged extensively, with the most recent Paliza timber sale in the late 1990s. That harvest randomly removed individual trees and did not accomplish any ecological objective. Pre commercial thinning scheduled to follow was not done. In the Conejos area, thinned stands were open to fuelwood gathering. The planned prescribed burning was not completed, so the thinning-slash remains. The 6000 acres planned to be burned was never conducted. Paliza Campground on the banks of Vallecitos Creek was marked to thin, but no one bid on the contract. The area around Paliza Campground is a popular dispersed camping and party area and potential ignition source. The main danger to the campground is from the flooding of Vallecitos Creek in the aftermath of a severe wildfire in Paliza Canyon. A wildfire would rapidly funnel up the canyon, driven by prevailing winds. It would be followed by severe mass wasting and flooding that would endanger the community of Ponderosa and the community's reservoir at the mouth of Paliza Canyon.

Three crown fires over 300 acres each in size, occurred in this area in the past 15 years (Nicole, Labor and Hondo fires). Two were lightning caused and one human-caused. They burned as crown fires for only one day then dropped to the ground due to sudden rains and wet weather. All three fires burned toward the northeast (per prevailing southwest winds). The burned areas filled with grass and oak brush, although some scattered ponderosa pine seedlings are present in the Hondo and Nicole fire areas. Some of those wildfire burn areas still show a lack of recovery to forest vegetation (Figure 47).

Thinning is ongoing in the Los Griegos area at the north end of the block, and has been completed along the perimeter of the Vallecitos de los Indios community. The thinned timber stands that sit to the south and west of Vallecitos de los Indios exhibit classic historical ponderosa pine stand structure; park like stands with large diameter trees and regeneration in a clumpy arrangement. The thinned area was open for fuel wood gathering but never prescribe burned.

Las Conchas

The Las Conchas area is in the area along State Road 4 between the National Forest and Preserve boundary. It is a relatively steep, higher elevation area than the rest of the National Forest land in this assessment area, and is composed of moist mixed conifer, spruce and aspen. The majority of the area is on north-facing slopes, and not in alignment with the prevailing southwesterly winds. Surface fuels are predominately short needle cast typical of a mixed severity fire regime. No additional reconnaissance plot data was collected here.

Fire Management and Community Protection

The interagency fire teams define wildland urban interfaces (WUIs) as areas where human habitation and development meet or intermix with wildland fuels (USDI and USDA. 2001). The Federal Register lists WUI communities in the vicinity of federal lands that are at high risk from wildfire (Federal Register 66(3) 751-777). Forest Service direction for managing WUIs is provided by the National Fire Plan, including the 10 Year Comprehensive Strategy- a Collaborative Approach for Reducing Wildland Risks to Communities and the Environment, 2001. The goals for managing WUIs are to: improve fire prevention and suppression; reduce hazardous fuels; restore fire adapted ecosystems; and promote community assistance.

The Forest Plan (pages 19 and 22) includes goals to protect life and property from wildfire; protect forest resources from wildfire at a level commensurate with the value of the resource; and utilize prescribed fire as a tool where it can effectively accomplish resource management objectives. The objectives the National Forest hopes to accomplish by 2020 are to (a) identify and treat areas of the forest in which hazardous fuel loadings are a risk to communities within the WUI, and (b) conduct hazardous fuels treatments to change behavior and result in moving fire from the crowns of trees to surface fires around at-risk communities.

In 2002, the Greater Jemez Mountains WUI Working Group of the national USA Firewise program prepared a fuel and fire risk assessment in the area. It includes recommendations on reducing fuels within 100 to 200 feet of ignitable structures. This group obtained grants to continue their efforts to reduce hazardous fuels on private lands in the area, and over 50 private properties in the assessment area were treated, based on State Forestry data.

In 2008, the Sandoval County's Community Wildfire Protection Plan (CWPP) was collaboratively completed (Sandoval County 2008). Recommendations in the CWPP were to increase defensible space, create and continue fuel breaks and fuel mitigation measures around communities, establish evacuation and egress routes and develop pre-fire plans. It defined WUIs within the assessment area and ranked the at-risk communities as to their relative fuel and wildfire hazard. Figure 49 shows the WUIs that cover a majority of the National Forest land in the assessment area.

The wildfire hazard ratings for WUI communities in the assessment area are as follows:

- Upper Jemez Springs: Extreme
- Lower Jemez Spring: High
- Cerro de Los Pinos: High
- Thompson Ridge: Moderate
- La Cueva: Moderate
- Ponderosa: Moderate

WUI community disasters almost always occur under extreme fire weather conditions such as high wind speeds and low humidity. Once a fire ignites under the worst weather conditions, it can spread rapidly at high intensities. Fire is often carried through live vegetation such as trees, grass or shrubs. The grassfires in Oklahoma in 2008 killed two people and destroyed over 100 homes. Preventing the ignition of flammable materials around the home is the best and most effective way to keep home from burning (Cohen 1999). When numerous homes become involved under extreme fire weather conditions, fire fighters, equipment and water supplies become depleted and overwhelmed. The Los Alamos Fire Department during the Cerro Grande Fire had enough water pressure in the municipal water system to fight one structural fire at a time (conversation with Steve Coburn, prevention chief). There were over 300 structures burning almost simultaneously during Cerro Grande, overwhelming the fire department's capacity.

Flame length is not the main cause for a WUI fire disaster. The primary factors affecting homes burning in the WUI are the ignitability of the home and its immediate surroundings (approximately 100 to 200 feet) known as the "Home Ignition Zone" (Cohen 1999). Manipulation of vegetation outside this zone has little or no effect on the chances of a structure surviving a wildfire. Thus, the most effective approach to reducing losses are improved home construction and reduced ignition hazards in the Home Ignition Zone. Touring the communities and discussions with State officials reveal that an estimated 20 percent of what was recommended in the CWPP have been completed (Conversation with Karen Lightfoot, NM State Forestry 2009).

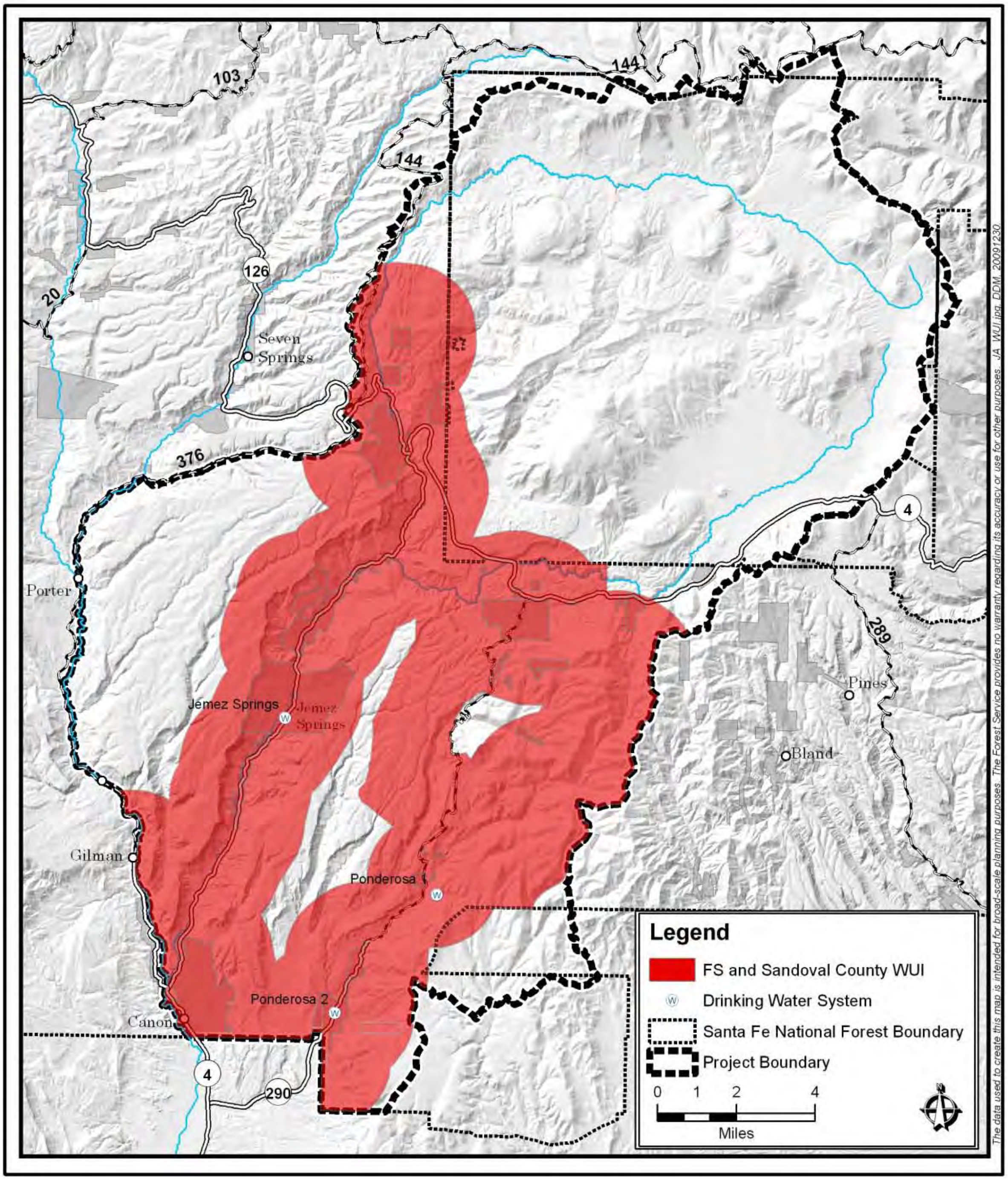

Figure 49. Wildland-urban interface (WUI) areas

Management of Natural Ignitions

Management of naturally ignited (lightning-caused) fires to accomplish specific resource management objectives is referred to as Wildland Fire Use. Areas where this may occur is defined in the Forest Plan and Fire Management Plan. These naturally ignited wildfires can be managed as prescribed fires to accomplish objectives within those pre-defined areas. Otherwise, if unwanted or unplanned fires result from natural or human-caused ignitions they are managed and defined as wildfires.

The 1995 Federal Wildland and Prescribed Fire Policy and Program review states: (1) the role of fire as an essential ecological process and natural change agent will be incorporated into the planning process; and (2) fire management plans, programs, and activities support land and resource management plans and their importance. Managing natural ignitions and planned ignitions as prescribed fires are complimentary ways to meet management objectives.

Figure 50. Unthinned forest on private land (left) adjacent to thinned area on National Forest Land (right)

Managing natural ignitions may only be done under safe, carefully planned conditions to benefit natural resources, reduce future fire suppression costs, help restore natural fire regimes, and achieve Forest management goals and objectives. Thus, it is an essential tool for restoring and maintaining fire-adapted ecosystems. However, in this assessment area, most stands need to be mechanically thinned before natural fire ignitions can be safely managed as prescribed fires. In part this is due to forest and fuel conditions, and in part due to the scattered communities and human developments (high value infrastructure) throughout the area, as indicated by the WUI map.

The fire management units (FMUs) identified in this area in collaboration with multiple resource specialists, agencies, and adjacent land owners, provide guidelines for managing wildfire ignitions. They indicate the most appropriate management strategy to apply to various areas on this landscape, although decisions must be made site-specifically on a case-by-case basis. The Forest Plan section D) describes the Forest's prescribed fire program fuels treatment objectives with respect to each FMU. Use of prescribed fire in any FMU should enhance fire-fighting capability, lower or maintain fuel profiles to reduce the severity of fire, and provide a buffer around communities. In WUIs and high fuel hazard areas, mechanical treatments are typically needed before prescribed fire, including use of natural ignitions as prescribed fire.

The following map shows the FMUs and associated fire use strategy.

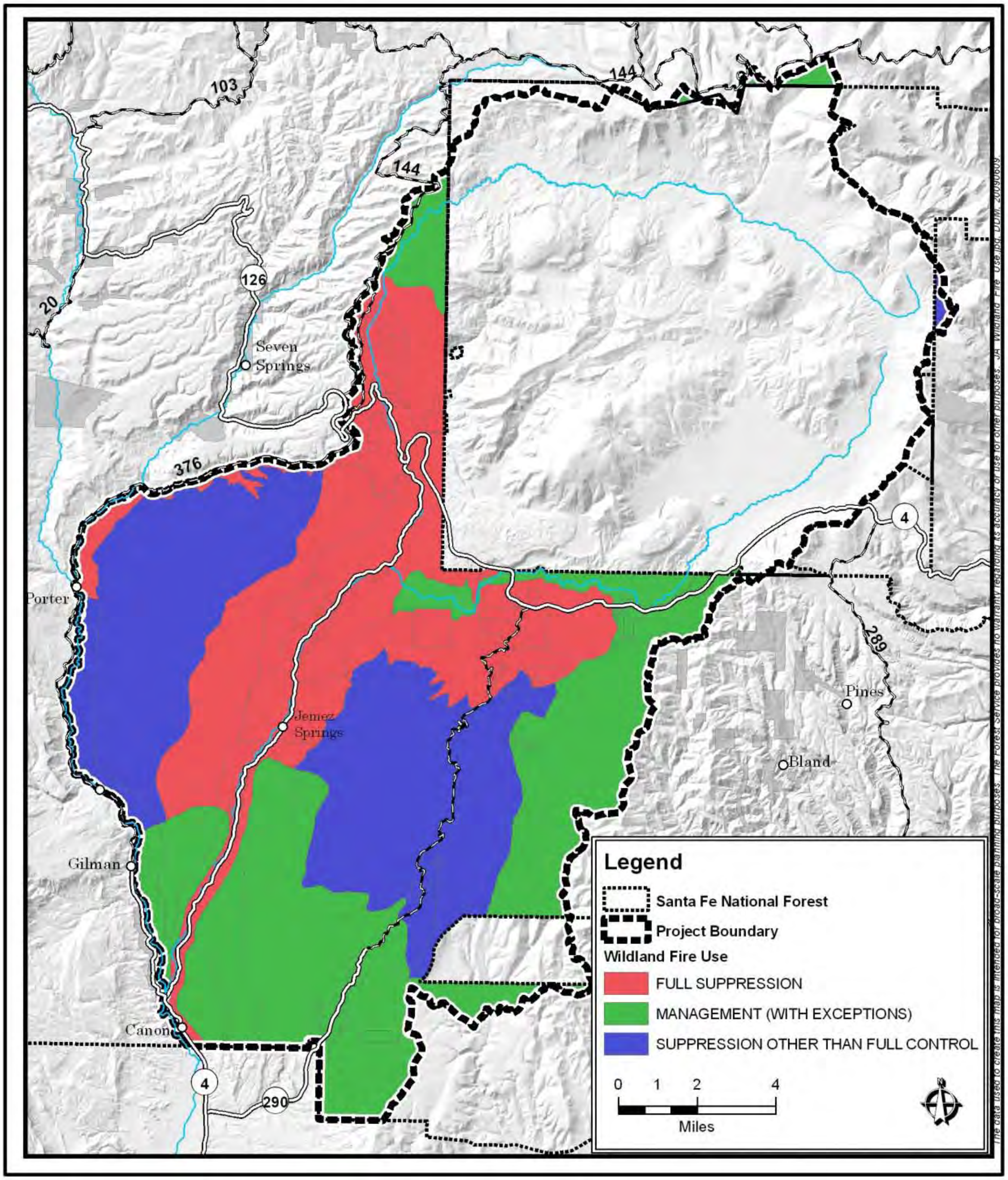

Figure 51. Fire management units – general levels of management control

Wildlife Habitat and Species

Introduction and Methodologies

This section evaluates and compares the existing and reference conditions of wildlife habitat and species within the assessment area. This comparison forms the basis for identifying restoration needs and opportunities. This section focuses on the National Forest lands within the assessment area, as a complement to the wildlife habitat and species description in the Preserve's existing conditions report. For National Forest lands in the area, this section describes:

- Proposed, endangered, threatened, and sensitive species (PETS)
- Management indicator species
- General wildlife

In addition, it will evaluate known occurrence and potential suitable habitat for the above-noted species. The area evaluated for existing conditions and referenced conditions will include only Forest System land.

Because of the confidential nature of locations of PETS species, maps of these locations are not included, but are kept in confidential files for analysis purposes rather than public distribution.

Forest Plan goals for managing wildlife habitat (page 19) are being routinely followed in managing resources in this assessment area, and include:

- Manage habitat to maintain viable populations of wildlife and fish species and improved habitat for selected species. Coordinate habitat management with other resource activities.
- Cooperate with the New Mexico Department of Game and Fish to contribute toward management goals and objectives specified in the State Comprehensive Plan.
- Identify, protect and enhance habitat that contains threatened, endangered, and sensitive species of plants and animals to contribute toward the goal of species recovery.

Forest Habitat

The forest ecosystem and topographic conditions previously described in this report describe some of the wildlife habitat concerns for native species in this assessment area, from species associated with narrow habitat niches to the habitat generalists. The primary habitat concerns related to forest ecosystem conditions previously described are as follows:

- The uniform, homogenous forest composition and structure across much of this assessment area, translates to degraded native habitat conditions and reduced wildlife species diversity. Virtually the entire forested area is composed of mid-aged, closed-canopy forest; substantially more than the historic condition in these ecosystems.
- The over-abundance of small diameter trees and lack of large old growth trees, as well as large logs and snags, further compromise the abundance and diversity of native wildlife species, especially species associated with mature and old growth forest characteristics. However, the tree mortality from past fires and insect/disease outbreaks has resulted in adding snags and downed logs for wildlife habitat, and they appear to be adequate across

most of the assessment area (Forest Plan, Appendix D, page 9). Snags are lacking near the most accessible roads as they are removed by the public for firewood.

- Understory plants have declined in abundance and diversity as well, creating a significant lack of cover and forage for large and small mammals, birds, and other wildlife.
- Stand densities and fuel conditions present an increased risk for uncharacteristic high severity wildfire, which can result in a loss of both habitat and species.
- Open grassy meadow habitat has been decreasing because of conifers encroaching into the meadows, due in part by grazing along with the lack of fire (Keane et al. 2002).
- Mast production (such as oak acorns and piñon nuts) is patchily distributed, and may be reduced in some areas from year to year.
- Aspen patches have declined as well due to encroachment by conifers and lack of regeneration by fire.
- Human activity and noise disturbance are prevalent over much of this area, as it is close to the largest population centers in the State and receives heavy use by locals and tourists alike.
- Vehicles using the high density of roads and trails disturb wildlife species and reduce habitat quality. There are many unauthorized routes created by off-road vehicles, including routes through breeding habitat for PETS species.
- Water tanks constructed in the area did not include ramps to allow small mammals, reptiles, or amphibians to escape. The Forest Plan notes that water tanks should be monitored, and in cooperation with livestock grazing permittees, escape ramps should be placed where needed.

Riparian Habitat

Water, an essential component for high quality wildlife habitat, is not abundant or widespread in this project area. Water is available year-round in perennial streams located in Virgin Canyon, San Antonio Creek, Rio Cebolla, Rio Guadalupe, East Fork Jemez River and Jemez River. On the mesa tops, water is available only seasonally, during snow melt and storm runoff, or in some springs, seeps or water developments (see the Water Resources section). Many springs and seeps that previously provided water for wildlife are now dry or have sharply declined in the amount of water available. Snow captured in the closed canopy forests is increasing lost to the atmosphere through sublimation (evaporation), which results in loss of surface and ground water supplies (see Water Resources).

Riparian corridors are being impacted by elk and livestock grazing, and by recreation use—anglers, camping, and vehicles. Vegetation is not reaching its potential in height, density, and species diversity, and there are areas of bare soil that add sediment to the streams. These activities are impacting the abundance and diversity of native riparian vegetation along streams and in wet meadows for several sensitive species, such as for NM meadow jumping mouse and other small mammals, native fish such as Rio Grande cutthroat trout, Rio Grande sucker, Rio Grande chub, and longnose dace, and amphibians like northern leopard frog. Additionally, some riparian corridors do not have sufficient aspen, willow, or other vegetation growth to sustain existing beaver populations, which are considered keystone indicator species for riparian health (Maehr 1999).

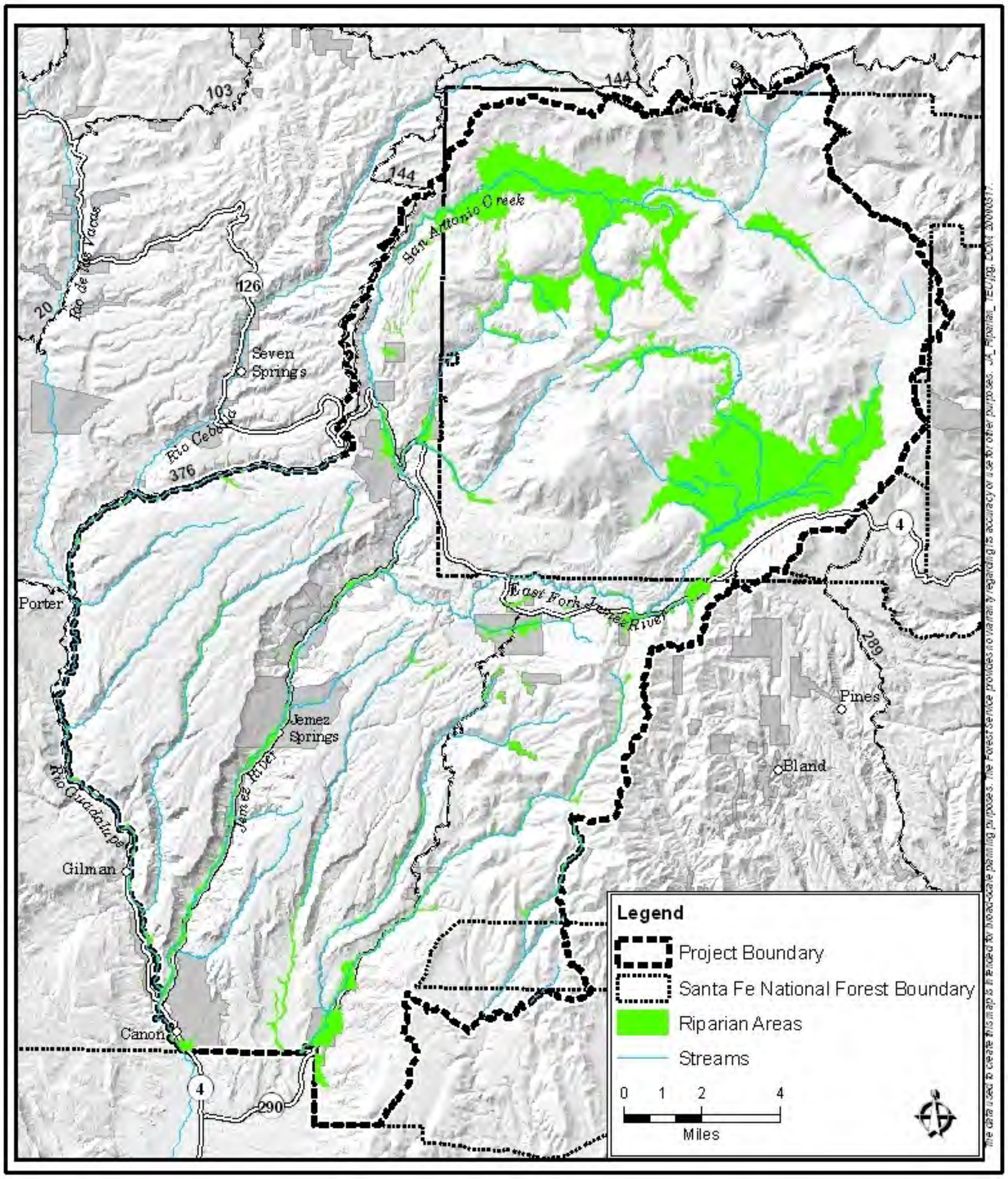

Figure 52. Riparian areas

The Forest Plan calls for regenerating aspen, especially in the higher elevation riparian areas, to improve beaver habitat; and then reintroducing beaver in riparian sites where sufficient aspen and willow exists to support and sustain population.

Invasive, non-native woody plants such as Siberian elm, Russian olive and tamarisk (salt cedar) are adversely impacting riparian habitat in the lower Jemez River, Rio Guadalupe, Rio Cebolla, and other streams in the area (see Invasive Plant section). These plants are causing the decline in native species like cottonwood, willow, sedges, and other native riparian plants, which impacts riparian-dependent wildlife species. Riparian restoration including invasive plant control treatments have been initiated along lower Jemez River, East Fork Jemez River, Rio Cebolla, and others, although there is still much more to be done to restore native species composition, structure and function (reach properly functioning riparian conditions).

Threatened and Endangered Species

Lists of threatened and endangered (T&E), along with federally proposed, and candidate species that may occur on the National Forest were reviewed to determine the likelihood of occurrence for these species or their potential habitat within the assessment area (US Forest Service 2004d). Of the T&E, proposed and candidate species reviewed, this area does not have habitat for Rio Grande silvery minnow or Holy Ghost ipomopsis (plant). It does have potential for Mexican spotted owl and Southwestern willow flycatcher (T&E), as well as western yellow billed cuckoo, Gunnison's prairie dog, Rio Grande cutthroat trout, and NM meadow jumping mouse (candidate species). More detailed information on each species can be found in the draft TES reference list for the National Forest (US Forest Service 2008).

Table 32. Endangered, threatened, proposed, and candidate species with potential habitat in the area

Common Name	Scientific Name	FWS Status	Potential for Occurrence in JLA Area
Southwestern willow flycatcher (and critical habitat)	*Empidonax trillii extimus*	Endangered	Some riparian areas are progressing toward suitable habitat, although no SWWF have been found on the Jemez District
Mexican spotted owl (and critical habitat)	*Strix occidentalis lucida*	Threatened	Several PACs; suitable mixed conifer habitat, and 23,000 acres of critical habitat
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Candidate	Potential in some lower elevation riparian canyons
Gunnison's prairie dog	*Cynomys gunnisoni*	Candidate	One small colony near Rio Cebolla has been found
Rio Grande cutthroat trout	*Oncorhynchus clarki virginalis*	Candidate	No occupied habitat: some streams designated for potential reintroduction
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	Candidate	Occupied and potential habitat located in assessment area

Mexican Spotted Owl - Threatened

There are four Protected Activity Centers (PACs) or breeding areas entirely within the assessment area and one PAC partially within the area. The PACs are named Hummingbird, San Juan, Virgin Canyon, West Mesa and Lake Fork, and altogether comprise about 2,465 acres. The assessment area contains about 17,000 acres (15 percent of area) identified as potential spotted owl habitat, within the mixed conifer forest ecosystem.

The amended Forest Plan and Fish and Wildlife Service's Recovery Plan provide specific requirements for managing Mexican spotted owl habitat (US Fish and Wildlife Service 1995, US

Forest Service 1996). They call for managing mixed conifer forests toward irregular tree spacing and various patch sizes; horizontal structural variation with natural canopy gaps; species diversity with all species of native trees represented including early seral species; at least 3 snags, 5 downed logs, and 10 to 15 tons of woody debris per acre. Management direction calls for identifying *protected* and *restricted* habitat. Protected habitat consists of all the PACs as well as mixed conifer and pine-oak types with slope greater than 40 percent where timber harvest has not occurred in the past 20 years. *Restricted habitat* consists of all mixed conifer, pine-oak and riparian forests outside of protected areas. The Recovery Plan (pp. 85-87) includes additional specific guidelines in protected habitat for establishing and monitoring PACs, avoiding road and trail construction, avoiding activities during breeding season, avoiding harvest of trees over 22.4 cm. in diameter (at breast height), implementing appropriate fire risk abatement treatments, minimizing impacts during fuelwood harvesting, and others. The Recovery Plan (pp. 93-97) includes additional guidelines for restricted areas including providing for replacement of nest habitat over time, incorporating natural forest structure variations and disturbance patterns, extending rotation ages, retaining trees over 24 inches in diameter, and other guidelines previously mentioned.

The assessment area contains 23,700 acres of designated critical habitat for the Mexican spotted owl, in Unit SRM-NM-1 (US Fish and Wildlife Service 2004). Each unit contains at least one primary constituent element: *those physical and biological features that support nesting, roosting and foraging*. Forest vegetation management treatments that occurred in this area over the past 10 years have been designed to maintain or increase the primary constituent elements for critical habitat for the Mexican spotted owl. The primary constituent elements are specific (a) forest structures such as large trees, snags, canopy cover, down logs and woody debris, (b) elements for tree and plant species diversity and levels of plan understory plant cover to help maintain prey species, and (c) elements related to canyon habitat in terms of water presence, clumps of specific vegetation types, canyon wall features, and ground litter and woody debris (US Fish and Wildlife Service 2004). Current conditions are not meeting these “reference” conditions—guidelines identified in the Recovery Plan, primarily due to the lack of structural and vegetation species diversity, large trees, and understory plants (as previously discussed under forested ecosystems habitat.

Gunnison’s Prairie Dog-Candidate

There is one known colony of Gunnison’s prairie dog in the assessment area. It is a very accessible area along FR 376, and highly visible to the public. If other (unrecorded) colonies are present within the assessment area, they are probably small populations.

Western Yellow-billed Cuckoo-Candidate

There are no known locations of this cuckoo on the Jemez District. There are no records of observations of this species within this assessment area. Suitable habitat could occur in deciduous riparian vegetation, especially cottonwood, along the Jemez River and Rio Guadalupe.

Rio Grande Cutthroat Trout -Candidate

This native fish species no longer occurs in any streams within the assessment area, primarily due to the prevalence of non-native brown and rainbow trout. The closest occupied stream is at least one mile to the west of the assessment boundary. Streams in the assessment area designated for reintroduction include: the Rio Guadalupe, Lower Rio Cebolla, San Antonio Creek, East Fork Jemez, and upper Jemez River down to tributary just north of Redondo Road on Highway 4 – Section 13. See the Fisheries and Aquatic Habitat section for further information.

New Mexico Meadow Jumping Mouse-Candidate

There are several sites of known jumping mouse occurrence within the assessment boundary. Suitable habitat is known to occur along the Rio Cebolla and San Antonio Creek where vegetation is of sufficient height and density immediately adjacent to stream. Other sites of potential suitable habitat may occur in other riparian corridors.

The distribution of this mouse and its habitat declined since the late 1980s (Frey and Malaney 2009). In a survey of current habitat, it was not found at 73 percent of historical localities surveyed in the Jemez Mountains. Sites within the landscape assessment area where jumping mice had been found in the past but where existing habitat was not deemed suitable include Virgin Canyon and San Antonio Canyon. Frey observed areas with potentially suitable habitat – La Cueva Picnic Area, Sulphur/Redondo Creek, Calaveras Canyon, Seven Springs Recreation Area, Rio Cebolla below Seven Springs, Rio Cebolla below Fenton Lake State Park, lower Rio Cebolla above Porter Landing (Frey 2007).

Sensitive Species

The Forest Service list of sensitive species for the Southwestern Region (Region-3) was reviewed to determine the species that occur or have potential habitat within the National Forest lands of this assessment area (US Forest Service 2007b). Wildlife on the Preserve is discussed in their Existing Conditions Report. Additional details about these species on the Jemez Ranger District (District) are available in District files. The following table shows the sensitive species that occur or have potential habitat in the area. It excludes those already discussed as candidates for the list of threatened and endangered species, and those without potential habitat on National Forest lands in the assessment area.

Table 33. Forest Service Region 3 sensitive species and potential habitat

Common Name	Scientific Name	Occurrence or Habitat Within the Area
Amphibians		
Jemez Mountains salamander	*Plethodon neomexicanus*	Occupied habitat; suitable habitat where surveys are needed to determine occupancy
Northern leopard frog	*Rana pipiens*	Known past occurrence; potential habitat near rivers, in springs, seeps, beaver ponds, and man-made water developments
BIRDS		
Bald eagle	*Haliaeetus leucocephalus*	Potential roosting/migration habitat present; no breeding habitat present.
Northern goshawk	*Accipiter gentilis*	Known nest areas present; suitable habitat is present throughout
American peregrine falcon	*Falco peregrinus anatum*	Several designated breeding zones located within assessment area
Boreal owl	*Aegolius funereus*	Potential in high elevation spruce-fir
Gray vireo	*Vireo vicinior*	Potential in low elevation piñon-juniper
FISH		
Rio Grande chub	*Gila pandora*	Potential habitat
Rio Grande sucker	*Catostomus plebeius*	Potential habitat
Mammals		
Cinereus (masked) shrew	*Sorex cinereus cinereus*	Potential in higher elevations
Dwarf shrew	*Sorex nanus*	Potential in higher elevations
Water shrew	*Sorex palustris navigator*	Potential in riparian areas
Preble's shrew	*Sorex preblei*	Potential
Spotted bat	*Euderma maculatum*	Potential
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	Potential
Southern red-backed vole	*Clethrionomys gapperi*	Potential in high elevation mixed conifer
Long-tailed vole	*Microtus longicaudus*	Potential
American marten	*Martes americana origenes*	Potential in high elevation mixed conifer; spruce/fir
Ermine	*Mustela erminea muricus*	Known occurrence along the Rio Cebolla within assessment area
Plants		
Yellow lady's slipper	*Cypripedium parviflorum var. pubescens*	Potential
Robust larkspur	*Delphinium robustum*	Potential
Wood lily	*Lilium philadelphicum*	Potential
Springer's blazing star	*Mentzelia springeri*	Potential

Jemez Mountains Salamander

This species is a lungless salamander with a narrow habitat range, primarily in moist mixed conifer forests where it primarily lives beneath logs, rocks and other organic matter on the soil. This area contains occupied habitat for this species, as well as potential habitat defined as Essential zones and Regular Survey zones, in accordance with the Cooperative Management Plan for the Jemez Mountains Salamander (NM Endemic Salamander Team 2000). Additional surveys were planned to occur in the essential habitat zone in 2009, although few were conducted due to insufficient rainfall. Surveys are planned again for the rainy season in 2010. The acres of Jemez Mountains salamander habitat in the assessment area is as follows:

- Occupied: 1,400 acres
- Essential Zone: 2,800 acres
- Regular Survey Zone: 14,400 acres

In the 1980s the greatest threat to these salamander populations and their habitat was forest logging and road construction. Today, with changes in Forest management objectives, the primary threat to this species is related to climate change and stand-replacing fires. Drought and long-term drying trends can cause habitat to dry out, and this species requires moist conditions to survive. Drought can increase forest fire severity, frequency, and duration, to the detriment of this species. The Jemez Mountains salamander has existed in fire-adapted ecosystems, although infrequent, high intensity crown fires are not natural in this area. High-intensity fire cannot only kill individual salamanders and its prey species, it can cause long-term degradation and destruction of the microhabitat it depends on.

The reference condition that provides for sustainable, well-connected salamander populations is described in the management plan previously listed. Current conditions differ from reference conditions. The reference condition habitat should experience natural fire regimes of low and moderate intensity fires that do not consume all the logs and tree cover, such that moisture regimes are retained, along with biological diversity. There should be a mosaic of seral stages, including more mature and older forests, more large-diameter logs and higher snag densities. These conditions do not currently exist in this area. To maintain the Jemez Mountains salamander across its already limited geographic distribution, it is prudent to conserve all extant salamander populations to allow the greatest potential for connectivity between populations of these relatively immobile organisms (New Mexico Endemic Salamander 2000, pp.13-14).

The management plan for this species has restrictions on types of projects that can occur in essential habitat, and requires consultation with the NM Endemic Salamander Team during project analysis. In August 2009, U.S. Fish and Wildlife Service announced a 90-day finding on a petition to list this species as Threatened or Endangered (US Fish and Wildlife Service 2009a). Consultation with the Salamander Team is on-going within this assessment area. The Salamander Team, Forest Service and others have been meeting to share information about salamander life history and habitat requirements; current forest conditions and likely impacts of climate change; what management practices and mitigations could help the salamander adapt to climate change, and other information.

Northern Leopard Frog

Suitable habitat for this frog occurs along rivers, streams, ponds and springs within this assessment area. The Forest wildlife database shows five records of past observations of northern leopard frogs in four areas within the assessment boundaries. In July 2009, U.S. Fish and Wildlife Service announced a 90-day finding on a petition to list the northern leopard frog as threatened or endangered (US Fish and Wildlife Service 2009b).

Bald Eagle

There is no breeding or foraging habitat for this species in the area, such as large bodies of fish-bearing water. Past records note that bald eagle occurrence is uncommon on the Jemez Ranger District; however, some have been observed in the winter months, including locations along Forest Road 376, Fenton Lake, the Preserve, and Jemez River. Wintering bald eagles near the Jemez Mountains use Cochiti Lake and upper Chama River. Migrating/wintering eagles could pass through and roost, on a transient basis. None of the assessment area watershed drains into bald eagle nesting habitat.

Northern Goshawk

The assessment area contains nine known post-fledging family areas (PFAs) completely within the assessment boundary, and one partly within the boundary. Surveys for new goshawk locations began during the 2009 field season within this area. Past surveys were completed in Lower Paliza Canyon, and portions of Schoolhouse, Stable, Virgin and Holiday Mesas. One new nest location was found, and a PFA drawn based on that nest site. A goshawk was seen in the Lower Paliza, but no nest found. This site will be re-surveyed during 2010, along with surveys within the other areas of the assessment area.

The Forest Plan (Appendix D) contains standards and guidelines to follow in designing and implementing projects in goshawk habitat, and an implementation guide (US Forest Service 2007c) provides additional guidance. Potential goshawk habitat covers a broad range of forest cover types, including all forest and woodland ecosystems outside of Mexican spotted owl protected and restricted areas.

The general vegetation management guidelines in the Forest Plan specify distribution for vegetation structural stages (VSS) for ponderosa pine, mixed conifer and spruce-fir forests. Because the goshawk guidelines were developed based on habitat needs for prey base for goshawk, thinning according to goshawk guidelines would be the desired condition over much of the ponderosa pine stands on the forest. Current conditions are highly departed from the reference conditions in the Forest Plan, as previously described in this document, primarily due to the lack of structural diversity, mature/old growth components, and ground vegetation. This species and its prey require maintaining an uneven-aged forest structure, down woody debris, old growth structures, and a mosaic of age classes and species across the landscape. The area is deficit in those conditions. Healthy riparian vegetation needed for goshawk prey species is also degraded. More grass/forb/shrub growth on the forest floor would not only enhance forage, cover and/or nesting habitat for goshawk, it would greatly benefit owls and other raptors, bats, small rodents, migratory birds, turkey, elk, mule deer, and many other wildlife species. Compared to reference conditions for goshawk, the current conditions have extremely low proportions of large trees, canopy openings, and structural diversity. Forest conditions do not currently support low intensity surface fires and instead create a risk of large-scale high intensity wildfire that would destroy potential goshawk habitat for long periods of time.

The table below shows the existing and reference vegetation structural stage (VSS) condition for ponderosa pine stands within the assessment area based on goshawk management direction in the Forest Plan. In general, VSS 1, 2, 5, and 6 are lacking within the assessment area. It is easy to restore VSS 1-2 because seedlings and saplings quickly fill in where openings are created in the forest canopy. It takes over 100 years to restore pre-suppression old growth forest conditions that are currently lacking throughout this landscape.

Table 34. Vegetative structural stage (VSS) distribution in ponderosa pine goshawk foraging areas

VSS Class	Reference Condition	Existing Condition	Foraging Area Desired Canopy Cover	Foraging Area Existing Canopy Cover
VSS 1 (.1-.9")	10%	6%		
VSS 2 (1-4.9")	10%	8%		
VSS 3 (5-11.9")	20%	51%		
VSS 4 (12-17.9")	20%	21%	40%	48%
VSS 5 (18-23.9")	20%	11%	40%	46%
VSS 6 (>= 24")	20%	3%	40%	45%

American Peregrine Falcon

Designated suitable breeding habitat zones for this falcon species are established across the National Forest, as zones A, B, C, and D, with management guidelines associated with each zone. There are ten designated suitable breeding habitat zones completely within the boundaries of the assessment area, and two with just portions of the zones within the boundaries: R26, R27, R28, R33-34, R35, R39, R41, R44, and R58; R20 (small portion of D zone), R37 (C and D zones). Forage for the small prey species consumed by peregrine falcon is threatened by the same conditions (ecologically departed from reference conditions) as described for the spotted owl and northern goshawk, such as lack of structural diversity, canopy openings, and ground vegetation.

Boreal Owl

No boreal owls have been recorded on the Jemez Ranger District, although suitable habitat exists in the higher elevation spruce-fir forests, especially in the Preserve. A survey using taped calls was done in 2009 surrounding Cerro Pelado, but no boreal owls were seen or heard.

Gray Vireo

No gray vireo observations have been recorded on the Jemez Ranger District; however, they were found adjacent on adjacent Jemez Pueblo land during a federal highway development project. Surveys will be done in suitable piñon-juniper in 2010.

Rio Grande Chub and Rio Grande Sucker

These native fish species occur in the area. See the Fisheries and Aquatic Habitat section.

Cinereus Masked Shrew

Potential suitable habitat is limited in this area to the small acreage (3,000 acres) of spruce-fir forest above 9,500 feet (other than on the Preserve).

Dwarf Shrew

There are no records of this species in the assessment area, although potential habitat occurs in approximately 16,900 acres of white fir and Douglas fir forest stands in this area.

Water Shrew

The water shrew is widespread in the Jemez Mountains, although not common (Frey 2007). This shrew is known to occur within the assessment area along the Rio Cebolla and San Antonio Creek. Suitable habitat occurs along most rivers and streams.

Preble's Shrew

There is known occurrence of this shrew in the assessment area, where it was collected in an open, park-like stand of ponderosa pine with Gambel oak, grass and forb understory. Potential habitat occurs in all ponderosa pine forest in the area.

Spotted Bat

This bat is known to occur within the assessment area along the East Fork of the Jemez River. Potential foraging habitat occurs throughout the entire assessment area.

Pale Townsend's Big-eared Bat

This species was seen near Jemez Springs, and potential foraging habitat occurs in all vegetation types in this assessment area.

American Pika

This species has been observed just outside of this assessment area near Ruiz Peak and on the Preserve. Suitable habitat within the assessment area is limited by lack of talus slopes at high elevations. In May 2009, the U.S. Fish and Wildlife Service announced a 90-day finding on a petition to list the American pika as threatened or endangered (US Fish and Wildlife Service 2009c).

Southern Red-backed Vole

There are four records of past occurrence of this species in the area and several just outside of the assessment area. Other suitable habitat occurs in spruce-fir forest (approximately 3,000 acres).

Long-tailed Vole

There are 15 records of past observations of this species in the area and several observations just outside the assessment area. Suitable habitat occurs in mixed conifer and spruce-fir forest.

American Marten

There are no records of past observations within the assessment area, although there have been sightings on the Jemez District in the past. Long noted that many seemingly good sightings were reported, but only a small portion of potential habitat was surveyed (pers. comm. 2006). Suitable habitat occurs in the Los Griegos area of this assessment area. Some surveys of this area may be done in 2010.

Ermine

Ermine have been documented on the Jemez Ranger District. One recent capture was along the Rio Cebolla within this assessment area (Frey 2007).

Sensitive Plants

Of the sensitive plants that could occur in this area, the wood lily is the only one with documented occurrence in the area, in several locations. There are no known records of occurrence for the robust larkspur, Springer's blazing star, or yellow lady's slipper on the Jemez District. The Region 3 botanist noted that yellow lady's slipper occur in Bandelier National Monument, so it could occur on the Jemez District as well (personal communication with McDonald, 2009).

Management Indicator Species

Management Indicator Species (MIS) for the National Forest, listed in the 1987 EIS for the Forest Plan, were originally selected to represent plant communities and seral habitats that management activities in the 1980s could affect. The 1970s MIS list for the Forest Plan is outdated but has not yet been revised or amended. The following table lists the MIS species that have habitat in the area and occur in the assessment area, such that population and habitat trends can be monitored. The National Forest's annual MIS monitoring report (on Forest website) provides additional details. (US Forest Service 1987b).

Table 35. Management indicator species and associated habitat

Species	MIS Associated Habitat	Occurrence in Assessment Area
Merriam's turkey *Meleagris gallopavo*	Mature ponderosa forest	Widespread throughout area
Hairy woodpecker *Picoides villosus*	Mature forest and woodland	Widespread throughout area
Rocky Mountain elk *Cervis elaphus nelsoni*	Mid elevation grasslands, meadows and forest	Widespread throughout area
Mourning dove *Zenaida macroura*	Mid and low elevation grasslands, woodlands and ponderosa pine	Widespread throughout area
Pinyon jay *Gymnorhinus cyanocephalus*	Piñon-juniper habitat	In piñon-juniper woodlands (approx. 31,000 acres suitable)
Mexican spotted owl	Late seral stage mixed conifer	In mixed conifer forest (approx.

Species	MIS Associated Habitat	Occurrence in Assessment Area
Strix occidentalis lucida		17,000 acres suitable)

Elk habitat is widespread across the District. Elk numbers were estimated in 2007 and 2008 (pre-season) to be 5,500 to 8,000 in Game Units A, B (Preserve), and C (National Forest), with about 3,500 of those on the Preserve (personal communication with Stewart Liley at NM Dept. of Game and Fish, Sept. 2009). Because of the large population of elk in the Preserve, a fair number have summer and calving areas on the National Forest, and move down to lower elevations during the winter. In coordination with NM Department of Game and Fish, the most important habitat for summer habitat/calving and winter habitat on the Jemez Ranger District is delineated and mapped in the Forest GIS database.

Other Wildlife

Mule deer are common, but populations are more patchily distributed on the district, according to locations of shrub/forage availability. The NM Department of Game and Fish, provided estimates for mule deer populations in Game Units 6A and 6C on the Jemez District based on studies conducted in December 2004/January 1005; thus, they are based on low numbers of observances. Without using models to estimate deer populations, the population is approximately 639, and using models the population is estimated at 1,186; however, there is a high degree of potential variability in these estimates (personal communication with Barry Hale at NM Dept. of Game and Fish, Sept. 2009)..

Beaver ponds are present on the Jemez River, East Fork Jemez, Rio Cebolla, San Antonio Creek, and Rio Guadalupe. A limiting factor for beaver occurrence is the availability of food sources, such as aspen and willow, to sustain long-term populations.

A wide variety of other wildlife is also found in this assessment area including many species of birds, mountain lion, gray fox, black bear, coyote, raccoon, amphibians, rattlesnake, lizards, other reptiles, small rodents, butterflies and other insects.

Current conditions compared to reference conditions for nearly all species that use this area are significantly lacking in the abundance and diversity of grass/forb/shrub on the forest floor, interspersed among the trees. It is also lacking in the proportion of mature, old growth stands and overall structural diversity across the landscape. Moving toward reference conditions with more of those elements would improve forage and cover habitat for turkey, bats, small rodents, small birds, deer, and elk, among others. It would increase prey base for falcon, goshawk, other raptors, owls, coyote, fox, and others. It would increase the mast crops that provide food for black bear, turkey, and many bird species.

Water tanks in the area are lacking escape ramps for small mammals and where possible, they should be included as a design feature in all water tanks being repaired or replaced.

Fisheries and Aquatic Habitat

Introduction and Methodology

This section describes and compares existing and reference conditions for fisheries resources, including stream and riparian habitat conditions. The assessment includes information relative to stream habitat and fish populations within the five perennial stream systems that occur in the assessment area outside the Preserve.

Figure 11 in the earlier Water Resources section of this report, is a map showing streams and waterbodies in the assessment area. In this section, Figure 53 shows which streams contain native fish species as well as the potential stream habitat for Rio Grande cutthroat trout, which currently do not reside in streams on the National Forest land in the assessment area.

Reference conditions used in this section come primarily from the Forest Service Region-3 Level I and II Stream Inventory Ratings of properly functioning conditions (US Forest Service 2005a), along with management direction from the Forest Plan (including plan amendments from management plans for the Jemez National Recreation Area and East Fork Jemez River Wild and Scenic River). Additional reference conditions come from conservation plans for Rio Grande cutthroat trout (RGCT Conservation Team 2009 and New Mexico Department of Game & Fish 2002).

Fish Species

An assemblage of native fish as well as introduced rainbow trout (*oncorhynchus mykiss*) and brown trout (*salmo trutta*) occur in the perennial (year-round) streams within the assessment area. The three native fish species present in the area include:

- Rio Grande chub (*Gila pandora*)
- Longnose dace (*Rhinicthys cataractae*)
- Rio Grande sucker (*Catostomus plebeius*)

The previous map shows the distribution of these species in the assessment area, along with streams where Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*) historically occurred in the assessment area. Rio Grande cutthroat trout (RGCT) is one of 14 subspecies of cutthroat trout native to the western United States (Behnke 2002). They are found primarily in clear, cold mountain lakes and streams in Colorado and New Mexico within the Rio Grande Basin (Sublette et al. 1990). On the National Forest, RGCT exist in mountain streams in the Sangre de Cristo and Jemez Mountain ranges in tributaries to the Pecos, Chama, and Jemez rivers, although there are no occupied streams within the assessment area.

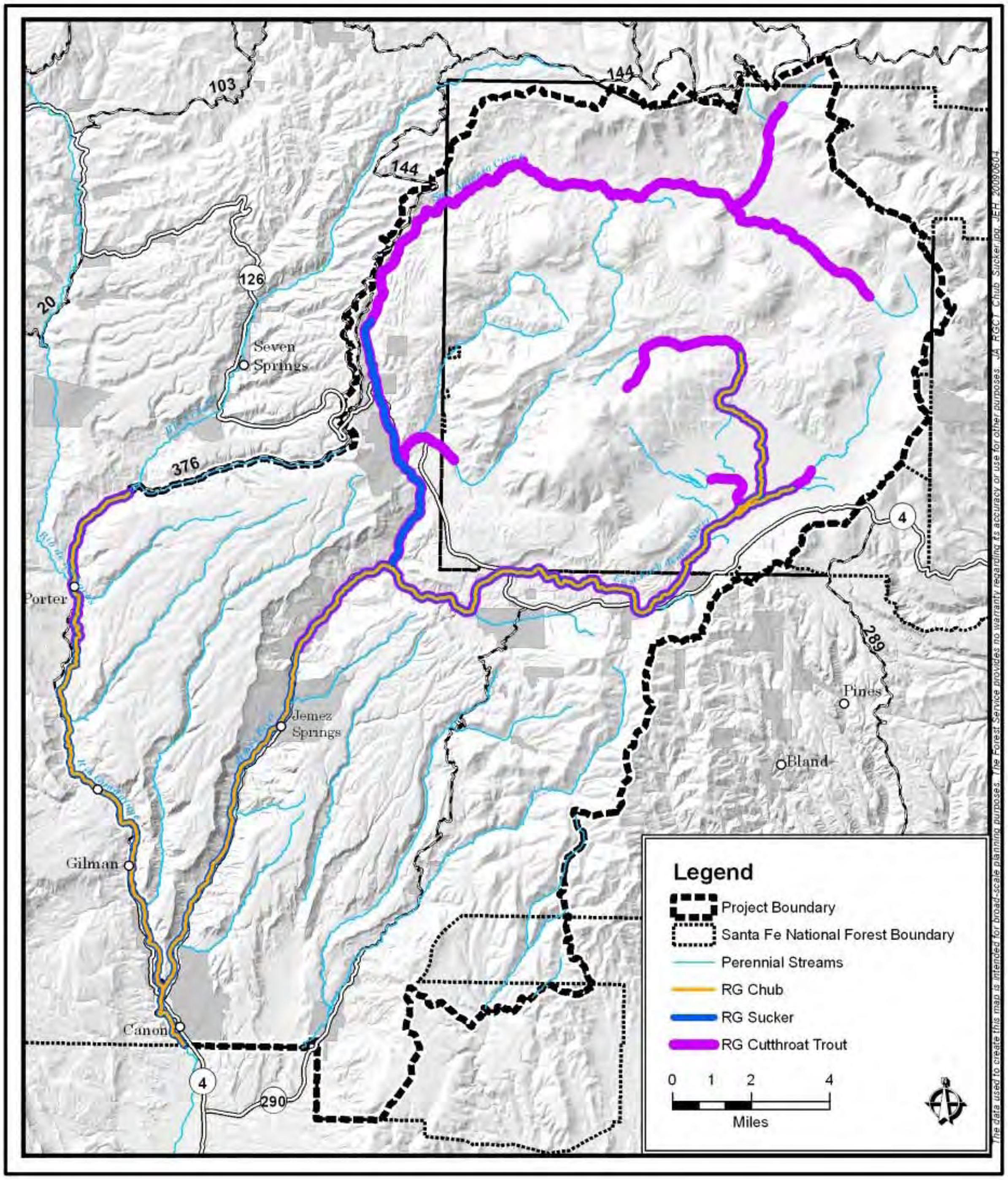

Figure 53. Rio Grande chub and sucker locations and potential Rio Grande cutthroat trout habitat

Studies indicate that RGCT historically occupied approximately 965 miles of the 1,072 miles of perennial streams on National Forest land, prior to stocking of non-native trout [first stocking record noted in New Mexico was in 1896 (Sublette et al. 1990)]. As of May 2007, New Mexico Department of Game and Fish (NMDGF) and National Forest have identified 39 streams as occupied with RGCT, totaling 138.3 miles. Of these occupied stream miles, 47.0 miles are currently considered secure (no invasion of non-native fish). In 2008, the U.S. Fish and Wildlife Service completed a status review for the Rio Grande cutthroat trout (RGCT) under the Endangered Species Act and found that listing the species was warranted but precluded by higher priority actions. As a result of that review, Rio Grande cutthroat trout was included on the candidate species list "with a listing priority of 9, because the threats affecting it have a moderate magnitude and are imminent" (Federal Register May 14, 2008).

The decline in RGCT in New Mexico is attributed to many factors including the dewatering of streams by irrigation and altering stream habitat. Introduction of non-native trout is the major culprit, as non-native trout prey upon or hybridize with RGCT. Brown trout introduced in the early 1900's occupy most perennial streams on the National Forest and limit RGCT productivity, although stocking streams with brown trout no longer occurs. Rainbow trout have continued to be stocked in cold-water streams and lakes throughout New Mexico since 1896 (Sublette et al. 1990). Rainbow trout compete for food and hybridize with RGCT, thereby limiting the genetic survival and productivity of RGCT.

Native RGCT are afforded protections as a State Sensitive Species and Species of Greatest Conservation Need (New Mexico Department of Game and Fish 2006), a US Forest Service Regional Forester's Sensitive Species (US Forest Service 2008), a Forest Plan management indicator species (US Forest Service 1987b), and a candidate species under ESA. In response to its population decline and current risk of being formally listed under the ESA, agencies in Colorado and New Mexico signed range-wide and state-wide conservation agreements for this species. The statewide conservation agreement states that the signatories shall *protect, maintain, and improve existing and potential RGCT habitat and manage these watersheds and stream-riparian habitats to ensure long-term conservation and persistence of the subspecies* (US Forest Service 2002c). In order to achieve this, the Forest shall *prevent or alleviate management related impacts that could degrade occupied or potential RGCT habitat and/or impair current populations* (RGCT Conservation Team 2009). This is to be accomplished by identifying all core and conservation populations and occupied habitat; securing, enhancing, and restoring conservation populations and watershed conditions; and conducting public outreach, data sharing, and interagency coordination.

Reference conditions related to native fish species in this assessment area include the following goals from the Forest Plan (as amended) and RGCT conservation plans:

- A native fish assemblage is fully represented on the landscape, including RGCT, Rio Grande sucker, Rio Grande chub, and longnose dace.
- Habitat for threatened, endangered, and sensitive aquatic species is identified, protected, and enhanced to contribute toward the goal of species recovery.
- Long-term viability of RGCT throughout their historic range is assured through maintenance of areas that currently support RGCT and management of other areas for increased abundance. New populations are established where ecologically and economically feasible in conjunction with NMDGF, including the East Fork Jemez River,

San Antonio Creek, and Rio Cebolla. Threats to wild RGCT are either eliminated or reduced to the greatest extent possible.

The Rio Grande silvery minnow (*hybognathus amarus*) is listed as *endangered* under the ESA. Although it has no current or historic distribution within the analysis area, the Jemez River watershed drains into designated critical habitat in the middle Rio Grande. Thus, significant impacts to water quality in the Jemez River watershed, which could occur following a severe wildfire, may impact silvery minnow habitat in the Rio Grande. Rio Grande silvery minnow was historically one of the most widespread and abundant fishes in New Mexico. Its current habitat is limited to about 7 percent of its former range and is fragmented by dams. The species appears to be limited to a 163-mile reach of the Rio Grande from Cochiti Dam to Elephant Butte Reservoir, and a 2.8 mile stretch of the Lower Jemez River, between the Jemez Canyon Dam and its confluence with the Rio Grande (U.S. Fish and Wildlife Service 2007, Platania and Dudley 2003).

Aquatic Habitat

Stream habitat conditions were assessed for the five major perennial stream systems that occur on the National Forest land in the assessment area. A separate report covers aquatic habitat and fisheries on the Preserve portion of the assessment area. Three partly perennial streams in the assessment area are not addressed because they have not yet been inventoried: Redondo Creek (6 miles in area), La Jara Creek (5.3 miles in area), and Vallecitos Creek (12.2 miles in area). Table 36 shows the perennial stream name, miles within the assessment area, and the 6th Hydrologic Unit Code (HUC) number and name in which the stream occurs.

Table 36. Perennial streams with completed habitat and fishery inventories

Stream Name	Miles in the Assessment Area	HUC 6 Number	HUC 6 Name
Rio Cebolla	3.41	130202020104	Outlet Rio Cebolla
San Antonio Creek	31.51	130202020204	Outlet San Antonio Creek
East Fork Jemez River	21.14	130202020203	East Fork Jemez River
Jemez River	16.86	130202020205	Church Canyon-Jemez River
Rio Guadalupe	13.21	130202020107	Rio Guadalupe

This assessment of fishery habitat conditions was derived from inventories of stream habitat conditions and fish populations. The stream habitat inventories were conducted using the Forest Service Region-3 Level I and II stream inventory protocol, modified from the Region -6 protocol (US Forest Service 2005a; Hankin and Reeves 1988). The inventory is designed on a hierarchical scale to provide the user the opportunity to choose an inventory protocol that meets the data needs for individual situations. Level I is the basic office procedure, which identifies standard attributes of the watershed and stream to be analyzed based on knowledge of the stream system. Level II is an extensive field inventory of stream channels, riparian vegetation, and aquatic habitat conditions on a watershed-wide scale. This level is to be used to determine the condition of a system during low flow periods. In the Level II inventory, stream habitats are broken up into riffles, pools, side channels, dry channels, culverts, and waterfalls and given a Natural Sequence Order number (NSO). In addition, tributaries, such as streams, seeps and springs are inventoried and given a NSO. Riffles, pools, culverts, and waterfalls are then tabulated to calculate stream length. The other NSO units are used to calculate available stream habitat, but not stream length. Inventories repeated over time are useful in measuring changes or trends in stream and habitat conditions, providing indicators for management and as a monitoring tool.

The Level II stream inventory catalogues aquatic habitat conditions using a matrix of quantitative and qualitative factors and indicators developed for various target species across the West. In the case of Region 3, a literature and peer review was conducted to develop a matrix for RGCT streams. This matrix is used to compare existing conditions to reference conditions for each aquatic (stream) system, as shown in Table 37. This Level II stream inventory, shown in Table 37, categorizes current conditions as ***properly functioning***, ***at risk***, or ***not properly functioning*** in comparison with the reference condition, which reflects the range of natural variability for occupied and historic RGCT streams. Thus, this table is used throughout this document as a guide to the comparisons of current conditions to reference conditions. An element *at risk* or *not properly functioning* indicates the element that has been altered or is departed from reference.

Additional reference conditions related to stream and riparian habitat in this area include:

- Streamside riparian zones along the Lower Jemez River and Rio Guadalupe are no longer at risk to non-native invasive plants.
- Non-system user created roads in riparian area along the Rio Guadalupe corridor are obliterated in order to protect soil and water resources. Areas where people can park and drive are designated.
- Recreation has minimal impact on stream and riparian resources, due in part to implementation of activities proposed under Respect the Rio and Leave No Trace Outdoor Ethics, including: development of educational brochures and installation of information kiosks along the Guadalupe corridor in order to inform the public about the value of riparian areas, techniques for river-friendly camping, designated parking areas, construction of restroom facilities, designation of appropriate dispersed recreation sites and removal/ rehabilitation of sites creating resource impacts near the river, and designation and management of pedestrian trails linking the dispersed sites to parking areas and the river.

Table 37. Factors and indicators of stream health for historic and occupied Rio Grande cutthroat trout streams as related to R3 stream habitat inventory

Factors	Indicators	Properly Functioning	At Risk	Not Properly Functioning
Water Quality	*Temperature – State of New Mexico Standards*	<20°C (68°F) (3 day avg. max)	≥20°C (68°F) <23°C (73.4°F) (3 day avg. max)	≥23°C (73.4°F) (3 day avg. max)
	Temperature – Salmonid Development	≤17.8°C (64°F) (7 day avg. max)	>17.8˚ (64ºF) < 21.1˚ (70ºF) (7 day avg. max)	≥21.1˚C (70˚F) (7 day avg. max)
Habitat Characteristics	Sediment	<20% fines (sand, silt, clay) in riffle habitat. Fine sediment within range of expected natural streambed conditions		≥20% fines (sand, silt, clay) in riffle habitat. Fine sediment outside of expected natural streambed conditions.
	Large Woody Debris[1]	>30 pieces per mile, >12” diameter, >35 feet in length	20-30 pieces per mile, >12” diameter, >35 feet in length	<20 pieces per mile, >12” diameter, >35 feet in length
	Pool Development[2]	≥30% pool habitat by area		<30% pool habitat by area
	Pool Quality	Average residual pool depth ≥1 foot		Average residual pool depth <1 foot
Channel Condition and Dynamics	*Width Depth Ratios by Channel Type*	Width/depth ratios and channel types within natural ranges and site potential		Width/depth ratios and channel types are well outside of historic ranges and/or site potential
	(utilize Rosgen type and range given if applicable)	Expected range of bankfull width/depth ratios and channel type	*Rosgen Type* A, E, G B, C, F D	*W/D Ratio* <12 12-30 >40
	Streambank Condition[3]	<10% unstable banks (lineal streambank distance)	10-20% unstable banks (lineal streambank distance)	>20% unstable banks (lineal streambank distance)

1 Large Woody Debris numeric are not applicable in meadow reaches
2 Pool Development numeric are applicable to 3rd order or larger streams
3 Streambank Condition numeric are not applicable in reaches with > 4 percent gradient

Rio Cebolla – Aquatic and Riparian Habitat Conditions

Reach 1 of the Rio Cebolla begins at the mouth, which is the confluence with Rio de las Vacas, near Porter Landing (T 18N, R2E, Sec. 1). This is the only reach of the Rio Cebolla within the assessment area. The survey of this reach started on July 4, and ended on July 17, 2001. The reach starts at 7, 190 feet above sea level and continues upstream for 3.0 miles, where Rio Cebolla enters a big meadow at 7,440 feet (T19N, R2E, Sec. 30). This reach has moderate gradient of 1.6 percent. A sand/silt substrate type dominates this reach. The Rosgen channel type for this reach is an E5 type channel (Rosgen 1994).

This stream reach includes Porter Landing, the site of a historic logging camp and the junction of a spur rail line that came up the Rio Guadalupe through Gilman Tunnels. Forest Service (FS) Road 376 parallels Rio Cebolla throughout Reach 1, allowing easy public access to dispersed recreation sites. Campsites are the main concern for water quality in this reach. During the survey, a portable toilet was found in the stream with human waste entering the water. Other campsites in the area included latrine sites and unburied human waste within 1 to 3 feet of the stream. Large amounts of litter were evident as well as numerous dispersed foot and ATV trails fording the stream, contributing to bank destabilization. Some minor beaver activity was observed, but most pools (both natural and man-made) had filled in or were filling in with fine sediment. Numerous small rock and woody debris dams were present in this reach. Most of these man-made structures were constructed to provide swimming holes for recreationalists.

Riparian vegetation consists mostly of woody species such as alder with some willow. Most of the ground was covered with various grass species, which are the dominant riparian vegetation. Reach 1 is a meadow reach, with a wide-open valley floor, with some pockets of forested overstory. The majority of the overstory throughout this reach consisted of ponderosa pine, with some Douglas-fir and juniper.

When compared to the indicators of stream health for historic and occupied RGCT streams, Reach 1 is **not properly functioning** for all habitat characteristics and channel conditions except pool quality. Streambank condition is **at risk**. Large Woody Debris (LWD) is excluded from analysis in this reach as it is a meadow reach. For example, riffles are **not properly functioning** for average sediment amounts, with 54 percent sand (sand, silt, clay, and fines), which is above the less than 20 percent criterion. Reach 1 is a low gradient reach, conducive for the settlement of fine substrates, although the high amount of fine sediments in riffles in Reach 1 is well above natural levels. This reach was **properly functioning** for pool quality, with an average residual pool depth over the minimum indicator of 1 foot. Reach 1 was **not properly functioning** for pool quantity, with only 7.5 percent of the reach in pools, which is below the 30 percent minimum criteron. Pool depth was also poor, with no pools deeper than three feet, and many filling in with sand (fine sediment). Although there are only 2 pools evaluated to base this analysis on, sand was the dominant substrate composition (75 percent) in those pools.

Reach 1 is defined as a meadow reach, so the lack of LWD may be natural. However, in the middle part of this century it was common for land managers to remove LWD from streams, as logjams were seen as barriers to fish passage. However, LWD does not hinder fish movements and is an essential part of pool formation, critical to providing thermal protection to over-wintering fisheries. Recreationists have physically removed LWD for use in campfires, and fire suppression practices that reduce tree mortality also contributes to reduced quantities of LWD in streams.

The bankfull width-to-depth ratio for Reach 1 was 9:1, which meets criteria for a typical “E” channel and a properly functioning condition. There is evidence of entrenchment that should be further investigated (Figure 54). Road 376 and the old railroad bed adjacent to the stream are prohibiting natural meandering, affecting the width-to-depth ratio, and forcing the stream to one side of the floodplain.

Figure 54. Entrenched channel with bank erosion on Rio Cebolla Reach 1, with willows growing at top of the slope

Streambank condition of Reach 1 is at risk, with 10 percent bank instability, which exceeds the properly functioning criterion of less than 10 percent. This bank instability is due to the heavy recreational use along the floodplain and is compounded by heavy grazing pressure. The photo in Figure 55 shows an example of where dispersed recreation activity has resulted in loss of ground vegetation and increased soil compaction and streambank instability. Both sides of the river are riddled with dispersed trails and recreation sites causing bank instability. With some rehabilitation, such as planting willows and other native grasses, the bank stability could be increased dramatically.

Figure 55. Dispersed campsite causing bank erosion on Rio Cebolla Reach 1, with wood being used to create a stream crossing

Pool development was the other criterion that was not properly functioning, but this can be easily remedied through increases in LWD. Adding LWD to improve pool formation would greatly improve fish habitat, bankfull width-to-depth ratios, and return the stream channel to its properly functioning condition. Sections of the rail line that are confining the stream channel and should be removed to allow natural meandering and floodplain functioning. This reach of the Rio Cebolla does not have a recorded fishery survey (NMDGF personal communication, January 14, 2010), so no fish data is available.

East Fork Jemez River - Stream and Riparian Conditions

The National Forest's fisheries crew conducted a stream survey on 21.43 miles of the East Fork Jemez River during the summer of 2001, from the mouth (Township 19N Range 3E Section 32 at 6,755 feet elevation) to the headwaters (8,523 feet elevation) where the East Fork Jemez River starts at a group of springs. The East Fork Jemez is a 4th order tributary to the Jemez River. The East Fork Jemez River and San Antonio Creek come together at Battleship Rock to form the Jemez River.

The East Fork Jemez River originates in the northwest corner of the Preserve. It drains Valle Grande, where it picks up several major tributaries, including Jaramillo Creek and La Jara Creek. It flows 21.43 miles to its confluence with San Antonio Creek, forming the Jemez River. The upper 9 miles are on the Preserve. The National Forest section of the East Fork Jemez River is a designated Wild and Scenic River and is part of the Jemez National Recreation Area. Management direction for the East Fork Jemez Wild and Scenic River require maintaining the natural water flow and water qualities for which it was designated (US Forest Service 1999).

East Fork Jemez River was evaluated based on eight different reaches, distinguished by stream and valley morphology and dramatic changes in stream flow (Table 38). The survey began at the mouth of the river and worked its way upstream. The stream reaches were numbered in an upstream progressive order.

Table 38. Description and length of stream reaches on the East Fork Jemez River

Reach	River Miles	Landmark at Beginning and End	Land Jurisdiction
1	0-1.95	Mouth to McCauley Warm Springs.	National Forest
2	1.95-3.15	McCauley Warm Springs to Jemez Falls	National Forest
3	3.15-5.0	Jemez Falls to NM Highway 4 Crossing	National Forest
4	5.0-6.01	NM Highway 4 Crossing to “The Box”	National Forest and Preserve
5	6.01-7.99	The Entrance of “The Box” to the Exit of “The Box”	National Forest
6	7.99-12.81	“The Box” to Entrance to Valle Grande	National Forest, Preserve, and Private
7	12.81-16.51	Entrance to Valle Grande to Confluence with Jaramillo Creek	Preserve
8	16.51-21.43	Jaramillo Creek to Terminus of Headwaters	Preserve

Overall, the gradient on the East Fork Jemez River is extremely variable, ranging from 0 percent in the headwaters to over 7 percent in Reach 2 downstream from Jemez Falls. This is atypical; since high mountain streams typically have the highest gradient reaches in the headwaters. However, the headwaters of the East Fork arise on the edge of Valle Grande in the Preserve, a vast low gradient meadow system. Valle Grande lies in the middle of a large volcanic crater. Valles Caldera originated approximately 1.2 million years ago, following the second of two cataclysmic volcanic eruptions that occurred 300,000 years apart from each other. Following the eruptions the center of the volcano collapsed inward, forming the caldera, which filled with water. Eventually, erosion caused by the East Fork Jemez River breached the southwestern rim of the caldera, draining the lake. In 1975, Valles Caldera was designated as a National Natural Landmark (Report on the Study of Baca Location No. 1).

From Reach 8 down through Reach 7, the East Fork meanders through a meadow system, which is broken up by tributaries such as Jaramillo Creek and La Jara Creek. This meadow system is located where the historic lake once occurred. In Reach 6 the river flows through a mixed canyon meadow system, where it then enters Reach 5, also known as “The Box”. This section of the river is extremely confined by a steep canyon mostly comprised of bedrock, which is characterized by numerous bedrock falls and chutes. This is the edge of the ancient caldera. The stream then enters a meadow area surrounded by bedrock walls that continues downstream to the last road crossing at NM Highway 4. From here to Jemez Falls, Reach 3 passes through another confined canyon with some falls and chutes. Below Jemez Falls, Reaches 1 and 2 pass through a canyon and then join with San Antonio Creek at Battleship Rock.

The stream is a flashy system where stream flows increase dramatically after typical summer monsoon rain events. It is also a flashy system due to the porous volcanic parent material and loss of wetlands. No irrigation withdrawals or active ditches were found during the survey. The East Fork has excessive fine sediment loads and high turbidity. A 1997 study found that the East Fork was not in compliance with the high quality coldwater fisheries standards for dissolved oxygen, pH, dissolved aluminum, and total phosphorous (Everett and Hodgins 1991). Water quality analysis conducted in 2001 by New Mexico Environmental Department Surface Water Department determined that the East Fork exceeded the following water quality standards for a quality cold water fishery: water temperatures below La Jara Creek; pH levels below La Jara Creek; dissolved oxygen (DO) concentrations above Jaramillo Creek; fecal coliform counts in East Fork Jemez and Jaramillo Creek; and turbidity levels below La Jara Creek.

During the habitat survey, the river was broken up into 562 total NSOs (habitat units), which measured a total of 113,160 feet in length. Of these 562 NSOs, there were 201 pools, 231 riffles, 4 culverts, 19 tributaries, 40 falls, and 67 side channels. There were no stream length measurements for tributaries, as they did not contribute to the habitat in the main stem of the river. Based on the indicators, the East Fork Jemez River is not properly functioning for all habitat characteristics and channel condition and dynamics, except pool quality and streambank condition. The East Fork Jemez River is comprised almost entirely of riffle habitat, with a pool to riffle ratio, 1:1.2. There is almost 8 times more riffle than pool habitat. For a stream to be properly functioning it must have at least 30 percent pool habitat. The lack of pool habitat is mostly in upper Reaches 6 to8, and attributed to stream widening, decrease in sinuosity, and sediment input. Sediment is filling in pools from the banks and erosion in the uplands of the Preserve. During the survey, one person recounted that he had not been to the East Fork for approximately ten years. During that time, it appeared to him that the pools were becoming shallower. One pool that he used to swim in was too shallow, becoming a riffle.

In the lower reaches, a few stretches of stream also had a lack of pool habitat, mostly attributed to the lack of LWD and sediment filling in pools. The high gradient of the lower reaches have increased the numbers of pools, but decreased the length of pools. Because the gradient is so high in these areas, a step pool system is created.

Although there are no guidelines for side channel habitat, having only 3 percent side channel habitat is very low. A little less than half of the river was meadow habitat, approximately 9 miles. The area of stream in the low gradient, high sinuosity meadow systems should have higher amounts of side channel habitat. During the survey, side channels were observed that were no longer active, these channels are also noted on USGS quad maps (Revised in 1993). Due to past grazing practices, these side channels have been converted to dry sites. In the non-meadow reaches, another contributor to the lack of side channel habitat is lack of LWD.

The amount of LWD per mile for the entire river was 8.31 pieces per mile, which is well below the 30+ pieces per mile that indicates a proper functioning condition. The lack of LWD is due in part to geomorphology of the stream channel, as a high gradient, flashy system transports LWD downstream. Other factors include fire suppression and public collection of firewood. The average length of riffles among reaches varies greatly. The lower reaches have numerous short riffles, while the upper reaches have a smaller number of riffles, and the average length increases dramatically. Several riffles in the Valle Grande Reaches (7 and 8) are close to a mile long (three times longer than the average riffle in the entire river), indicating a lack of quality pool habitat. The Valle Grande is mostly one long riffle for 8 to 9 miles. An under-sized bridge created the most prominent pool (albeit unnatural) feature in Valle Grande. If this bridge was repaired, it is very likely that this pool would fill in with fine sediment. Meadow systems like Valle Grande are typically comprised of a meandering riffle system dominated by gravels, along with long deep pools. However, in Valle Grande, the system has been altered by past grazing practices. The undercut banks have begun to slough off, and the stream has become wider and shallower, adding fine sediments to the stream. The fine sediments have filled in pools and helped create the very long riffles.

Average sediment levels in riffles throughout the entire river far exceed allowable levels for a properly functioning habitat.. The amount of fines (sand, silt, and clay) in the riffles is 27 percent, compared to the properly functioning level of less than 20 percent. Riffles are typically dominated by a gravel/cobble substrate. The amount of fines is largely due to inputs from the Valles Caldera. The lower river is very turbid from sediment carried downstream, and the turbidity begins to diminish in Reach 8, above Jaramillo Creek.

Pool habitat quality is properly functioning, for the indicator of average residual pool depth, which is of 2.7 feet. However, the number of pools is far below the acceptable pool: riffle ratio of at least 1:1. Unfortunately, there are more riffles than pools in the entire river. The river has only 10.7 percent pool habitat, lower than the 30 percent indicated for a properly functioning fisheries stream. The amount of pools declines below The Box. There are only 36 pools in the last 13.4 miles of stream (2.7 pools/mile), and 27 of these are in Reach 6. Unstable banks comprise 8.7 percent of the entire river, excluding Reaches 1 and 2. Reaches 1 and 2 have average gradients greater than 4 percent, and streambank condition does not apply to such high gradient reaches. The river as a whole has a properly functioning streambank condition, with less than 10 percent defined as unstable. . However, the upper reaches had exceptionally high percentages of unstable banks.

Thus, the degree of bank erosion varies by reach, with the highest amount in Reaches 7 and 8 in the Preserve, and low bank erosion in Reaches 2 to 5. Reach 1 had a higher amount of bank erosion due to heavy recreational use along an unconfined high gradient section. The riparian areas in the lower reaches are well developed and, in some cases, limit bank erosion. The amount of unstable banks in the upper reaches is due to historic grazing, and heavy recreational use in Reach 6. Due to past grazing, Reaches 7 to 8 have been converted from Rosgen E type channels to C type channels. Undercut banks are sloughing into the channel, sediment is filling pools, and there is a lack of sinuosity and side channels. Reaches 2 to 5 have the most LWD, which seems natural as these are forested reaches with a confined floodplain. However, most of the LWD is old and there is little new LWD entering the channel. In Reach 4, the double culvert has one pipe that does not allow transport of LWD or floodwater, which creates a drastic change in gradient and substrate downstream from the culvert. It is also causing fine sediment to accumulate above the culvert. Two other culverts in this river system are having similar negative impacts on stream morphology and water quality. An open bridge construction would be a beneficial alternative to those culverts and allow the stream to recover.

East Fork Jemez River Fishery

On July 6, 2009, staff from New Mexico Department of Game and Fish and the National Forest conducted a survey on the East Fork of the Jemez River to gather information about the fish. Two sites were surveyed using a three-pass electro-shock depletion protocol, including an upper site at the Las Conchas Fishing Access, and a lower site near the Jemez Falls turnout. The survey areas were 80 and meters long, respectively. All captured fish were weighed and measured after each pass (in grams and mm). The exception was the rainbow trout, as they were obviously stocked fish. The first 10 rainbow trout were measured, and all others were just counted.

Table 39 displays the fish species and percent caught of each, at the upper and lower survey sites sampled. Survey results showed that the most abundant species at both the upper and lower survey sites is brown trout, comprising 51 and 42 percent of the catch respectively. There are approximately 962 brown trout per 1,000 meters, weighing 136 kg/ha. Least abundant are the Rio Grande chub and sucker, which are native fish species.

Table 39. Fish species distribution, East Fork Jemez River

Species Name	Common name	% of Catch at Upper Site	% of Catch at Lower Site
Salmo trutta	Brown trout	51	42
Oncorhynchus mykiss	Rainbow trout	16	25
Rhinichthys cataractae	Longnose dace	23	8
Gila pandora	Rio Grande chub	1	17
Catostomas plebius	Rio Grande sucker	9	8

San Antonio Creek – Stream and Riparian Conditions

San Antonio Creek is a 5th order stream originating from springs in Valle Toledo within the Preserve, and ending at the confluence with the East Fork Jemez River near Battleship Rock forming the Jemez River (see Streams and Waterbodies map, Figure 11). It flows 30.5 miles from the mouth (6,755 feet elevation) to the headwaters (8,760 feet elevation). The San Antonio Creek drains the area between East Fork of the Jemez River and Rio Cebolla. Upper reaches, upstream from the town of La Cueva, are on the Preserve, and lower reaches are mostly on the National Forest, with portions flowing through private lands in and around La Cueva.

The entire stream was surveyed in 2002 using the USFS Region 3 Stream Survey Protocol from the modified Region-6 protocol (Hankin and Reeves 1988, US Forest Service 2005a). Streams were surveyed from the mouth moving upstream, and separated into riffle, pool, side channel, dry channel, culvert, and falls habitat types by specific attributes. Tributaries were also surveyed and classified as a seep, spring, or stream. Habitat types were assigned a Natural Sequence Order number (NSO) and grouped into a sequence of reaches.

Fish populations are present from the mouth (T19N, R3E, Sec. 32) at 6,755 feet to the headwaters at 8,760 feet.

San Antonio Creek is divided into 11 reaches, each with similar habitat characteristics and stream morphology. The average gradient of is 1.3 percent, and ranges from 0.1 to 4.9 percent. It flows across volcanic parent material that is highly erosive. It has excessive fine sediment loads and high turbidity, exacerbated by historic and current grazing practices, historic logging on the Preserve, and recreational and road-related impacts. Stream flow fluctuates between high flow events during spring runoff and summer monsoon rains, to low flows the rest of the year. The driest year in the past 20 years occurred in 2002, which is when the stream survey was conducted. Water diversions include one irrigation ditch and one pond. The ditch near San Antonio Campground diverts approximately half of the stream flow to the left bank. The constructed pond is constantly fed by a negligible quantity of water from San Antonio Creek in Reach 4 (La Cueva). (US Forest Service 2005b and 2003a).

Water quality monitoring by the State in 1998 and 1999 (at two sites) found water quality to generally meet the standards. However, turbidity exceeded standards twice during spring runoff and once in the fall. Total organic carbon (TOC) exceeded standards once in the fall at each site and could be attributed to decomposing deciduous vegetation (NMED 2001).

The pool:riffle ratio by number of habitats is 1:1.5, the same ratio by length of habitat is 1:13.0. The pool to riffle volume ratio is 1:1.7. A higher volume to length ratio in pools is due to pool shape. The riffle habitat is much greater than pool habitat.

San Antonio Creek contains a mix of not properly functioning and properly functioning characteristics. The parameters that are not properly functioning include: water temperature, sediment content in riffles, density of large woody debris (LWD), pool development, and width-to-depth ratio. Properly functioning characteristics include stream bank condition.

Water temperature is a crucial parameter for fish health and development. Water temperature data from five sample sites was compared to both National Forest and NMED standards. The National Forest standard classified San Antonio Creek as not properly functioning for salmonid development at all sites except station 5, near the headwaters. The NMED standard classified two of the five sites as not properly functioning for water quality. Future management actions should mitigate human-caused elevation of stream temperatures on San Antonio Creek. .

Riffle substrate content is important to the spawning and reproductive success of fish. The relative quantity of fine sediment in San Antonio Creek is not properly functioning by matrix standards, as riffle sediment content was about 30 percent.

Pool habitat is important over wintering, resting, and feeding habitat for fish. The relative pool habitat volume (depth) is not properly functioning, well below the greater than 30 percent standard. In addition, the quantity of pool habitat is of concern in all reaches except Reach 2 (34 percent). The relative quantity of pool habitat ranges from about 0.4 percent (Reach 10) to 14 percent (Reach 7).

The amount of LWD is related to habitat complexity and the health of fish populations in stream habitats (Fausch and Northcote 1992). In all reaches except those classified as a meadow, LWD density is not properly functioning. In non-meadow reaches, LWD density ranges from 0.0 pieces per mile in Reach 2 to 17.0 in Reach 5. All non-meadow reaches are far below the greater than 30 pieces per mile standard. Thus, there is a need to increase LWD, which would also improve other degraded conditions including lack of pools and excess sediment in riffles.

As defined by Rosgen stream classifications, each stream class has an expected natural bankfull width-to-depth ratio, which is related to how the stream should react to its valley formation (Rosgen and Silvey 1998). Reaches 1, 6, 8 and 11 are not properly functioning for the expected width:depth ratio for their respective Rosgen stream classifications. These reaches should be further analyzed to determine if this is surveyor error or management related. The other reaches are properly functioning excluding Reach 3, which was not surveyed or classified. The width:depth is not properly functioning in Reach 6 and at risk in Reach 1. Also, two of the 10 surveyed reaches are at risk for length of unstable banks: Reach 6 is at 11 percent and Reach 10 is at10 percent. . The remaining reaches are properly functioning for streambank stability.

Figure 56. Long riffle habitat and bank instability San Antonio Reach 6, 2002

The following table shows the relative density of fish species based on a July 2009 survey conducted at two sites in San Antonio Creek. The upper site was within a special trout water area and the lower site was above the Highway 126 crossing. The special trout water designation requires that anglers use artificial fly or lure with a single barbless hook--catch and release only. The survey found brown trout density at about 362 to 375 fish per 1000 meters, weighing 52 to 57 kg/ha. Longnose dace (a native fish) was found to be the most abundant, followed by brown trout (a non-native). Rainbow trout is the least abundant.

Table 40. Fish species density in San Antonio Creek

Species Name	Common name	% of Catch at Lower Site	% of Catch at Upper Site
Salmo trutta	Brown trout	41	20
Oncorhynchus mykiss	Rainbow trout	0	1
Rhinichthys cataractae	Longnose dace	59	79

Jemez River – Stream and Riparian Conditions

The Jemez River is a 5th order tributary to the Rio Grande. It starts from the confluence of San Antonio Creek and East Fork Jemez River at Battleship Rock, and flows all the way into the Rio Grande. The Upper Jemez flows through the National Forest land and some private land within the assessment area about 12.7 miles to its confluence with Rio Guadalupe. It begins below the Preserve. It has five reaches and the gradient ranges from 1.0 to 2.2 percent.

The upper Jemez River was surveyed in the summer of 2006, using the USFS Region 3 stream survey protocol previously described (a modification of the Region 6 protocol (US Forest Service 2005a).

The Jemez River has some reaches with not properly functioning conditions for: sediment, density of LWD, and pool development. Properly functioning characteristics include pool quality, stream bank condition, and width-to-depth ratio. The riffle habitat comprises 89 percent of the stream habitat throughout this River, reflecting a lack of adequate pool habitat. Sediment content in riffle habitat is27 percent, which indicates it is not properly functioning. The dominant substrate type is cobble followed by sand. Pool quality is properly functioning in the Jemez River with 90 percent of the pool habitats with at least a 1-foot residual depth. Residual pool depth is poor, at almost twice the properly functioning indicator. The length of pool habitat is also of concern in every reach. Pool quantity in reaches that are not properly functioning range from 4.0 percent in Reach 4 and to 12 percent in Reach 3, with the average quantity at only 10 percent.

The density of LWD is not properly functioning in all reaches of the Jemez River. The average LWD density is only 2.6 pieces per mile. The LWD density ranges from 1.45 pieces per mile in Reach 5 to 4.65 pieces per mile in Reach 4. Increasing the low densities of LWD should be a focus in the management of the Jemez River. Size of the LWD is also generally below the minimum standard of 12 inches in diameter at the large end and 35 feet long. Increasing the LWD density should be a focus in the management of the Jemez River, to improve several stream and fisheries habitat conditions.

Bank stability is highly variable, averaging 4.2 percent instability, which is properly functioning. Reach 1 is not properly functioning for bank stability, with 13 percent instability, due to activity at the developed recreation and fishing access areas.

In July 2009, a fish survey was conducted at two sites along the Jemez River within the assessment area: the upper site at the gauging station and the lower site just below the Ranger Station. Longnose dace, a native species, is the dominant species at the lower site (31 percent of the catch). Brown trout, a non-native species, is the most dominant species at the upper site (42 percent of the catch). Rainbow trout are least abundant. Table 67 shows the relative abundance of each fish species in this 2009 Jemez River survey.

In 2003, the number of brown trout was significantly higher at the lower site near the Ranger Station. The reasons for the differences are not understood because habitat characteristics between the 2003 and 2009 surveys were similar. The surveys may have coincided with a “boom and bust” incidence where a rise and fall in population numbers occurs as a result of forage abundance, annual recruitment, predation, angler take, and other factors. It may be that the brown trout are at carrying capacity for the stream, given the demand for food by the other resident fish species, or that the 2003 result was an anomaly and no longer relevant.

Stream temperatures in the Jemez River are too high to support a Rio Grande Cutthroat Trout (RGCT) population. At the Jemez River site below the Ranger Station, water temperature on the day of the survey was measured at 19 ºC. At the upper survey site water temperature was 21 ºC.

Table 41. Fish species density on the Jemez River

Species Name	Common name	% of Catch at Upper Site	% of Catch at Lower Site
Salmo trutta	Brown trout	42	15
Oncorhynchus mykiss	Rainbow trout	7	6
Rhinichthys cataractae	Longnose dace	35	31
Gila pandora	Rio Grande chub	0	20
Catostomas plebius	Rio Grande sucker	15	27

Comparison of Existing and Reference Conditions

The following table summarizes the comparison of existing and reference conditions based on key aquatic stream and riparian habitat indicators for fisheries resources. Each of the major perennial stream systems evaluated in this report are included, along with the Jaramillo Creek and Rito de los Indios Creeks where additional stream surveys were conducted. The Ecosystem Elements column lists key ecosystem structure, composition, or functional indicators or attributes used to compare current to reference conditions. The last two columns describe the departures or gaps between current and reference conditions and the causes for those departures from the natural range of variability.

However, stream and riparian habitat conditions have substantially improved over the past 10 years. Since 2001, the National Forest's Respect the Rio program has resulted in improving stream and riparian conditions within the assessment area. Respect the Rio includes environmental education, on-the-ground projects to improve water quality and watershed conditions, and public involvement to empower local communities and forest users to participate in watershed restoration. This program has helped to decrease stream temperatures and sediment delivery in these stream systems, in partnership with other agencies and organizations. The program integrates multiple disciplines in the treatment of dense forest stands, maintenance of riparian meadows, improvement of stream health, management of range (grazing), roads, trails, and dispersed recreation, and enforcement of federal regulations that emphasize water quality. Public education is one of the largest components of Respect the Rio, to reduce recreation-related impacts and build public support for the restoration activities.

Table 42. Comparison of existing and reference conditions – stream and fish habitat

Ecosystem Elements (Key Structure, Composition or Function Attributes as Indicators)	**Current Conditions (Quantified if Possible)**	**Reference Conditions or Mgt. Standards**	**Departures: Gap Between Current And Reference Conditions (Quantified; or Surplus or Deficit)**	**Causes (For Departure)**
Aquatic & Riparian Ecosystem: **East Fork Jemez River** (21.1 miles)				
Aquatic Habitat Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	Not properly functioning Not properly functioning Not properly functioning Properly functioning Properly functioning	Properly functioning	Excess fine sediment in riffles, lack of large woody debris, too few pools	Probable Cause of Impairment: Streambank destabilization, loss of large woody debris & riparian habitat, grazing, roads, recreation,

Table 42. Comparison of existing and reference conditions – stream and fish habitat

Ecosystem Elements (Key Structure, Composition or Function Attributes as Indicators)	Current Conditions (Quantified if Possible)	Reference Conditions or Mgt. Standards	Departures: Gap Between Current And Reference Conditions (Quantified; or Surplus or Deficit)	Causes (For Departure)
Native fish species occurrence **Rio Grande cutthroat trout,** **RG chub,** **RG sucker,** **Longnose dace**	Not present; brown & rainbow trout present Present, all reaches Present, all reaches Present, all reaches	Present Present Present Present	Loss of native trout species	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat
Aquatic & Riparian Ecosystem: **Jaramillo Creek (12.1 miles)**				
Aquatic Habitat Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	Not properly functioning N/A – meadow reach Not properly functioning Properly functioning At risk	Properly functioning	Excess fine sediment in riffles, too few pools, streambanks in degraded condition	Probable Cause of Impairment: Streambank destabilization & degradation of riparian habitat as a result of grazing, roads, recreation,
Native fish species occurrence **RGCT** **RG chub,** **RG sucker,** **Longnose dace**	Not present; brown & rainbow trout present Present Present Present	Present Present Present Present	Loss of native trout species	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat
Aquatic & Riparian Ecosystem: **Jemez River** (16.9 miles)				
Aquatic Habitat Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	Not properly functioning Not properly functioning Not properly functioning Properly functioning Properly functioning	Properly functioning	Excess fine sediment in riffles, lack of large woody debris, too few pools	Probable Cause of Impairment: Streambank destabilization, loss of large woody debris & riparian habitat, grazing, roads, recreation,
Native fish species occurrence **Rio Grande cutthroat trout,** **RG chub,** **RG sucker,** **Longnose dace**	Not present; brown & rainbow trout present Present Present Present	Present Present Present Present	Loss of native trout species	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat

Table 42. Comparison of existing and reference conditions – stream and fish habitat

Ecosystem Elements (Key Structure, Composition or Function Attributes as Indicators)	Current Conditions (Quantified if Possible)	Reference Conditions or Mgt. Standards	Departures: Gap Between Current And Reference Conditions (Quantified; or Surplus or Deficit)	Causes (For Departure)
Aquatic & Riparian Ecosystem: **Rio Cebolla** (3.41miles)				
Aquatic Habitat / Channel Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	 Not properly functioning Not properly functioning Not properly functioning Properly functioning At risk	Properly functioning	Excess fine sediment in riffles, lack of large woody debris, too few pools, high level of streambank instability (borderline not properly functioning)	Probable Cause of Impairment: Streambank destabilization, loss of large woody debris & riparian habitat due to grazing, roads, recreation
Native fish species occurrence **RGCT** **RG chub,** **RG sucker,** **Longnose dace**	 Not Present due to browns & rainbows Uncertain Uncertain Uncertain	Native fish community present in sufficient numbers	Loss of native trout species	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat
Aquatic & Riparian Ecosystem: **Rio Guadalupe** (12.7 miles)				
Aquatic Habitat / Channel Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	 properly functioning not properly functioning not properly functioning properly functioning properly functioning	Properly functioning	Lack of in-stream large woody debris, too few pools	Probable Cause of Impairment: localized streambank destabilization & degradation of riparian habitat due to grazing, roads, recreation
Native fish species occurrence **Rio Grande cutthroat trout,** **RG chub,** **RG sucker,** **Longnose dace**	 Not Present; brown & rainbow trout present Present Present Present	Native fish community present in sufficient numbers	Loss of native trout species	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat

Table 42. Comparison of existing and reference conditions – stream and fish habitat

Ecosystem Elements (Key Structure, Composition or Function Attributes as Indicators)	Current Conditions (Quantified if Possible)	Reference Conditions or Mgt. Standards	Departures: Gap Between Current And Reference Conditions (Quantified; or Surplus or Deficit)	Causes (For Departure)
Aquatic & Riparian Ecosystem: **Rito de los Indios (4.5 miles)**				
Aquatic Habitat / Channel Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Pool Quality:** **Stream bank condition:**	 not properly functioning N/A; meadow stream not properly functioning not properly functioning at risk	Properly functioning	Excess fine sediment in riffles, too few pools which are too shallow, high level of streambank instability (borderline not properly functioning)	Probable Cause of Impairment: Streambank destabilization, loss of large woody debris & riparian habitat, grazing, roads, recreation,
Native fish species occurrence **Rio Grande cutthroat trout,** **RG chub,** **RG sucker,** **Longnose dace**	 Not present; brown trout Present; very low density Not present Not present	Present Present Present Present	Loss of native trout species, RG suckers, & longnose dace	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat
Aquatic & Riparian Ecosystem: **San Antonio Creek** (31.5 miles)				
Aquatic Habitat Condition **Riffle sediment:** **Large woody debris:** **Pool development:** **Width/depth ratio:** **Stream bank condition:**	 not properly functioning not properly functioning not properly functioning not properly functioning properly functioning	Properly functioning	Excess fine sediment in riffles, lack of large woody debris, too few pools which are too shallow	Probable Cause of Impairment: localized streambank destabilization, loss of large woody debris & riparian habitat due to grazing, roads, recreation
Native fish species occurrence **RGCT** **RG chub,** **RG sucker,** **Longnose dace**	 Not present due to browns & rainbows Present, lower reaches Present, lower reaches Present	Present Present Present Present	Loss of native trout species & loss of RG chubs & suckers from upper reaches	Probable Cause of Impairment: introduction of non-native species, degradation of stream & riparian habitat