VALLES CALDERA NATIONAL PRESERVE

Soils

Existing Condition Report

VALLES CALDERA TRUST

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Introduction

Soils with forest cover account for roughly 58,000 acres of the Preserve. Soil development and productivity on the Preserve's forested uplands is regulated by water holding capacity and tracks strongly with geomorphic features. These forest soils are generally rocky compared to the deep loamy grassland and footslope soils of the valles. The soils are well drained, though may have enhanced water holding capacity from atypical organic accumulations. Water holding capacity is enhanced from the ash accumulation in the topsoil and some clay accumulation in the subsoils. Grassy understories or montane meadows have high productivity from built up organic matter in subsurface soils.

Hillslope soils favor growth of coniferous or shrubland species given the relatively rapid drainage and less productive capacity. Lower slopes with shallower gradients, swales, or broad ridges may have rich herbaceous undergrowth given the more advanced soil development and antecedent higher water holding capacity. In addition, some spring areas or old grassland patches on caldera rims support higher herbaceous growth than the slope setting would imply.

Soil Types

Using understory vegetation as an indicator of soil productivity, figures from the Santa Fe National Forest Terrestrial Ecosystem Survey (TES) put production from 25 to 250 tons/ac (Santa Fe National Forest, 1993) for forested areas. Monitoring during the last decade indicates that open woodlands may have from 100 to 2,300 lbs/ac (TEAMS Enterprise Unit, 2007). The monitoring highlighted that production varied drastically from year to year based on moisture received. The implication is soils play a critical role in regulating moisture depending on the functional ability to hold moisture.

Figure 1 shows the distribution of major soils characterizations. The dark mollic soils, which are the most productive, follow the grassland dominated understory with woodlands common on the fringes. Ash dominated soils are found in the southwestern corner of the preserve. The ash itself has little nutrient value, but lends moisture holding capacity and serves as an excellent growing substrate for soil microbes and plants (Garrison-Johnston, Mika, Miller, Cannon, & Johnson, 2005). Most of the preserve has ash influence, although these particular soils in the southwest corner of the preserve have ash greater than 18 cm in the upper solum. In particular, pumice dominated soils are found around Cerro la Jara, southwest of headquarters and within El Cajete.

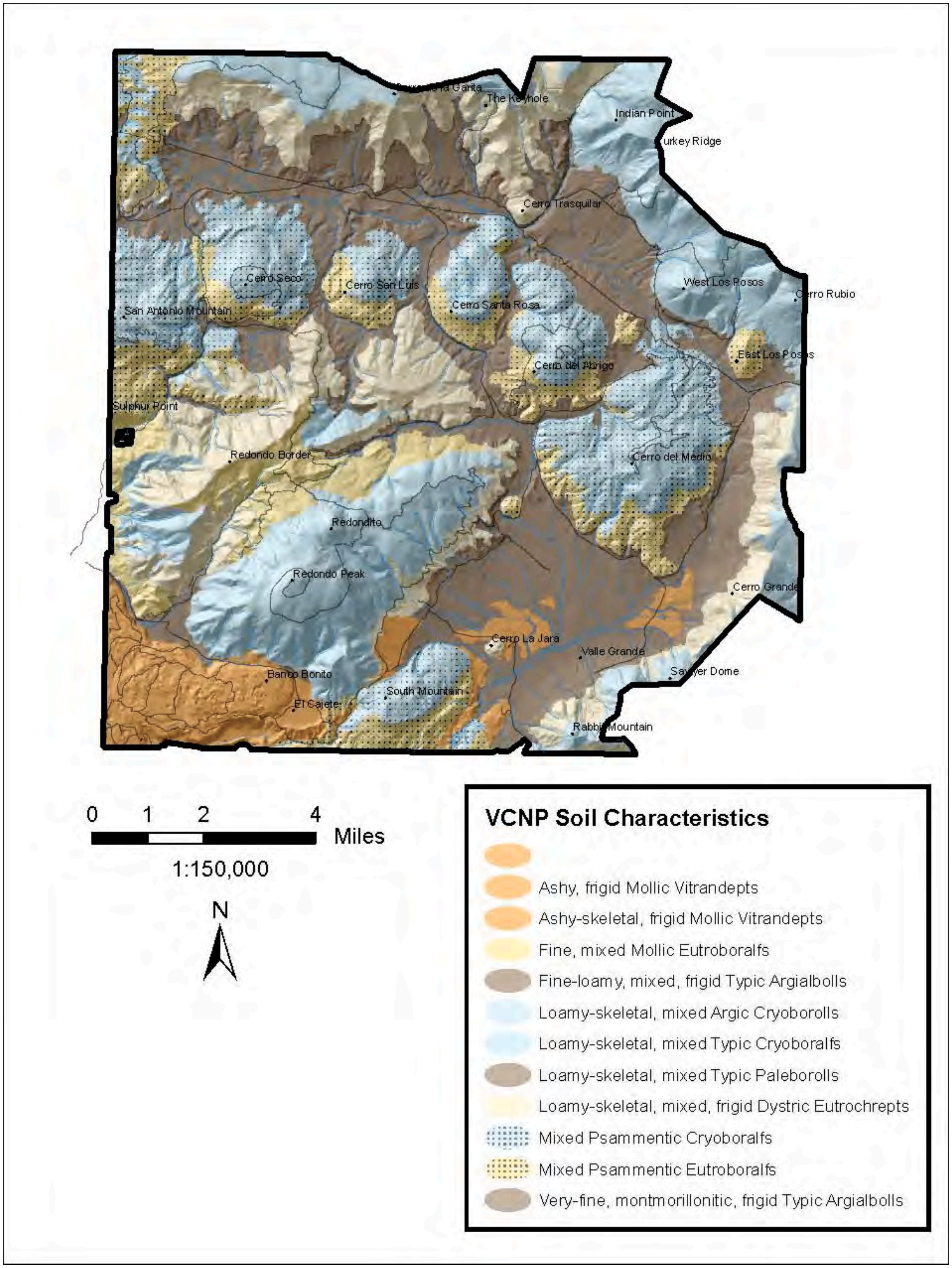

Figure 1 - Soil family from NRCS (1999) SSURGO data highlighting major soil characteristics: ash (orange), cryic (blue), mollic (dark brown), clay subsoils (yellow) and inceptic soils (crème).

Soils could be broken into two groups based on geomorphic features: (1) moderate to steep rimrock slopes and those of the domes, and (2) the alluvial/colluvial fans that shoulder the valles. The steep slopes of the Quaternary resurgent domes, and those of the older, Tertiary, caldera rim are mainly composed of rhyolite and dacite flow rock and welded or non-welded ash flow forming a chunky matrix that has well drained conditions. The footslope fans that in some cases are extensive such as in San Antonio watershed, have very thick mix of landslide, alluvial and colluvial material derived from the upper slopes. These are secondary features that have material deposited over underlying volcanics.

Water availability on the steep hillslopes of the rimrock and domes is roughly a 1/3 of the grassland soil bottoms. Soil textures are dominantly sandy loams and thus well drained. Despite these drainage conditions, topsoils are dark from fine rooted understory grasses and forest herbs that create conditions for organic matter buildup. Where they occur, quaking aspen's typically highly concentrated roots, and quick decay rate further incorporate organic matter. Prior NRCS reports for the Valles Caldera specific soil series Redondo and Cajete soils indicate soil organic matter ranges from 2-3 percent in the upper profile (USDA-NRCS, 1999). Organic matter is key to formation of soil aggregates which greatly enhance soil surface area and water retention.

We theorize that the rock mantle on the moderate to steep hillslopes increases water availability as well. Many of the dome slopes have minimal drainage dissection, thus soil through-flow is likely a major trajectory for snowmelt and rainwater. Many of the domes have oversteepened slopes with landslide debris and colluvium that mantles the surface. This mantled surface increases water holding capacity by providing a heterogeneous medium, including finer textured silt and clay.

In general, soils are less productive where slopes are steep and where cold conditions limit soil biotic function. Cryic soil conditions, where cold limiting conditions exist, are shown in Figure 1. The breakline between frigid and cryic conditions whereby temperature is considered limiting on growth is found roughly at 9,200 ft elevation using the NRCS mapping (1999). Colder conditions are also found within cold pocket drainages and north aspects.

The volcanic domes have sandy loam textures and rocky, skeletal soil matrix that facilitates drainage. These soils are related to the varied age rhyolite and dacite tuff. Water holding capacity in these soils is some of the lowest on the Preserve from the rapid drainage. The forest floor, accumulated organics in the profile and soil aggregation in the topsoil are key to retaining moisture in the upper soil profile. Water holding capacity is from 0.05 to 0.07 in/in concave draws or areas of grassland vegetation are the most productive areas on these domes.

Redondo peak is the oldest dome and highest in elevation, producing secondary geomorphic features on the bench land formation to the east. These lower slopes have colluvial and alluvial deposition from old landslides that create a more heterogeneous medium for soil development. Soil water holding capacity is from 0.1 to 0.13 in/in (USDA-NRCS, 1999). The high elevation peaks have very little water retention within the Felsenmeer rock fields and are altogether a harsh growing environment given the limited growing season. Felsenmeer rockfields have somewhat active downslope movement and lack soil development (Muldavin & Tonne, 2003). Along the lower elevation near flat benches and hillslope grasslands, productivity is appreciably higher; soils have very strong mollic components with deep accumulation of soil organic matter in mineral soils.

Soils derived on the northern rimrock include some very sandy members where drainage is likely excessive. Slopes break distinctly and active soil creep and slumping were apparent in several locations along the northeastern rimrock of the caldera (see Figure 2). Exposures of Bandelier tuff had particularly poor soil development. The subsequent fans adjacent to the rimrock contrast sharply with robust productivity where surfaces are stable. However, active drainage development was frequent leading to shallow or no soil development. Stable surfaces have lake bed sediment influence, especially in the north eastern corner of the preserve.

Figure 2 - Hummocks showing active soil movement on northern preserve rim.

Water holding capacity on the footslope fans of the domes and the rimrock is robust from the thick organic topsoils with robust grass and forb understory and the layered colluviums/alluvial materials. The juxtaposition of heterogeneous subsurface layers from both varied deposition events and soil translocated clays enhance water holding capacity. Deposition includes landslides from the rimrock, lakebed sediments and alluvial/colluvial fan material from sheetwash. Buried soils have strong subsurface clay layers that increase water holding capacity. The lower slope position also is a collector for upper slope wash and through-flow. The rimrock fans have perched water tables which lead to springs and isolated wet areas, with many wet areas observed along the fans north of San Antonio. Water holding capacity is listed as 0.19-0.21 in/in for the dome and rimrock fans.

Erosion

The caldera context shows instability along the rimrock, where faulting continues to destabilize slopes. Incoherent rock types form weak slopes where uncovered. The fault influenced White Sulphur Creek has instability from the combination of relatively active faulting, destabilizing slopes the colluvial slopes materials. In contrast, the resurgent domes themselves have fairly stable surfaces with recent mass erosion not as common. Drainage densities are minimal with broad even slopes along many of the domes. The lack of drainage development is surprising given the Quaternary aged domes.

Surface erosion does not appear active in the upper hillslopes even within heavily roaded areas, but rather tracks with erosive geologic forms and geomorphic features. Generally, soil losses are considered most extreme on steep slopes when groundcover is lost from disturbance (Elliot, Hall, & Graves, 1998). However, field observations found the Preserve's roads to have limited soil erosion on the steep hillslopes of the domes, likely from the combined effects of surface rock armoring against erosion loss and high infiltration rates diffusing erosive surface flows.

Most of the erosion sign observed on the Preserve was found on finer textured footslope soils where soils have inherently higher erosivity and rainfall and snowmelt runoff is concentrated. Soil erosivity was rated using Kf factors of the Revised Universal Soil Loss Equation from the NRCS soil mapping (USDA-NRCS, 1999)with refinements from the newly mapped geology (USGS, In Press) that refined geomorphic designations. The main erosive materials are associated with the slope deposits from rhyolite tuff, lakebed sediments and certain members of rhyolite tuff. These materials are not coherent and unravel easily once gullying is initiated. Figure 3 highlights soils where inherent erosivity is high (red), moderate (orange), low (yellow) and very low (green).

Fieldwork in summer 2009 found slope deposits from the following formations most susceptible to gully formation: ryholite tuffs of the Valle Grande member of Valles Rhyolite Formation in the lower Valle San Antonio, around San Antonio Mountain, Cerro Saco and Cerro San Luis; a vitric member of the volcanic dome rhyolite forming Cerro del Medio, also of the Valles Rhyolite. This last member occurs on the lower slopes on the north side of the dome above Obsidian Valley and on the south side above Valle Grande and in line with the springs feeding the East Fork Jemez. In both cases the typical rhyolite debris is liberally littered with obsidian pieces. Lastly a cliff exposure of the Bandolier Tuff, at the upper end of Valle de Los Posos (and precisely were the gas pipeline crosses) is a remarkably unstable slope that has induced massive land sliding about 150 years ago.

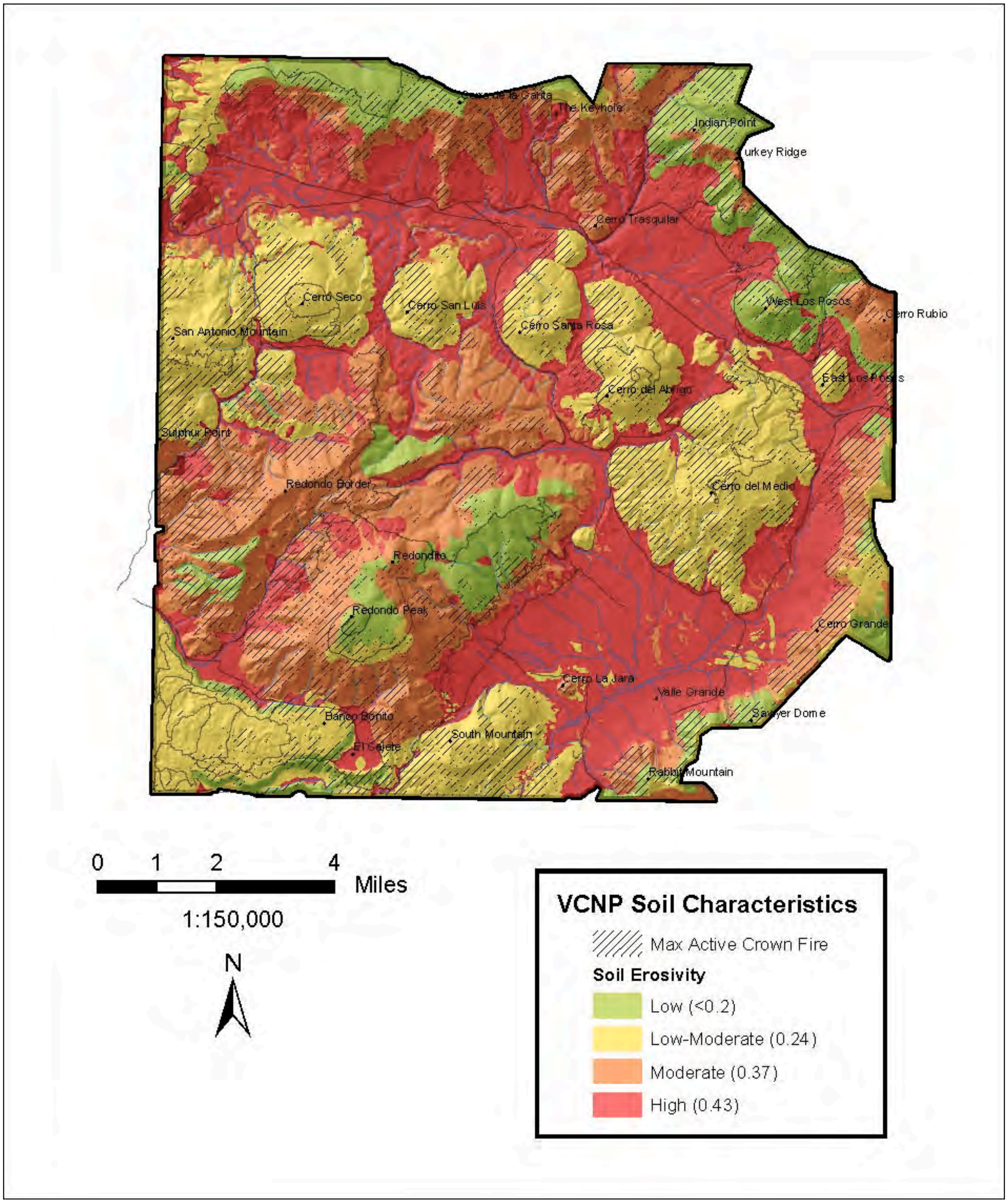

Figure 3 - Soil erosivity using Kf values from NRCS (1999) SSURGO data. Overlay is crown fire modeled from driest historical climate.

Small-scale gullies are prevalent in the footslopes with ashy deposits, and where the tuffs of the Redondo Creek member of the Valles Rhyolite formation occur. Gullying is historical, most probably forming in the nineteenth and early twentieth century, caused by intensive livestock grazing. Many of the current gully systems were visible in the historical 1935 aerial photos.

More recently, the gullies appear to have stabilized. The banks of gullies and incised channels in draws are predominantly re-vegetating, appear at stable angle of repose, and have floodplain development along the active channel; all signs show a degree of healing and decreasing impacts. We observed gully bottoms with subtle organic matter accumulation up to 2 inches in depth.

This context of erosion is important when considering future wildfire and prescribed burning. The risk for crown fire was super-imposed over soil erosivity and compared across 6th code HUC watersheds. The modeled crown fire uses the driest conditions from nearby climate stations (see Fire Behavior section). Figure 3 shows the relationship between crown fire and soil erosion for the Preserve. The greatest risk for crown fire where soils are erosive is in the Redondo Creek drainage and localized areas in Seco Creek and along the northern rim of the caldera.

The risk for soil erosion after fire depends on a high intensity rainfall event during the period of regrowth, typically modeled as 3-5 years using water erosion software Disturbed WEPP (USDA-Forest Service, 2009). However, the incidence for thunderstorms extreme enough to drive overland flow is fairly common due to the monsoonal climate. Our results point to the fact that most of the erodible soils are within the bottomlands and toeslopes, spatially explicit from most of the heavily forested upper hillslopes where high intensity fire is more likely. The overlap of crown fire and soils with high erosivity is only 1 to 2% within the three major watersheds of the preserve (Table 1).

The risk for erosion after fire is still explicit when considering moderate erosive soils. From a watershed perspective, crown fire during the driest years could have potentially the most risk for erosion in the Sulphur watershed. This watershed has moderately steep sides and a mix of soil types, likely from the fault line control lending inherent instability.

Table 1 - List of acreage of maximum crown fire potential (driest years) and highest erosive soils.

Watershed	6th Code HUC Area	Crown Fire	High and Moderate Erosion	Watershed Percent *
Jemez	31272	7786	3484	11 (1)
San Antonio	34403	9016	5088	15 (2)
Sulphur	19611	7594	7024	36 (1)
Jemez lower (partial VCNP)	995	213	0	0

*Bracketed percents are for highly erosive soils.

Risk for erosion from fire may also center on the already established gullies along the lower footslopes that ring the valles. High energy runoff may have localized erosion upslope, but would concentrate in the gullies if forest cover was removed from fire. The risk may not be for reduced soil productivity along hillslopes, but rather increased gullying and rilling within already established hydrologic routes. The extended network would further advance gullying already established from prior disturbance. The roaded network would have uncertain impacts with channeling of storm wash in some cases, while intercepting hillslope overland flow in others.

List of Preparers

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