VALLES CALDERA NATIONAL PRESERVE

Forest, Grassland, Riparian, and Shrubland Vegetation

Existing Condition Report

VALLES CALDERA TRUST

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Introduction

The vegetation of the VCNP follows elevational banding and is influenced by soils, climate, and topography. The predominate vegetation types are forests and grasslands with smaller components of woodland and riparian shrubs and rocky outcrops. Compared to other high elevation sites in the southern Rocky Mountains and Colorado Plateau, the vegetative communities of the preserve are quite diverse and harbor many plant communities that are unique to the landscape of the Valles Caldera (Valles Caldera Trust, No Date). The New Mexico Natural Heritage Program has documented 65 plant associations within the Preserve encompassing high elevation sub-alpine forests, mixed conifer and pine woodlands, high montane grasslands, and valley floor wetlands. Table 1 lists the dominant cover types found and Figure 1 displays their distribution.

Table 1 – Dominant vegetation and area covered (Muldavin E., 2006) listed in order of dominance.

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

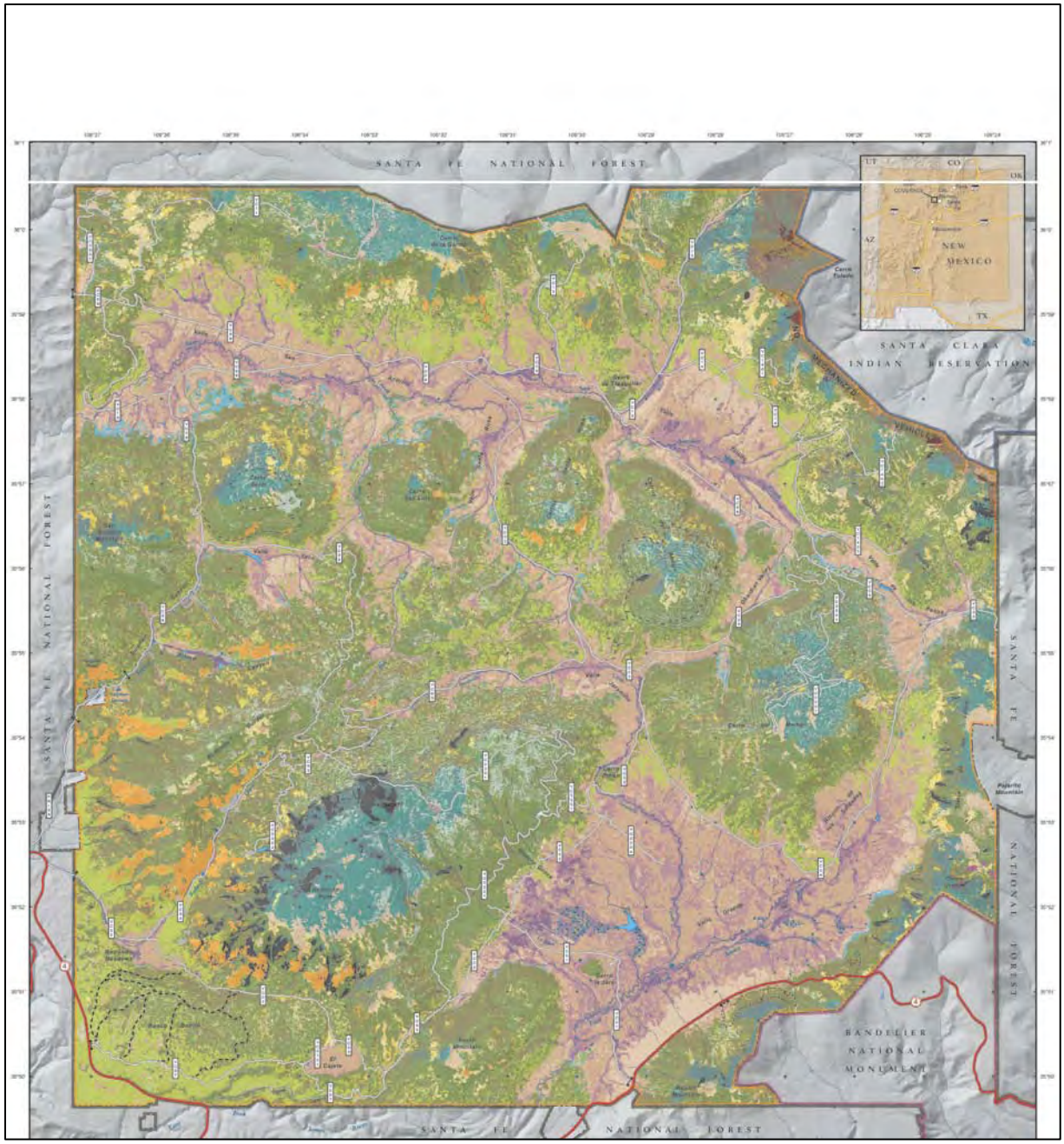

Figure 1 – Major vegetation alliances of the VCNP (Muldavin E., 2006)

Assessment Methodology

Ecological Departure

Ecological departure of the preserve's forests was determined using the Fire Regime Condition Class (FRCC) methodology. FRCC analysis is a systematic process for identifying a reference condition and evaluating the existing condition of vegetation composition and structure relative to the reference condition. FRCC represents the current ecological trend as measured by the composite of structure, composition, and processes across the landscape, providing a more holistic view of the current condition than a discussion of vegetation alone.

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

Table 2– Fire Regime Condition Class attributes criteria

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

The FRCC class is based on the distribution of S-Classes within a landscape relative to the reference condition as well as a comparison of the frequency and severity of recent disturbance relative to the natural fire regime. The natural fire regime considers the frequency and severity of fire during the reference period.

Ecological departure needs to be assessed at a scale that allows for natural variability over the landscape and in context with the region as a whole. This document presents an assessment completed for the VCNP which was consistent with assessments completed by the Nature Conservancy for the Jemez Mountains Region and an assessment prepared for the Southwestern Jemez Mountains Landscape.

FRCC determination requires an understanding of several key terms and concepts including *Biophysical Setting (*BpS*), Historic Range of Variability (*HRV*), Fire Regime,* and *Forest Succession (*S-Class*).*

Biophysical Setting Models

BpS models are the primary environmental descriptors used for determining a landscape's natural fire regimes, vegetation characteristics, and resultant FRCC category. BpS models incorporate both classification (taxonomic) and map unit concepts. Each model is identified by a 2-digit map unit and 4-digit vegetation classification. For FRCC purposes, biophysical settings use dominant vegetation types and their associated fire regimes as a proxy for the integration of a landscape's biotic and abiotic components. Biophysical settings can often be described according to their respective fire regimes and associated vegetation composition (native overstory

species) and structures (major successional stages) based on the best available research describing HRV.

Historical Range of Variation

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

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

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

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

Fire Regime

A natural *fire regime* is a general classification of the role fire would play across a landscape in the absence of modern human mechanical intervention but including the possible influence of aboriginal fire use (Agee, 1993);(Brown, 1995). Course-scale definitions for five fire regimes are classified based on the average number of years between fires or *mean fire interval* (MFI) combined with characteristic fire severity reflecting percent replacement of dominant overstory vegetation. The forests of the Preserve have evolved under three fire regimes as presented in Table 3.

Table 3 - Natural Fire Regimes (USDA - Forest Service - Interagency Fuels Group, 2005)

Group	Frequency (MFI)	Severity	Severity Description
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.
III	35 – 200	Mixed/low	Generally mixed severity, can also include low severity.
IV	35 - 200	Replacement	High severity, replacing more than 75% of the overstory vegetation.

Succession Stages

Forest succession is defined in the FRCC Guidebook as, "*The progression of change in the composition, structure, and processes of a plant community through time.*" A succession class, or *S-Class,* is defined by specific compositional and structural traits associated with phase of succession. S-Class traits and the associated successional pathways in response to growth, maturation, and periodic disturbances are modeled using Vegetation Dynamics Development Tool (VDDT), an open source vegetation dynamics model. Table 4 depicts the S-Classes for growth and maturation in a forest ecosystem; Figure 2 illustrates the successional pathway. Not all ecosystems conform to the standard 5-box model. Some grassland types might have only two or three succession classes, and some classes might have age and canopy characteristics different from those in the forest ecosystem model (USDA - Forest Service - Interagency Fuels Group, 2008).

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

S-Class	A - Early Development	B - Mid-Development, Open Canopy	C - Mid-Development, Closed Canopy	D - Late Development, Open Canopy	E - Late Development, Closed Canopy
Description	Early-seral, post replacement, seedlings and saplings generally under 5-in dbh[1]	Trees, immature, generally from 5 – 16 in dbh Canopy closure generally less than 50 percent	Trees, immature, generally from 5 – 16 in dbh Canopy closure generally greater than 50 percent	Trees mature, generally greater than 16-in dbh Canopy closure generally less than 50 percent	Trees mature, generally greater than 16-in dbh Canopy closure generally greater than 50 percent

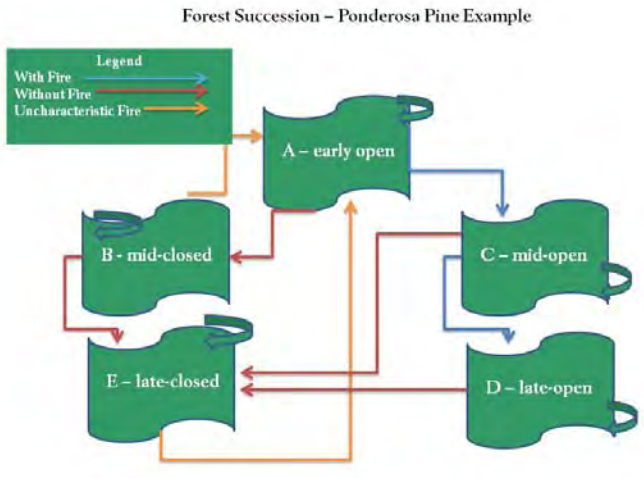

Figure 2 – An illustration of a vegetation dynamics model for a growth and maturation in ponderosa pine forest ecosystem

[1] The acronym "dbh" refers to the standard of measuring the diameter of a conifer 4.5 feet above the ground.

Existing Condition

Spruce-fir Forest and Woodland

Description

Spruce-fir forests are a minor component in the Jemez Mountains region but are a major element in the preserve's forest ecosystem, covering approximately 8,200 acres. They occupy much of the upper slopes and ridgelines along the caldera rim and on Redondo Peak. There are two distinct forest types represented in the spruce-fir forests: the cool, moist *Rocky Mountain Subalpine Mesic Spruce Fir Forest and Woodland,* and the *Rocky Mountain Subalpine Dry- Mesic Spruce Fir Forest and Woodland*. Both forest types are in Fire Regime IV, characterized by replacement fires every 35 – 200 years.

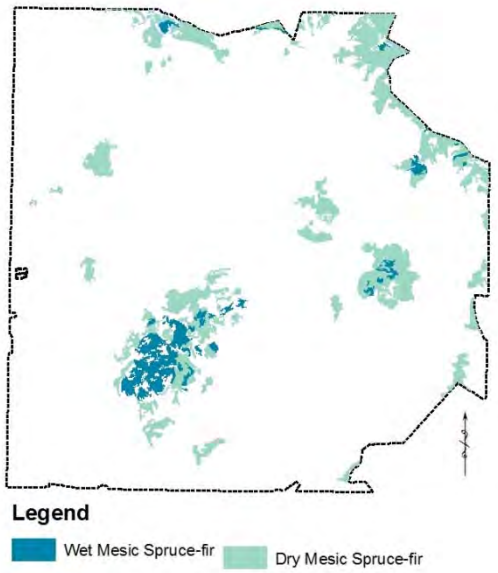

Figure 3 – Distribution of spruce-fir forests

Spruce-fir forests are dominated by Engelmann spruce and subalpine fir and comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico. These forests often represent the highest elevation forests in an area. Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snow is often deep and late-lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches.

The overstory is typically dominated by Engelmann spruce and/or subalpine fir. Aspen is notably absent in the wet mesic type but may be a component of the dry mesic as shown in Table 7. Disturbance includes occasional blow-down, insect outbreaks and stand-replacing fire. Disturbance by fire is primarily long-interval stand replacement fires, with minor amount of terrain influenced by moderately long-interval mixed severity fires.

Structure and Composition

The spruce-fir forests of the preserve were heavily impacted by historic logging and are dominated by mid-succession, closed canopy forest as shown in Table 5. This structure is setting the stage for an increase risk of stand replacement fire due to potential interactions with climate and insects. The long fire interval within these forests is due to the very short season in which forest fuels are dry enough to carry fire. Climate trends initiating an earlier, longer fire season (Running, 2006; Westerling, Hidalgo, Cayan, & Swetnam, 2006), could increase the risk of a stand replacement event in these young forests. Other risks are from insects. Western spruce budworm and bark beetles are the most damaging insects in these high-elevation forests. The

past few years have seen major mortality events among corkbark/subalpine fir throughout the Southwest, including the VCNP.

Table 5 – Spruce-fir forest structure and departure

Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland (BpS Model 281056)						
Succession Class	A	B	C	D	E	Totals
Acres	-	1,158	364	-	-	1,522
Reference	15%	20%	15%	20%	30%	100%
Current		76.1%	23.9%			100%
Departure	Deficit	Surplus	Similar	Deficit	Deficit	65 FRCC 2
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (BpS Model 281055)						
Acres	-	6,300	380	-	-	6,680
Reference	15%	20%	15%	20%	30%	100%
Current		94.3%	5.7%			100%
Departure	Deficit	Surplus	Deficit	Deficit	Deficit	84 FRCC 3

Table 6 – Spruce-fir forests average percent cover by size class; Percent Cover (Percent of Cover)

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

Table 7 – Spruce-fir forest species composition

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

* Total is less than the sum of cover by species due to overlap; percent cover was calculated using FVS and field sampled data.

Understory Structure and Composition

In dry mesic stands shrubs and sub-shrubs typically dominate the understory, but on the coldest sites most vascular vegetation is replaced by soil mosses. Grassy understories occasionally occur adjacent to upper montane grasslands. In moist mesic stands the understory is dominated by

herbs that can be diverse and luxuriant in cover. With the exception of Rocky Mountain maple, shrubs and sub-shrubs are typically poorly represented (Muldavin, 2006).

The most common plant associations within the spruce fir types on the preserve are the Engelmann Spruce/Forest Fleabane, Engelmann Spruce/Whortleberry and Corkbark Fir/Whortleberry plant associations. The latter two occur primarily on upper slopes and drier sites with the understory distinctly dominated by the low-lying sub-shrub whortleberry (*Vaccinium myrtillus*), with only a few scattered forbs or grasses. The Engelmann Spruce/Forest Fleabane plant association is usually found on lower slopes under more mesic conditions that lead to the development of a richer herbaceous layer that often exceeds 30% cover (Figure 4), with a minimal amount of shrubs. Forest fleabane (*Erigeron eximius*) is usually the dominant forb, but an overall rich complement of mesic forbs is characteristic including strawberry (*Fragaria vesca*), Canadian white violet (*Viola canadensis*), fringed brome (*Bromus ciliatus*), and northern bedstraw (*Galium boreale*). All three of these associations are widely distributed in the Southwest and into the southern Rocky Mountains (Muldavin & Tonne, 2003) The Engelmann Spruce/Parry's Oatgrass plant association was found in the most exposed conditions on northerly slopes and ridges on the borders with montane meadows at elevations above 10,000 feet. This association is characterized by an open canopy of Engelmann spruce and scattered limber pine, and a grassy understory dominated by Parry's oatgrass (*Danthonia parryi*) with occasional bunches of Thurber fescue (*Festuca thurberi*) and Arizona fescue (*Festuca arizonica*). An assortment of forbs commonly associated with montane meadows may also be present. This association may signify encroachment onto montane grasslands by spruce as a result of fire exclusion. Using historical photography, some authors reported a similar invasion of spruce-fir in high elevation grasslands on Sierra Blanca in south-central New Mexico. This association has not been reported elsewhere in the Southwest, and it may be transitory pending re-establishment of natural fire regimes on the preserve (Muldavin & Tonne, 2003).

Figure 4 – Engelmann Spruce/Forest Fleabane association on the north facing slope of South Mountain. This area was selectively harvested in the first half of the 20th century.

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

associations. Although this association may be found near montane meadows, the understory composition, presence of Engelmann spruces in a diversity of size classes, and a closed canopy suggests that this does not represent an invasion of montane meadows. It's presence on forest soil types also supports this assumption (Muldavin & Tonne, 2003).

Aspen Forest

Description

Just over 6,700 acres of the *Intermountain Basin Aspen-Mixed Conifer Forest and Woodland* have been mapped on the preserve (Figure 5), although it should be noted that aspen is often present within most forest types in response to disturbance by historic logging. As a major succession species aspens can vigorously re-sprout post-disturbance and can come to dominate a site for decades or even centuries. Aspen regeneration is particularly strong on severely burned sites, but may be controlled to some degree by preferential elk and deer browsing in those areas. Although some aspen forests are known to be self-perpetuating, conifers will typically regain a site in the absence of fire and with adequate conifer seed sources.

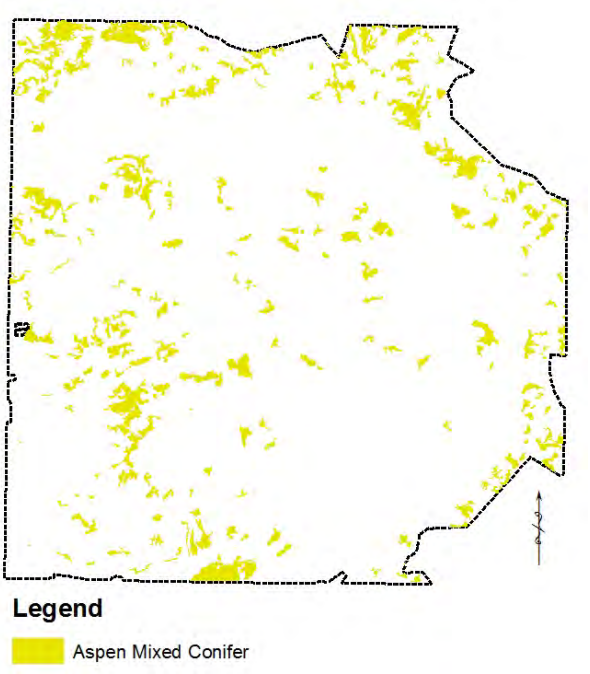

Figure 5 – Distribution of aspen mixed conifer forests

Forest Structure and Composition

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

Figure 6 – Iconic single story aspen forest.

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

Aspen exist in single-storied (Figure 6) and multi-storied stands depending on disturbance history and local stand dynamics.

Conifer species are common stand components, often comprised of subalpine fir and Engelmann spruce with minor amounts of Douglas-fir and pine species.

Aspen is host to many damaging insects and diseases, a factor in its relatively short life-span. Elevated levels of aspen mortality have been observed throughout much of the interior West, including northern New Mexico in the past few years. Some recent dieback and mortality was seen on the preserve during site visits and was mapped during the regional 2009 aerial detection. Although most of the stands are dominated by mid-succession, closed forests, as displayed in Table 8, field sampled data finds a greater diversity in size class distribution within the stands as displayed in Table 9. Species composition indicates only minor competition from conifers at this time as shown in Table 10.

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

Table 8 – Aspen forest structure and departure

Intermountain Basin Aspen - Mixed Conifer Forest and Woodland (BpS Model 281061[2])						
Succession Class	A	B	C	D	E	Totals
Acres	8	6,595	143	-	8	6,754
Reference	25%	40%	5%	30%	0%	100%
Current	0.1%	97.6%	2.1%	0.0%	0.1%	100%
Departure Status	Deficit	Surplus	Similar	Deficit	Similar	58 FRCC 2

Table 9 – Aspen forest average percent cover by size class; Percent Cover (Percent of Cover)

Intermountain Basin Aspen Mixed - Conifer Forest and Woodland				
Size Class	1-4.9 in dbh	5-8.9 in dbh	9-15.9 in dbh	16+ in dbh
% Cover	8 (8%)	29 (35%)	37 (45%)	10 (12%)

Table 10 – Aspen forest species composition

Intermountain Basin Aspen - Mixed Conifer Forest and Woodland									
Species	Blue Spruce	Corkbark/ Subalpine Fir	Douglas-fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total*
% Cover	2	2	9	8	T	12	42	5	64

[2] The interdisciplinary team referred to the BpS Model descriptions for mapping unit 28 which includes the preserve and mapping unit 25 adjacent to the preserve as well as VDDT model outputs to estimate the reference condition.

* Total is less than the sum of cover by species due to overlap; percent cover was calculated using FVS and field sampled data.

Understory Composition

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

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

Mixed Conifer Forest and Woodland

The middle elevations of the preserve are dominated by mixed conifer forests composed of various mixtures of conifers (Douglas-fir, white fir, blue spruce, southwestern white pine, limber pine, and ponderosa pine) along with scattered aspens. Approximately 34,348 acres of this forest type was mapped on the preserve through the forest stand delineation (Figure 7). The 2006 map of major vegetation alliances identified a similar, slightly higher acreage (Muldavin E., 2006).

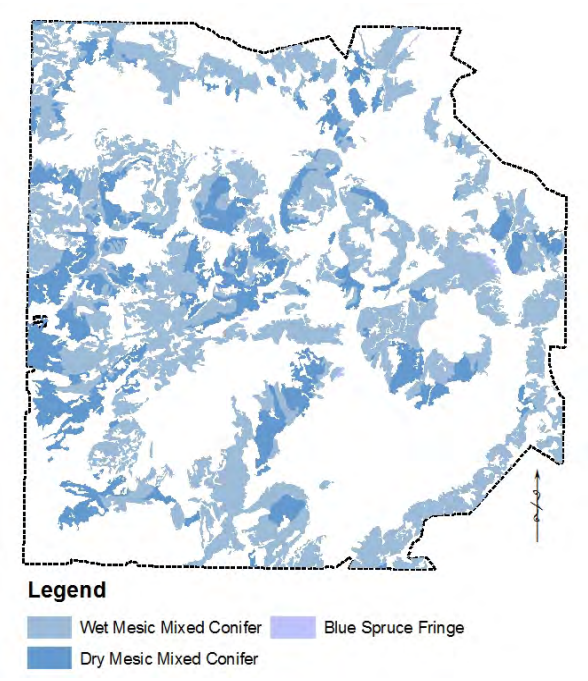

Figure 7 – Distribution of mixed conifer forests

Two distinct forest types are represented in the mixed conifer forests of the preserve: *Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland* and *Southern Rocky Mountain Dry-mesic Montane Mixed Conifer Forest and Woodland*. Fringes of pure blue spruce have recently gained importance (Muldavin E., 2006).

This distribution is strongly driven by moisture gradients such as aspect and elevation. It is found on all aspects and slopes and a wide elevational band bounded by ponderosa pine forests at the low end and the spruce-fir forest on the upper end.

The mixed conifer is a transitional forest and therefore best thought of as a continuum that follows a moisture gradient driven by elevation and aspect. The major tree species found in the mesic montane mixed conifer forests are Douglas-fir, ponderosa pine, blue spruce, Engelmann spruce, white fir, and aspen. The dry-mesic includes greater amounts of ponderosa pine and less aspen and spruce. Gambel oak may play a more dominant role in the understory of the dry-mesic model.

Fire is the primary disturbance although insects can also play a major role. Fire frequencies are variable and the wet mesic supports a mixed fire regime (Fire Regime III) with mixed severity fires occurring every 6-60 years. Lethal fires are usually at longer intervals, exceeding 100 years.

Frequent low intensity surface fire typical of Fire Regime I is the dominant mode of disturbance in the dry-mesic model with fire intervals range from 2-71 years and an MFI of 15 years. Lethal fires can occur on a limited scale as a part of a more widespread surface fire.

Forest Structure and Composition

Due to past intensive logging, 96-97 percent of the mixed conifer forests are currently characterized as mid-succession, closed canopy forests. The distribution of forest succession is displayed in Table11. Table12 shows the average distribution by all size classes at the stand level. Species composition is displayed in Table13.

Western spruce budworm (Choristoneura occidentalis) has historically been the most widespread and noticeable insect affecting conifers on the preserve and throughout much of northern New Mexico. In recent decades, budworm activity has been of chronic occurrence, with the more severe infestations often shifting location from year to year. In favorable years (such as 2009), at least some defoliation can be observed throughout most of the mixed conifer type. Bark beetle activity, especially fir engraver beetle (Scolytus ventralis) and Douglas-fir

beetle (Dendroctonus pseudotstugae), has been high the past several years. Douglas-fir dwarf mistletoe (Arceuthobium douglasii) is common and widespread on the preserve, with over 50 percent of the host type (acres) affected.

Table11 – Mixed conifer forest structure and departure

Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland (BpS Model 28052)						
Succession Class	A	B	C	D	E	Totals
Acres	-	23,346	846		103	24,295
Reference	10%	40%	25%	10%	15%	100%
Current		96.1%	3.5%		0.4%	100%
Departure Status	Deficit	Surplus	Deficit	Deficit	Deficit	56 FRCC 2
Southern Rocky Mountain Dry-Mesic Mixed Conifer (BpS Model 28051)						
Acres	-	9,766	287	-	-	10,053
Reference	15%	15%	10%	50%	10%	100%
Current		97.1%	2.9%			100%
Departure Status	Deficit	Surplus	Deficit	Deficit	Deficit	82 FRCC 3

Table12 – Mixed conifer average percent cover by size class; Percent Cover (Percent of Cover)

Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland				
Size Class	1-4.9 in dbh	5-8.9 in dbh	9-15.9 in dbh	16+ in dbh
Cover	8 (12%)	17 (25%)	30 (43%)	14 (20%)
Southern Rocky Mountain Dry-Mesic Mixed Conifer Forest and Woodland				
% Cover	5 (10%)	12 (24%)	23 (46%)	10 (20%)

Table13 – Mixed conifer forest species composition

Southern Rocky Mountain Mesic Mixed Conifer Forest and Woodland									
Species	Blue Spruce	Corkbark/ Subalpine Fir	Douglas-fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total*
% Cover	9	1	20	8	3	7	14	9	56
Southern Rocky Mountain Dry-Mesic Mixed Conifer Forest and Woodland									
% Cover	6	1	12	1	3	11	10	9	44

* Total is less than the sum of cover by species due to overlap; percent cover was calculated using FVS and field sampled data.

Understory Composition

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

Eight plant associations have been identified for the White Fir Alliance with a variety of understories and canopy structures. The White Fir/Forest Fleabane (*Abies concolor/Erigeron eximius*) plant association has a rich and often luxurious undergrowth dominated by mesic forbs and grasses that include, beside forest fleabane, woodland strawberry, Canadian white violet, fringed brome, and Ross sedge (*Carex rossii*). Sites are typically cool, northerly mid to lower slopes down to elevations of 8,800 feet. In drier upper slope positions this association grades into those dominated by shrubs and sub-shrubs. Specifically, the White Fir/Whortleberry plant association dominated by sub-shrubs such as whortleberry and myrtle boxleaf (*Paxistima myrsinites*), and the White Fir-Douglas-fir/Common Juniper plant association dominated by taller shrubs such as common juniper (*Juniperus communis*), and mountain ninebark (*Physocarpus monogynus*). Alternatively, these upslope sites can be dominated by the White Fir-Douglas-fir/Creeping Barberry plant association where both shrub and herbaceous cover are minimal. This association is typified by scattered individuals of creeping barberry (*Mahonia repens*) and myrtle boxleaf, and a low overall species richness. The sparse understory may result from a combination of dense overstory canopies and dry shallow soils. In contrast, the White Fir-Douglas-fir/Thurber Fescue plant association has a distinctive grassy understory similar to the montane grasslands on which it is known to border (Muldavin & Tonne, 2003).

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

Among the five plant associations identified for the Douglas-fir Alliance, four have close analogs in the White Fir Alliance: the Douglas-fir/Rocky Mountain Maple, Douglas-fir/Five-petal Cliffbush, Douglas-fir/Creeping Barberry, and Douglas-fir/ Whortleberry plant associations. The

main difference is the lack of white fir in the canopy and perhaps a tendency for somewhat warmer site conditions. In addition, a Douglas-fir-Limber Pine/Rocky Mountain Trisetum plant association was identified on high exposed ridgelines, above 9,500 feet. Under these dry conditions, the canopies are moderately open, and the understory is typically grassy and dominated by Rocky Mountain Trisetum (*Trisetum montanum*), Ross' sedge, and fringed brome along with a scattering of forbs. One association from the Limber Pine Alliance—the Limber Pine/Common Juniper plant association--- has been identified. This association has a similar herbaceous layer to the Douglas-fir-Limber Pine/Rocky Mountain Trisetum plant association but with a shrub layer dominated by common juniper (Muldavin & Tonne, 2003).

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

A forb-rich Blue Spruce/Forest Fleabane plant association, a graminoid-dominated Blue Spruce/Dryspike Sedge plant association, and a Blue Spruce-Douglas-fir/Sparse plant association have been identified. These associations can form mature stands on mesic lower mountain slope sites and occur most commonly as dense-canopied "blue spruce fringes" along the borders of the valle grasslands. These fringes are narrow, and because of moisture conditions and the relatively heavier grassland soils, do not seem to be actively encroaching further into the valle grasslands in a significant manner (Muldavin & Tonne, 2003). Early photographs taken from around the turn of the century show this fringe to be largely absent on the preserve as shown in Figure 8. Although they are natural they likely represent an uncharacteristic condition.

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

Figure 8 - A comparison between 1906 (left) and 1996 (right) of the same slope in the Valle San Antonio showing the development of a fringe blue spruce forest adjacent to the grasslands (Muldavin & Tonne, 2003).

Ponderosa Pine Forest and Woodland, and Savanna

Description

Southern Rocky Mountain Ponderosa Pine Forest and Woodland **and** ***Southern Rocky Mountain Ponderosa Pine Savanna*** **represent about 10,245 acres comprising the lower and warmer zones of the forests on the preserve. Understories range from shrub to grass dominated (Muldavin E., 2006). Small inclusions of piñon pine woodland also occur on southerly slopes on the west side of the preserve. Fire has played an important role in shaping the structure and composition of ponderosa pine forests and woodlands. Because ponderosa pine is highly fire tolerant and drought tolerant, it often occupies sites that are drier and that have higher natural fire frequencies than those of the mixed conifer zone. Ponderosa pine forests evolved under Fire Regime I with low-intensity fires burning every 7 to 15 years, removing competing understory vegetation and woody debris. Ponderosa pine savannas with their high grass cover were likely to have the most frequent ground fires, while forests tend to occur on steeper, rocky slopes with less "fine fuels," hence fire return intervals were likely longer. After fires, shade-intolerant seedlings become established in open areas, usually in pulses correlated to favorable precipitation years. Fire exclusion appears to be responsible in part for expansion of ponderosa pine into the valle grasslands. Monitoring has shown that moderate cattle grazing combined with fire exclusion has favored interior ponderosa pine seedling establishment on ponderosa pine/grassland ecotonal communities of the Colorado Front Range. Before fire exclusion, frequent fire likely excluded the majority of ponderosa pine seedlings at the ecotonal boundary. Now on the preserve, trees at the back of the stands against the hills can be 200 years or older while those at the front are less than 50 years, indicating relatively recent colonization of sites previously dominated by herbaceous vegetation (Muldavin & Tonne, 2003).**

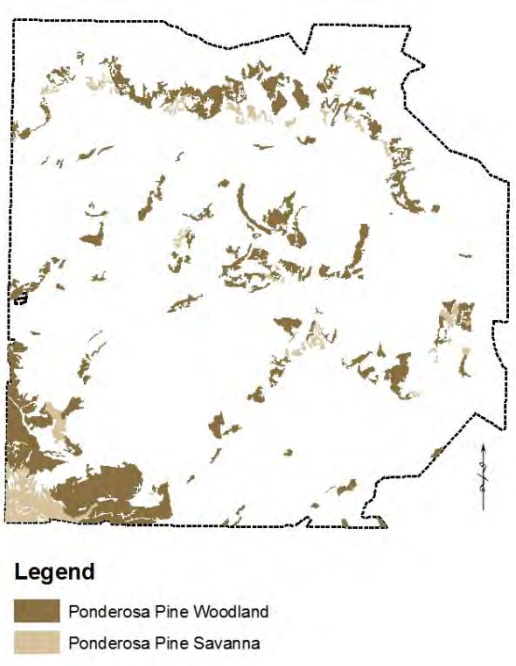

Figure 9 – Distribution of ponderosa pine forests

However fire suppression may not be the sole causal factor behind encroachment of ponderosa pine into grassland communities. Studies also suggest that climate change may be exerting its influence on the expansion of this forest community. The spatial position of the forest/grassland ecotone in the large valles of the VCNP may be at least in part determined by frost. Cold air accumulation subjects valley bottoms to frequent summer frosts and drops minimum temperatures 5-7° C below those of adjacent slopes which has been shown to exert strong effects on seedling growth. Historically, slowly growing, frost-damaged seedlings would have been extremely vulnerable to the low-severity fires that frequently burned valley margins until the late 19th century. Over the last one hundred years mean annual and winter temperatures have increased therefore recent forest encroachment (resulting in a nearly 18% decline in the area of

the preserve's grasslands since 1935) may be driven by both rising minimum temperatures and cessation of frequent fire (Coop & Givinish, 2007).

Ponderosa pine woodland accounts for nearly 83 percent of the ponderosa pine type and occurs from the lower treeline between grassland and shrublands up to the more mesic coniferous forests. Elevations range from 6500 ft to 8000 ft and occurrences are found on all slopes and aspects and on soils featuring good aeration and drainage, medium to fine textures, neutral to slightly acidic pH, an abundance of mineral material and rockiness, and periods of drought during the growing season.

Ponderosa pine is the dominant conifer, but Douglas-fir, Gambel oak may also be present with more dense stands of Douglas-fir occurring on north-facing slopes. This vegetation type varies in its fire regime based on site and climate and may be considered in either Fire Regime I or III. Historic fire intervals ranged from 7-22 years, and replacement severity occurred at intervals of 150 – 400+ years and was restricted to closed canopy forests. Topography (aspect, slope, substrate depth, position etc.) exerts a strong control over fire behavior producing spatially and temporally mixed severity regimes (LANDFIRE, 2006). In the Jemez Mountains it has likely evolved under Fire Regime I (Allen, 1989).

Figure 10 – VCNP ponderosa pine forest in S-Class B

The ponderosa pine savanna exists in forests with elevations ranging from 6500 to 8400 ft. on a variety of topographic features, including mountains, mesas and canyons. This vegetation type model is best described as a savanna that has widely spaced mature groups of ponderosa pine; other conifer species are generally not present. The grassy understory includes Arizona fescue and mountain muhly; minor amounts of Gambel oak may be present. Mean surface fire intervals have been found to be 5-15 years. Drought and other weather events (eg, blowdown), parasites and disease may play a minor role, and have very long rotations. Insects may be a significant, but infrequent occurrence. These effects may contribute to rare stand replacement events although there is no evidence of stand replacement events in this forest type in the Jemez Mountains during the reference period (Allen, 1989).

Forest Structure and Departure

Due to past intensive logging in combination with fire exclusion, nearly 90 percent of the ponderosa pine woodland on the preserve is currently within S-Class B as seen in Figure 10. The ponderosa pine savanna is also heavily dominated by mid-closed forest however; mid-open forests are also well represented. The current structure and departure is displayed in Table 14.

Table 15 displays the average distribution by all size classes at the stand level. Species composition is displayed in Table 16.

A review of the field sampled data and site visits indicate that diseases and insects typical for this forest type are present and active in the preserve although no epidemic levels were observed. These include ponderosa pine dwarf mistletoe (Arceuthobium vaginatum spp. cryptopodum), a parasitic flowering plant. The parasite occurs in roughly 1/3 of the pine type on the preserve. Infection is chronic, and tends to be patchy within stands and across the landscape. Some extensive infestation was observed in the southwest corner of the preserve. Armilllaria root disease is common in the pumice soils of the Jemez Mountains, affecting ponderosa pine and other conifers. Other diseases of ponderosa pine observed (at low frequency) during site visits include Elytroderma needle blight and Western gall rust (Endocronartium harknessii). While causing deformities on affected trees, these fungal diseases are generally of minor importance in the southwest. Limb rust (Peridermium filamentosum) is fairly common in the Jemez Mountains, causing progressive branch mortality, usually within the center of the crown, and mostly affecting older trees.

The most imminent risk to the ponderosa pine forest type is from uncharacteristic wildfire supported by the current structure rather than insects. While well adapted to frequent, surface fires this forest type may be moved to an uncharacteristic structure and composition following large, replacement fire without the mechanisms to move back to a natural path for growth and succession.

Table 14 – Ponderosa pine forest structure and succession

Southern Rocky Mountain Ponderosa Pine Forest and Woodland (BpS Model 281054[3])						
Class	A	B	C	D	E	Totals
Acres		7,531	851	110		8,492
Reference	10%	10%	25%	40%	15%	100%
Current		88.7%	10.0%	1.3%		100%
Departure Status	Deficit	Surplus	Deficit	Deficit	Deficit	79 FRCC 3
Southern Rocky Mountain Ponderosa Pine Savanna (BpS Model 281117)						
Acres	-	1,274	479	-	-	1,753
Reference	10%	10%	25%	40%	15%	100%
Current		72.7%	27.3%			100%
Departure Status	Deficit	Surplus	Similar	Deficit	Deficit	65 FRCC 2

[3] BpS Model descriptions and reference conditions were reasonable although local information indicates that Fire Regime I more accurately describes the fire history rather than Fire Regime III identified in the model description.

Table 15 – Average percent cover by size class; Percent Cover (Percent of Cover)

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

Table 16 – Ponderosa pine forest species composition

Southern Rocky Mountain Ponderosa Pine Forest and Woodland									
Species	Blue Spruce	Corkbark/ Subalpine Fir	Douglas-fir	Engelmann Spruce	White Pine	Ponderosa Pine	Quaking Aspen	White Fir	Total*
% Cover	2	0	5	0	T	34	8	5	48
Southern Rocky Mountain Ponderosa Pine Savanna									
% Cover	0	0	0	0	0	52	0	T	52

* Total is less than the sum of cover by species due to overlap; percent cover was calculated using FVS and field sampled data.

Understory Composition

Five associations from the Ponderosa Pine Alliance have been identified, and occur along lower mountain slopes and at the interface with valle grasslands. The Ponderosa Pine/Parry's Oatgrass and Ponderosa Pine/Arizona Fescue plant associations are open forests and woodlands with grassy understories dominated by either Parry's oatgrass or Arizona fescue along with Thurber fescue, prairie junegrass, and Kentucky bluegrass. Figure 11 from the north edge of the Valle Grand shows this plant association. This is the only continuous area on the Preserve spared from the historic logging.

Figure 11 – Ponderosa Pine/Arizona Fescue association (photo by Michael Mudd)

There is also a variable complement of grassland-related forbs such as bluebell, bellflower, Fendler's sandwort (*Arenaria fendleri*), Rocky Mountain iris (*Iris missouriensis*), hairy golden aster (*Heterotheca villosa*), yarrow (*Achillea millefolium*) and nodding onion (*Allium cernuum*). Shrubs are minor or absent(Muldavin & Tonne, 2003). The Ponderosa Pine/Trumpet Gooseberry/Sun Sedge plant association grows further upslope from the former two plant associations and has a similar complement of grassland forbs and grasses, but it also has a conspicuous shrub element dominated by trumpet gooseberry, and Woods' rose (*Rosa woodsii*). The herbaceous layer is dominated by sun sedge

and Kentucky bluegrass. This association has not been reported elsewhere (Muldavin & Tonne, 2003).

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

In contrast to the other associations, the Ponderosa Pine/Gambel Oak/Arizona Fescue plant association is not linked directly to valle grasslands. Rather, it occurs along slopes of the southern flank of Redondo Peak and Redondo Border (Figure 12) and in the rolling terrain of Banco Bonito (and occasionally along the caldera rim). It has been noted that the Gambel oak shrub component seemed under-represented relative to other sites in the Southwest. Arizona fescue is also poorly represented, but both the low cover of Gambel oak and fescue may be due to increased tree canopy due to fire suppression or simply the dryness of the sites. It is particularly in this association that fire suppression has led to increased densities of younger ponderosa pines, forming dense "dog-hair" stands that significantly increase the hazard of crown fires as shown previously in Figure 10.

Figure 12 – Ponderosa Pine/Gambel Oak/Arizona Fescue association on Redondo Border

Grassland, Riparian, and Shrubland Vegetation

Assessment Methodology

Approximately 27,000 acres in the preserve are non-forested (Figure 13) or have a dominant life form cover of grasses, forbs or shrubs. The grasslands of the preserve fall into several categories: riparian (wetlands or wet meadows), upper and lower montane grasslands, and forest meadows. Montane Shrublands and riparian shrublands have both been delineated.

In 2007 TEAMS, a USDA Forest Service Enterprise Unit completed a detailed assessment of the ecological condition and departure of the preserve's grasslands finding these systems to be moderately departed from the reference condition. This assessment considered field sample data which measured species composition and structure and riparian composition and water quality measures.

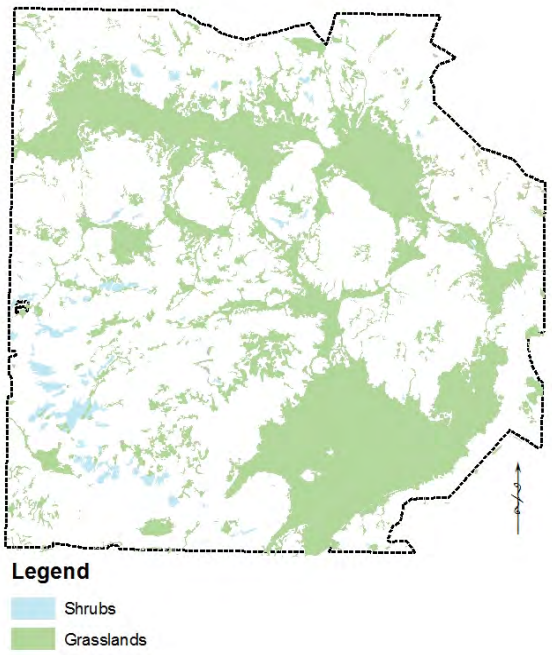

Figure 13- Distribution of non-forested vegetation types.

Montane Grasslands

Montane Valley Grasslands make up the majority of the grasslands on the Preserve, covering over 17,000 acres and dominating the expansive lower elevation valles. They are also found at higher elevations along the caldera rim (Figure15) and in small interior mountain valleys. Despite their seemingly high abundance on the VCNP, montane grasslands are relatively uncommon in New Mexico. Other than in the Jemez Mountains, they are found only at the highest elevations of the Sangre de Cristo Mountains along with scattered occurrences in the Sacramento Mountains and in the Gila.

On the Preserve, Muldavin and Tonne identified five montane grassland alliances based on relative dominance, i.e., the Parry's Oatgrass, Thurber Fescue, Arizona Fescue, Pine Dropseed *(Blepharoneuron tricholepis),* and Kentucky Bluegrass Alliances. Besides the dominant grasses, these alliances are typified by the presence of meadow species such as Fendler's sandwort, bluebell bellflower, Parry's bellflower *(Campanula parryi),* yarrow, beautiful

Figure14 - High elevation montane grassland on Garita Ridge

fleabane *(Erigeron formosissimus),* heartleaf buttercup *(Ranunculus cardiophyllus),* yellow owlclover *(Orthocarpus luteus),* woolly cinquefoil *(Potentilla hippiana),* and Rocky Mountain iris. Overall, Muldavin and Tonne described highly diverse communities, with over 125 species of grasses and forbs recorded so far.

An investigation to better estimate the historic fire return interval in the grasslands is ongoing. Initial investigations based on a small sample of fire scarred trees surrounding the valles and an application of general fire occurrence indicates that the grasslands that ringed the valles are likely within a frequent fire regime. The exclusion of fire has permitted trees to encroach into the valle edges, while cold air drainage limits the encroachment into the interior of the valles(Coop & Givinish, 2007). Montane grasslands away from the valles have been subject to more widespread encroachment of trees (Figure15) due to fire exclusion and historic grazing

Forest Meadows

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

Riparian Vegetation

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

Figure15 - Riparian vegetation along Jaramillo Creek in the Valle Grande

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

Based in ecological indicators such as cover and species richness these systems are considered moderately departed from the reference condition and are on an upward trend (TEAMS Enterprise Unit, 2007). However, this assessment only considered the condition of the existing wetlands and wet meadows. Prior to the turn of the century and the introduction of domestic grazing it is suspected that the valles were dominated by extensive wetlands supported by a multi threaded marsh as opposed to a single channel system.

Montane Shrublands

The preserve contains just under 1500 acres of montane shrublands dominated by Gambel oak (*Quercus gambelii)* and New Mexico locust (*Robinia neomexicana*) that are less than 15 feet tall. Trees are usually scattered and occupy less than 10% cover. Stands are typically considered successional to lower-elevation ponderosa and mixed conifer fir forests following fire, but clonal Gambel oak shrublands can be long- lived and occupy a site for long periods, particularly with repeated burning. These shrublands provide important habitat areas for a variety of species.

Riparian Shrublands

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

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

Figure16 – Riparian shrubland in Redondo Canyon

These woody riparian habitats are mostly restricted to mountain stream drainages associated with Redondo Peak and the canyons to the west of Redondo Border in the southwestern portion of the preserve. Understories are forb-rich and luxuriant, and typically have numerous obligate wetland species (Muldavin E., 2006). In the upper reach of La Jara Creek that drains the east flank of Redondo Peak, researchers identified a riparian Blue Spruce/Thinleaf Alder/Fendler's

Waterleaf plant association. Here blue spruce forms a moderate overstory with a sub-canopy of thinleaf alder (*Alnus incana* ssp. *tenuifolia*), and a very diverse herbaceous layer of over 40 grasses and forbs. Many these are obligate or facultative wetland species such as Canada reed grass (*Calamagrostis canadensis*), Fendler's waterleaf (*Hydrophyllum fendleri*), seep monkey flower (*Mimulus guttatus*), Columbian monkshood (*Aconitum columbianum*), and Fendler's cowbane (*Oxypolis fendleri*). A similar Blue Spruce/Thinleaf Alder/Kentucky Bluegrass Association was described from streamside terraces along Redondo Creek where blue spruce along with other conifers occupy the lower slopes and terraces adjacent to the streams, and where the undergrowth is distinctively grassy. There are also sites where the conifers have either been removed or have died out leaving scattered thinleaf alder thickets along the streams adjacent to drier terraces that support grassy meadows dominated by Kentucky bluegrass(Muldavin & Tonne, 2003).

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

Figure 17 – Montane grasslands in the Valle San Antonio in the foreground; encroachment by ponderosa pine with a mosaic of forest and shrublands in the background.

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