# *East Fork of the Jemez River Wetlands Action Plan*

New Mexico Environment Department,
Surface Water Quality Bureau,
Santa Fe, New Mexico
2023

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# Table of Contents

**List of Figures**



**List of Tables**

**List of Acronyms**

| Acronym | Full Name |
|---|---|
| AMO | Atlantic Multidecadal Oscillation |
| BISON-M | Biota Information System of New Mexico |
| CWA | Clean Water Act |
| EARTh™ | Erosion Analysis and Restoration Techniques |
| EFJR | East Fork Jemez River |
| ENSO | El Niño-Southern Oscillation |
| FACW | Facultative Wetland |
| GIS | Geographic Information System |
| HGM | Hydrogeomorphic |
| HQCAL | High Quality Cold Water Aquatic Life |
| JNRA | Jemez National Recreation Area |
| KRE | Keystone Restoration Ecology |
| LANL | Los Alamos National Laboratory |
| Los Amigos | Los Amigos de Valles Caldera |
| NM | New Mexico |
| NMAC | New Mexico Administrative Code |
| NMDGF | New Mexico Department of Game and Fish |
| NMED | New Mexico Environment Department |
| NHNM | Natural Heritage New Mexico |
| NMHPD | New Mexico Historic Preservation Division |
| NMISC | New Mexico Interstate Stream Commission |
| NMOSE | New Mexico Office of State Engineer |
| NPS | National Park Service |
| NRCS | Natural Resource Conservation Service |
| PDO | Pacific Decadal Index |
| Q | Discharge |
| RGCT | Rio Grande Cutthroat Trout |
| RPA | Rio Puerco Alliance |
| SWQB | Surface Water Quality Bureau |
| TES | Terrestrial Ecosystem Survey |
| TMDL | Total Maximum Daily Load |
| U.S. | United States |
| UNM | University of New Mexico |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USDOE | United States Department of Energy |
| USEPA | United States Environmental Protection Agency |
| USFS | United States Forest Service |
| USGS | United States Geological Service |
| VCNP or Preserve | Valles Caldera National Preserve |
| WAP | Wetland Action Plan |
| WRAS | Watershed Restoration Action Strategy |
| WSR | Wild and Scenic River |

## Summary of Findings and Plan of Action

The present-day ecosystems of the Valles Caldera National Preserve (VCNP) include grasslands, mixed-conifer forests, and a variety of aquatic habitats (including geothermal hot springs, cold-water springs, acid pools, fens, and two major mountain stream watersheds). Over 550 species of plants, constituting nearly 60 vegetation associations, are supported across these ecosystems. The caldera also supports a rich community of mammals, birds, and invertebrates, along with smaller contingents of reptiles, amphibians, and fishes. Although a considerable part of the caldera is in relatively good condition, other sections exhibit signs of degradation, likely due to historic human land uses such as livestock grazing, forestry, and road development.

The headwaters of the East Fork of the Jemez River (EFJR) originate from a spring in the northwest corner of the Valle Grande and the river continues draining the Valle Grande for nine miles before reaching Santa Fe National Forest land. The wetlands associated with the East Fork have been seriously compromised by the history of over 140 years of grazing, both sheep and cattle, in addition to heavy forestry and road development. Elk also utilize the area extensively. The EFJR stream system is classified as a Rosgen E4 channel type. This is a gentle sloping broad riverine valley system. The EFJR has segments functioning within the landscape setting and others not functioning within the landscape setting.

In the Valle Grande, there is an overall lack of quality in-stream habitat where the typical riffle-pool sequence expected in the area has been replaced by near continuous riffle sections that persist for the majority of the stream length across the Valle Grande. These long riffles are broken at features such as side channels or tributaries. The riffles throughout the entire river are dominated by a fine substrate. The amount of fine substrate is largely due to the delivery of fines from the surrounding the VCNP. Lack of pools means limited over-wintering habitat for fish, decreased thermal protection, and poor fish habitat overall.

The VCNP and partners like Los Amigos de Valles Caldera, Rio Puerco Alliance (RPA), Keystone Restoration Ecology (KRE), and others have been working since 2007 to restore the hydrology of the river and its associated wetlands. A lot of work has been done, but new problems may be arising. Scientists have identified the Southwest as a climate change hotspot—an area whose climate is particularly vulnerable to an increase in greenhouse gases in the atmosphere. (Diffenbaugh et al., 2008) Effects of climate change that are predicted for the Jemez Mountains and throughout New Mexico include (Enquist et al., 2008; NMOSE/NMISC, 2006; USGCRP, 2009) the following:

- Temperature is expected to continue to rise, resulting in increased evaporation and evapotranspiration.
- Precipitation is expected to be more concentrated and intense, so that increases in the frequency and severity of flooding are also projected.
- Streamflow is projected to decrease overall due to lower snowpack and higher evapotranspiration, and peak runoff will occur earlier and be diminished.

Additional stresses on wetlands due to increasing temperatures, evaporation, and intense precipitation events magnify the importance of protecting and restoring wetland resources. Wetlands provide buffering qualities to receiving streams. Wetlands also provide a mechanism for the subsurface hydrology to move slower through the system, and provide a barrier to moving sediment during flashy precipitation events.

Continued drying and loss of the headwater wetlands will result in diminished watershed health overall. Loss of headwater slope wetlands has negative downstream effects including increased erosion, sedimentation, fragmented wildlife habitat, loss of riverine wetlands/riparian vegetation, encroachment of upland vegetation, reduced base flows, increased nutrient loading, and warmer stream temperatures. Restoring headwater wetlands has significant positive downstream effects that buffer climate change by increasing the quality and quantity of downstream riverine wetlands, reducing stream sediment, nutrient loading, and temperature, supporting wildlife habitat, and regulating and increasing stream base flows.

Long-term climate data for the State of New Mexico suggest that the Jemez Mountains are warming at a faster rate than other regions of the state. (VCNP, 2018) The VCNP and the broader Jemez Mountains form an isolated sky island (rather than a mountain chain) that reduces migration options for many sensitive plant and wildlife species. Climate change vulnerability at the VCNP in recent decades has already been expressed through warmer temperatures and drought and an associated increase in risk for catastrophic wildfires such as the 2011 Las Conchas and 2013 Thompson Ridge wildfires, which, combined, burned approximately two-thirds of the VCNP. The 2011 Las Conchas Fire was particularly damaging, with large areas of high burn severity, high tree mortality, and profound post-fire erosion. Assessment and adaptation planning is needed to understand the range of potential effects of climate change on uncharacteristic wildfire activity, ecosystem processes, hydrology, archeological resources, and biodiversity in this temperature-sensitive high-elevation environment. Possible threats include the following:

- Climate change could affect vegetation associated with traditional uses and practice.
- Historic building materials could be damaged by severe weather events, associated erosion, and rodents.
- Severe fire and post-fire erosion could affect cultural landscapes through changes in character-defining features including biota, cultural features, geomorphology, and hydrology.
- Climate change and insect outbreaks could impact native flowers and plants in the preserve.

The 1,200-acre East Fork Jemez River Headwaters demonstration project area has several spring-fed slope wetland areas. Vegetation in these areas, specifically Tufted Hairgrass (*Deschampsia cespitosa*), a facultative wetland (FACW) indicator species, suggests that wetlands were formerly more abundant. The project has already re-wet at least 65 acres of wetlands by constructing innovative treatments that redistribute runoff.

The design and installation of this project is increasing the quantity and ecological functioning of wetlands, thereby helping mitigate effects of climate change in the watershed. These impacts have partially drained the wetlands, reducing their size and quality.

**Potential Future Actions:**

**1. Soldades**

Repeat the EFJR demonstration project in the Soldades area, which is closer to the Headwaters.

**2. East Fork Stream Capture**

There has been an area on the East Fork where the stream has been captured and moved to the north side of the valle. The water is now all in a swale on the north side, and the East Fork (blue/red lines) is dry. (See Figure 25.) We discussed this at the October 7, 2022 Stakeholder's Meeting and it was decided that a win-win solution would be to block the new channel so water backs up and then returns to flowing down the original channel.

This would keep the new wetland but reduce the sediment source.

**3. Further Climate Change Mitigation**

More projects in the EFJR like the EFJR Headwaters project. LANL has shared report data from Carbon-sequestering monitoring they did. Preliminary data suggests that Nina's Spring on the San Antonio may be sequestering more carbon than a relatively healthy nearby wetland area that was not restored. So our wetland restoration projects may be helping to sequester more carbon from the atmosphere than we thought.

**4. Road Remediation**

Poorly designed and constructed low-standard roads, with little or no culvert or other drainage structures, and poor maintenance, have led to poor distribution of runoff onto the wet meadows. Specifically, the EFJR sub-watershed has numerous gullies that are being exacerbated by erosion from trails created by livestock walking up and down the drainage channels. These trails captured water and funneled it directly down the channel, creating V-shaped gullies. These gullies are some of the demonstration sites for the contour swales, sod bowls, and sod berms.

Poorly maintained roads have contributed significantly to sedimentation and have degraded fish habitat. The increased fine stream sediment concentrations that result from poorly constructed and badly maintained roads has been associated with decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes.

The Jaramillo/EFJR watershed road system was poorly designed, very difficult to adequately maintain and adds significant sediment to the streams. Major improvements to the drainage facilities of the road system would need to be undertaken to restore the watershed wetlands to pre-road ecology.

**5. Wildfire Flood Protection**

The reducing conditions that develop in restored wetlands can help buffer transport of nutrients to downslope areas and streams, and the extent of reduction observed suggests such ponds may be effective for reducing concentrations of some redox sensitive contaminants. Sampling at restoration sites even showed restored wetlands can process slurry from fire retardant that was captured in a plug and pond structure. The nutrient spike occurred after a heavy rainfall event, and levels returned to baseline in one month's time in the highly reducing environment sub-surface.

Plug and pond and other restoration structures could be utilized as a protective measure for post-fire flood management, either immediately after the fire, or preventively, before a watershed burns. The installation of a series of plugs could capture a great amount of the sediment and nutrient produced by post-fire flooding and use this sediment to restore gullied wetlands and alluvial fans while protecting downstream resources such as water quality, wildlife, and infrastructure.

## Introduction

A Wetlands Action Plan (WAP) is a planning document designed specifically to address wetlands within the boundaries of a specific watershed. Technically, wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987)." To be considered for federal regulation and protection under the Clean Water Act, a wetlands must show all of the following attributes: (1) at least periodically, the land predominantly supports hydrophytes (plants dependent on saturated soils or a water medium); (2) the substrate is predominantly un-drained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. The State of New Mexico, however, only requires one of those, defining "Wetlands" as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. (NMAC 20.06.4) Wetlands generally include swamps, marshes, bogs, fens, and similar areas; lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface of the land or is covered by shallow water.

Because the health of wetlands in many cases is inherently bound to its surrounding environment and water resources, the condition of associated riparian areas and water sources are contained in the WAP. This Wetlands Action Plan covers the following categories:

- An overview of the watershed and its history and components (i.e., geology, forestry, geomorphology, hydrology, soils, vegetation, climate, etc.).
- Identification and inventory of existing wetlands resources in the watershed, GIS coverage.
- Identification of the condition of wetlands and riparian resources.
- Identification of threats and impairments.
- Preliminary recommendations to protect, restore, enhance and create new wetlands.
- An outreach component that will address educational programs focusing on wetlands, and build a core of volunteers that will engage in a variety of activities as public service to protect wetlands resources.
- List of funding sources that can help pay for project work.
- Monitoring component to help identify impacts to wetlands and to measure success of implemented projects, and a wetlands tracking component.
- Prioritization of sites with potential for restoration of ecological integrity of the resource.
- List of proposed projects to protect, restore, enhance and create new wetlands.

## East Fork of the Jemez River

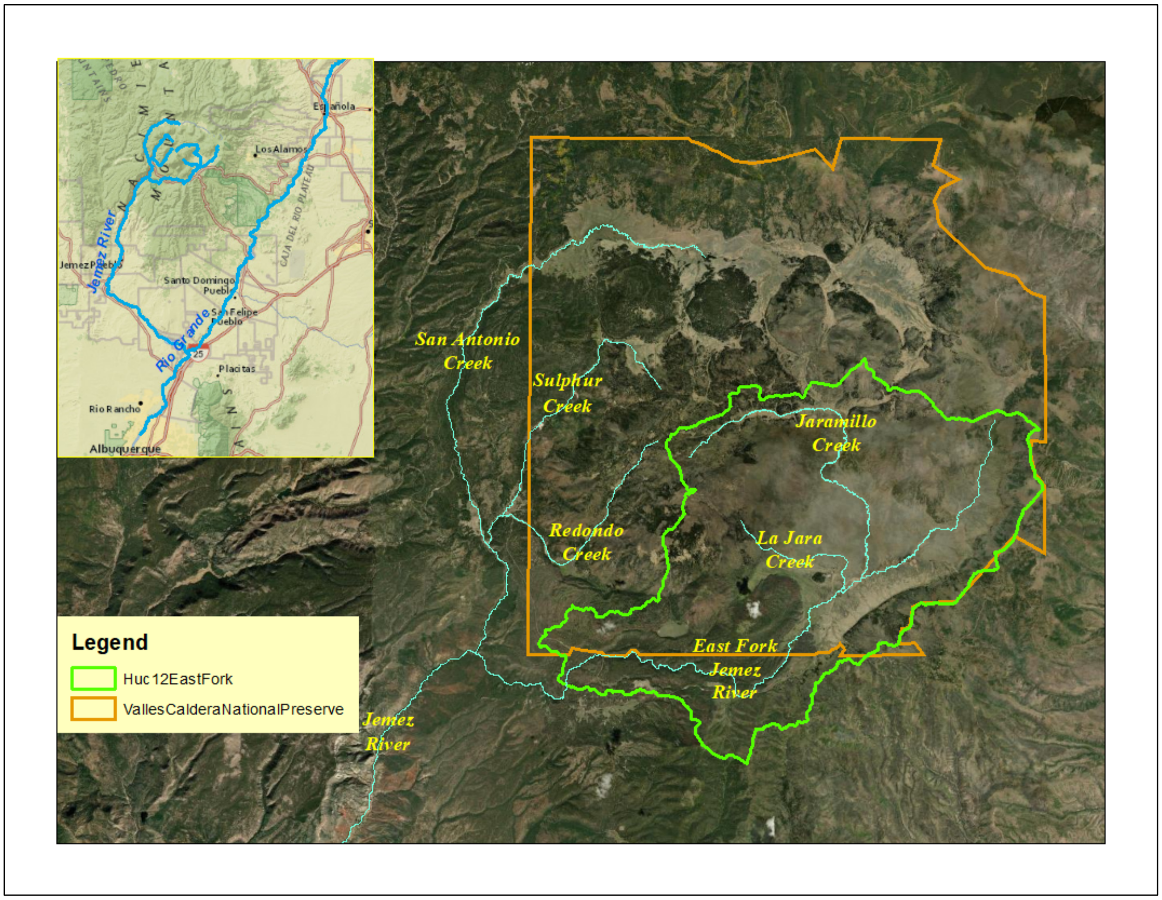



*Figure 1. East Fork of the Jemez River Watershed.*

### Physical Geography

The East Fork Jemez River (EFJR) and its associated wetlands are located in the Jemez Mountains in north-central New Mexico, USA (Figure 1). It originates from spring sources in the northwest corner of the Valle Grande on the Valles Caldera National Preserve (VCNP), managed by the National Park Service (NPS). It is a low-gradient, high-sinuosity, high-elevation (~2590 m), 3rd-order perennial stream. (The smallest flows from upland areas, as well as springs and seep sources that maintain defined streambeds throughout the year, are first-order streams. Where two first-order streams combine, a second-order stream is designated; and two second-order streams joining create a third-order stream. [Bedford County Conservation District])

The East Fork Jemez drains the Valle Grande, where it picks up several major tributaries, including Jaramillo Creek and La Jara Creek (Figure 2).

From the spring source, the East Fork flows 21.43 miles to its confluence with the Rio San Antonio. (Fishing occurs from the mouth of the confluence (T 19N, R3E, S32) to the headwater terminus.) The East Fork and the Rio San Antonio join to form the main stem of the Jemez River below La Cueva, New Mexico. The Rio San Antonio flows west in a northward curve, through Valle Toledo and Valle San Antonio. The East Fork Jemez flows west in a southward curve, through Valle Grande. These valles are all part of the Valles Caldera. (A *valle* approximates the English word *valley*, but is not entirely synonymous with it. Valles are always open and treeless, whereas a valley is often heavily wooded and pronouncedly lower than surrounding land.) The two tributary streams join near Battleship Rock in Cañon de San Diego, forming the Jemez River's main stem. The upper nine miles of the river are located on the Preserve.

***The EFJR on the Preserve.*** The gradient on the East Fork is nearly 0% in the headwaters. 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 eastern edge of the Valle Grande in the Preserve, a vast low-gradient meadow system. The EFJR has an average base Q (discharge) ranging from 0.06 to 0.09 m3/s and a topographical gradient that ranges from near 0 to 7%. (Summers, et al., 2020)

The East Fork meanders through a meadow system, which is broken up by some of the major tributaries such as Jaramillo and La Jara Creeks. Home to both introduced brown and rainbow trout, the EFJR meanders through the largest valle—Valle Grande—within the 13.7-mile wide volcanic caldera that makes up the Valles Caldera. The 6.5 miles of river in the Preserve are popular destinations for anglers, hikers, and sightseers alike.

The river flows through a mixed canyon meadow system where it enters "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 is a flashy system, with flows increasing dramatically after monsoon events typical to the Jemez Mountains, then just as rapidly returning to base conditions. No irrigation withdrawals or active ditches are located on the East Fork. The rock in this area consists mainly of igneous formation and includes pumice and tuff. This porous bedrock material and the loss of wetland formation are what make the watershed so flashy. (See Geology Map on p. 14.) Some obsidian flows can be found in some of the rock formations along the river. Excessive fine sediment loads and high turbidity are now found in EFJR, due in large part to historic grazing and logging practices.

In 1918 the Redondo Development Company, an investment group based in Pennsylvania, sold Baca Location No. 1, including all of today's Valles Caldera National Preserve, to Frank Bond. But the company did not sell Bond all its interest in the property. It held back the rights to the timber of the caldera, in expectation that the lumber resource would become extremely valuable once reliable roads penetrated the area and allowed the efficient transport of logs to mills and markets.

That day came in 1935, when the Civilian Conservation Corps finished construction of an evenly graded and reliably drained road from Ponderosa (near Jemez Pueblo) northward into the Valle Grande and thence eastward over the rim of the caldera to the Pajarito Plateau. Immediately the Redondo group sold the timber of the Baca Location to the New Mexico Timber and Lumber Company, which thereafter commenced operation within the caldera. Between 1935 and 1972, when Bond's successor in ownership, Patrick Dunigan, managed at great expense to terminate the timber lease, New Mexico Timber logged more than 36,000 of the caldera's timbered acres, much of it by clear-cutting. (Valles Caldera Trust, 2003)

Sediment input from bank and upland erosion has greatly diminished pool volume in the EFJR. The amount of fine sediment from the erosion has begun to fill in much of the pool habitat. There are no standards and guidelines for side channel habitat, but having only 3% side channel habitat is very low. (Santa Fe National Forest, 2002) A little less than half of the river is meadow habitat, approximately nine miles. The area of stream in the low-gradient, high-sinuosity meadow systems should have much higher amounts of side channel habitat. (Santa Fe National Forest, 2002) (A side channel is **a small channel that branches from a main channel of a braided river**. Because the landscape of a river is constantly changing due to movement of sediments, side channels can form, disappear, or become main channels over time.) Due to past grazing practices, these side channels have been converted to dry sites due to loss of meadow habitat.

By the 1830s livestock production had developed in New Mexico to the point that large herds of sheep were exported annually south to Chihuahua and west to California. The grasslands of the Valles Caldera were receiving significant use. When The Valles Caldera Trust was formed in 2000, it inherited a long history of ranching.

Early Spanish settlement began in New Mexico when Don Juan de Oñate arrived in 1598, bringing with him the first wave of colonial settlement. The Spanish brought with them cattle, sheep, goats and horses. Pastoral grazing became a primary means of subsistence for both Spanish settlers and many Native Americans. "**By 1757 the Pueblos and Hispanics of** New Mexico together owned significant numbers of livestock, including seven times more sheep than cattle: 7,356 horses, 16,157 **cattle, and 112,182 sheep.**" During this time, sheep grazing was the dominant land use activity at the Preserve. The arrival of the Santa Fe Railroad in the 1880s brought with it access to Eastern markets. Consequently, both cattle and sheep grazing boomed. By 1950, owners of the Baca ranch were grazing 30,000 sheep and 5,000 cattle. By the time the Trust inherited the Preserve it was heavily overgrazed. (Ancheutz & Merlan, 2007)

Española merchant Frank Bond, who leased the grazing rights of the Baca Location from the Redondo Development Company in 1918, ultimately acquired title to the property in 1926. During Bond's tenure, grazing within the caldera gradually shifted from sheep to cattle, a transition that Pat Dunigan completed after he purchased the property from the Bond family in 1962. Ultimately, the Dunigan family converted the ranch to a yearling operation, receiving steers in May after snowmelt and shipping them out in September before the cycle of snowfall began again. (Valles Caldera Trust, 2003) In his 1968 testimony before 10th Circuit Court of Appeals, J. B. Harrell, Jr., a Dunigan employee, states that Dunigan ran about 7,000 yearling steers on the Baca Location (Baca Co. v. NM Timber, Inc., 1967). (Ancheutz & Merlan, 2007)

Elk were reintroduced to the location in the 1940s and 1960s and the herd has grown to between 2,500-3,500 in the summer according to the Department of Fish and Game. (Valles Caldera Trust, 2003)

The East Fork stream system is classified as a Rosgen E4 channel type. This is a gentle sloping broad riverine valley system. Materials comprising the channel are gravel beds, accumulations of sand, and occasional cobble-sized material. Stream banks are composed of sandy/gravel mix with dense root mats. Slopes of less than two percent with a width/depth ratio of less than 12:1, sinuosity of more than 1.5 and an entrenchment ratio of more than 2.2:1 characterize the system. The East Fork has segments functioning within the landscape setting and others not functioning within the landscape setting.

In the Valle Grande, there is an overall lack of quality in-stream habitat where the typical riffle-pool sequence expected in the area has been replaced by near continuous riffle sections that persist for the majority of the stream length across the Valle Grande. These long riffles are broken at features such as side channels or tributaries. The riffles throughout the entire river are dominated by a fine substrate. The amount of fine substrate is largely due to the delivery of fines from the surrounding Valles Caldera. Lack of pools means limited over-wintering habitat for fish, decreased thermal protection, and poor fish habitat overall.

Streams associated with meadow systems, like the Valle Grande, are typically comprised of sinuous meandering riffle systems dominated by gravels and interspersed with long deep pools. Within these pools, the banks are deeply undercut providing habitat for fish, and shading the water from the sun. Due to the extensive sinuosity of streams associated with the E-channel type, deeper pools are found with deep undercut banks at meander bends. However, in the Valle Grande, the system has been significantly altered by past grazing. The undercut banks have begun to slough off into the stream, and the stream has become wider and shallower and unstable. This bank erosion is removing the undercut bank habitat and adding fine sediments to the stream. Typical E channels are unstable, relying on the dense root structure of wetland vegetation for bank stabilization. See photo on page 27. The large amounts of livestock and wildlife grazing over the years has had significant impact on that bank stability.

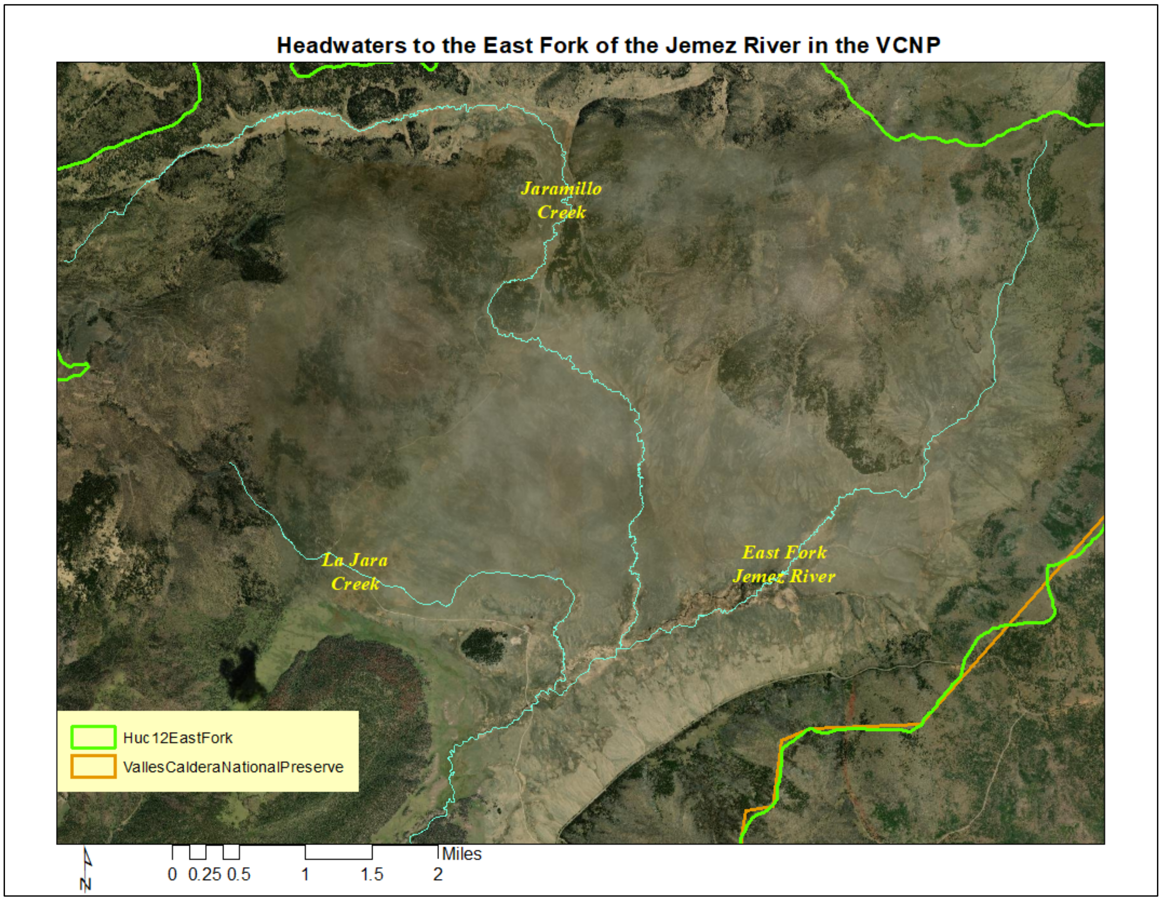



*Figure 2. Headwaters of and Tributaries to the East Fork Jemez River.*

There are four perennial tributaries to the EFJR, of which only two have official names, La Jara Creek, which produces 15% of the stream flow, and Jaramillo Creek, which comprises 50% of the stream flow. (See Figure 2.) The floodplain and riparian corridor of the Jemez Watershed Tributaries include the Rio San Antonio, Sulphur Creek, Redondo Creek, and Vallecito Creek. Nineteen tributaries were identified on the EFJR (note that seeps and springs are classified as tributaries). The majority of these were found on the VCNP. The EFJR is cooler in the lower reaches than it is coming off the Preserve onto

Forest Service managed public land. (Santa Fe National Forest, 2002)

Peak flows in EFJR are governed by snowmelt, typically spiking in the spring, usually late May to early June. The river is spring fed at its headwaters. Low flow often persists from late summer until the snowmelt in the spring. The East Fork Jemez Watershed typically receives monsoon events in July through September, although some of this is being altered by climate change.

Precipitation in the EFJR watershed is typically bimodal because of winter snowfall and summer monsoons. Data from the United States Geographical Survey (National Water Information System; https://waterdata.usgs.gov/nwis) stream gauge 08324000 on the Jemez River (main stem) downstream from the confluence of the EFJR and Rio San Antonio show that spring snowmelt greatly influences peak Q in years with a substantial snowpack. The timing and magnitude of snowmelt for the Jemez Mountains is also influenced by El Niño-Southern Oscillation (ENSO) climate patterns. Specifically, el Niño years typically produce higher peak and total Q from snowmelt than la Niña years.

There are no lakes or reservoirs on the EFJR. There are two ponds on the Preserve above the headwaters that were created to capture snowmelt and rainwater for cattle. These stock ponds have eliminated channel-forming events above Jaramillo Creek. Some water is withdrawn from La Jara Creek on the Preserve for tap water for all of the buildings. Approximately 2.69 ac/ft of water is withdrawn from La Jara Creek for Preserve personnel.

Vegetation in the river valley mainly consists of montane grassland, whereas Ponderosa pine (*Pinus ponderosa*) and mixed conifer forests dominate higher elevations within the catchment. The riparian vegetation is sedge-dominated (*Carex spp.*) grassland. No trees or shrubs occur, which results in an open canopy over the stream. The annual growing season ranges from March to November, and peak primary production usually occurs between May and August for both aquatic and terrestrial primary producers. (Summers, et al., 2020) Benthic algal assemblages increase in biomass immediately following snowmelt and remain active throughout the growing season. Additionally, the biomass of the two dominant submerged macrophyte taxa (*Elodea canadensis* and *Ranunculus aquatilis*) increases between the on-set of spring (April–May) through early autumn (September–October), with mean total macrophyte biomass estimates ranging from 56 to 158 g ash free dry mass/m2 throughout the growing season. (Thompson et al., 2019) Previous solute injection experiments have identified nitrogen as the limiting nutrient for primary production in this stream. (Van Horn et al., 2012)

On the Preserve no woody species are present within the riparian zone and wet meadows of the East Fork. From historic photos, it appears it has been that way for a long time. In the upper section of the river, shrubby cinquefoil, a native species associated with dry sites, was observed. Finding cinquefoil in the riparian area is a red flag that indicates the riparian area is being converted from a wet to a dry site. This is usually associated with major disturbances such as overgrazing and soil compaction. The majority of the cinquefoil was associated with the reaches within the Preserve, where grazing from cattle and sheep has occurred for 140 years.

The floodplain and riparian corridor of the EFJR should be protected and restored for the purpose of improving aquatic habitat and stabilizing the floodplain and river overbanks. The floodplain and riparian corridor of the EFJR has the potential for some of the highest quality habitat of all the areas within the watershed, supporting many of the plant and animal species found in this watershed.

***The EFJR on the Santa Fe National Forest.*** Eleven miles of the EFJR on the Santa Fe National Forest is designated a Wild and Scenic River (WSR) and managed that way by the Forest Service. The 11 miles go from the boundary with the Preserve to the confluence with the Rio San Antonio, and are divided into three sections, Recreation, Scenic, and Wild. The WSR corridor is within the congressionally designated Jemez National Recreation Area (PL 103-104, 1993). Two parcels of private land are located within the WSR corridor comprising a total of about 67 acres.

The *Wild* segment, which is four miles long, is defined as being free of impoundments, with unpolluted waters and generally inaccessible except by hiking trail. The *Scenic* segment, which is five miles long, includes those river segments that are free of impoundments but are accessible in places by road with shorelines or watersheds largely undeveloped. The *Recreation* segment, which is two miles long, is characterized by a river segment that is already accessible by road, that may have development along its shoreline, and may have undergone some impoundment or diversion in the past [PL 90-542 Sec. 2(b)].

Specific to the East Fork WSR, the Recreation segment is characterized by low stream gradients and easy access for recreational activities. In contrast, the Wild segment includes a tight box canyon with moderate stream gradient, big boulders and difficult access. The Scenic segment is characterized by a steeper gradient, including Jemez Falls, dropping into a narrow canyon with limited access. The stretch before joining San Antonio Creek has numerous boulders, pools and eddies, creating some suitable fish habitat and attractive pools for swimming.

The scenic beauty of the landscapes within and surrounding the WSR are extraordinary. The geology of the Jemez Mountains provides a variety of dramatic landforms with vibrant colors. Scenic attractions include striking views of conifer-covered mountain peaks, open mountain meadows, impressive volcanic rock formations, dazzling multicolored rock cliff faces, and the tumbling river with its lush vegetation.

The river originates as a small meandering stream in the vast grassland crater of the Valles Caldera. Through the Recreation segment, the river winds its way through small riparian meadows, creating a pastoral scene through which Forest Trail 137 traverses. Within the Wild segment, the river enters a rugged stretch of canyon where cliffs and huge boulders emerge among slopes densely covered with mixed varieties of conifers. In places the river flows from canyon wall to canyon wall, making passage impossible without wading or using footbridges along the stream.

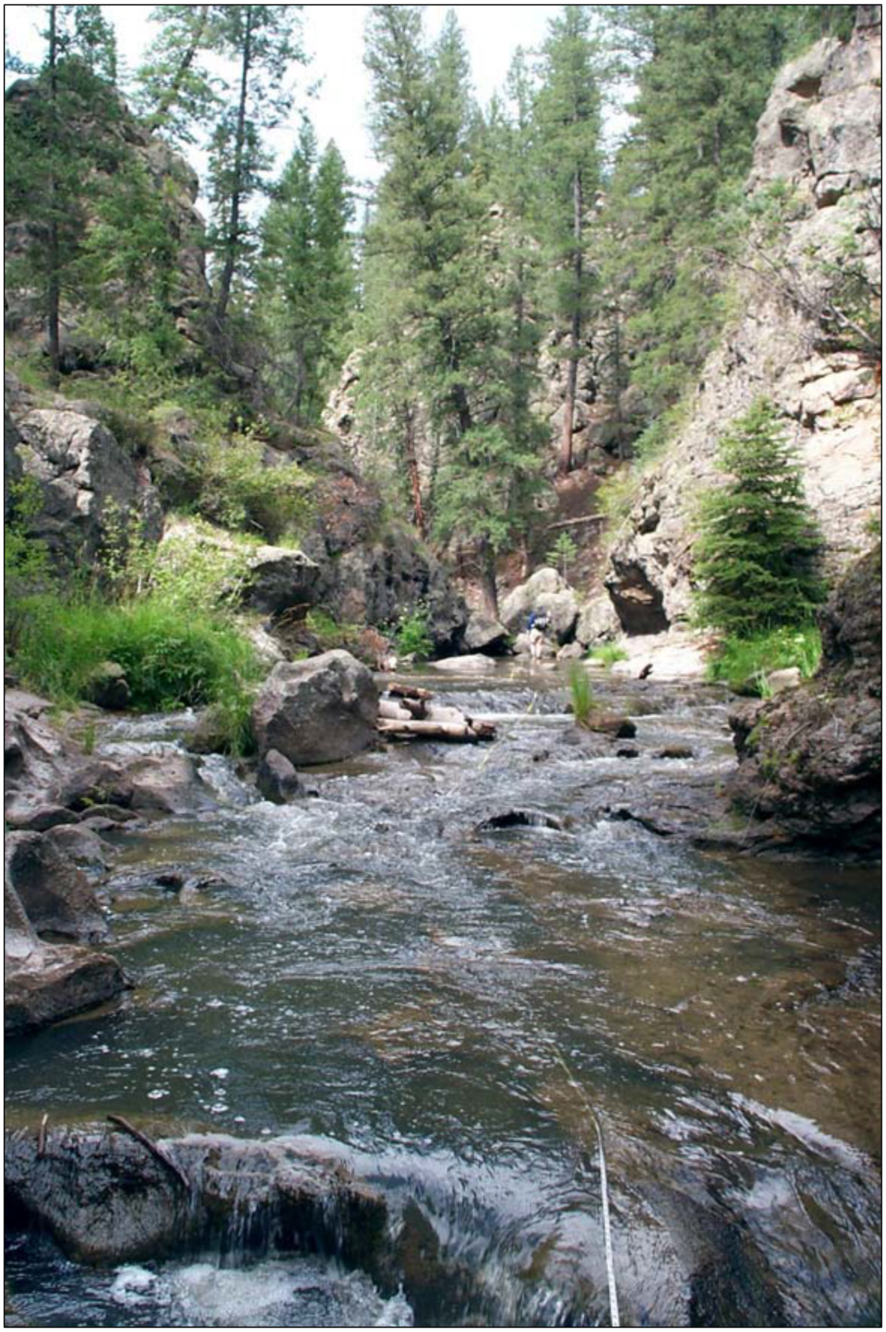


*Figure 3. Typical riffle from the reach from Jemez Falls to NM HWY4 Crossing. Notice the bedrock substrate, riparian grasses, and deep eroded potholes in the bedrock. (Photo courtesy of the Santa Fe Fisheries Crew, 2001.)*

The Scenic segment of the river continues through another rugged canyon, and tumbles over the bedrock creating Jemez Falls, a cascade dropping more than 100 feet. From the falls, the river flows through a steep canyon with limited access. The canyon opens up as it approaches the looming solid rhyolite monument of Battleship Rock.

The WSR corridor has long been a recreation destination for visitors from the region, as well as from around the country. Throughout the WSR corridor, day use is high in the summer months, and overnight use, both in developed sites and dispersed sites, occurs spring through autumn. Commonly observed activities include hiking, fishing, camping, photography, and sightseeing. After snowfall, day use is again high when cross-country skiing, snowmobiling, tubing, and snowshoeing are popular.

The Recreation segment has one developed site, Las Conchas Fishing Access, and Las Conchas Trailhead, which accesses Trail 137. This popular portion of the trail closely follows the river for a mile. In the Wild segment, the canyon walls are right up to the river, but anglers often hike up the box canyon to their favorite fishing spots. Half a mile in from the highway at each end of the box canyon, people access the river for a variety of other recreational activities. The very large boulders and deep pools in the river create popular sites for jumping and swimming. Snowplay, cross-country skiing, and snowmobiling also occur. The Scenic segment is a destination for anglers from all over the state, especially the urban areas of Albuquerque and Santa Fe. Access is primarily up the river from Battleship Rock.

Cataclysmic eruptions rocked the Preserve area 1.2 million years ago and 50 cubic miles of volcanic ash and rock were ejected. Around 85,000 years ago, the volcano erupted again. This recent geologic event produced Battleship Rock, a colorful, striking vertical abutment at the confluence of San Antonio Creek and the East Fork. Battleship Rock was put in place all at once by a volcanic flow into an ancient river canyon cutting through sedimentary rock formations. Weathering over time has removed the relatively softer sediments, leaving the "prow" of the battleship exposed as a towering monolith.

The WSR passes through a variety of vegetation communities including meadows, conifer stands, riverine habitat, rock cliffs, and volcanic formations. Each community is comprised of a mosaic of smaller habitats. Elevation is as high as 8,600 feet at its eastern edge with the Preserve, to 6,700 feet at Battleship Rock. This variety has resulted in a diversity of ecological systems within the WSR corridor.

Two unique plant species occur within the corridor, giant helleborine and bunchberry dogwood. The giant helleborine is proposed as a rare species in New Mexico, and the bunchberry dogwood population in the WSR is thought to represent the extreme southern range of this species.

The East Fork once hosted the largest populations of Rio Grande cutthroat trout (RGCT) in the Jemez Mountains. Historically, the native fish assemblage throughout the East Fork was comprised of RGCT, Rio Grande chub, Rio Grande sucker, longnose dace, and fathead minnow. The current native fish assemblage excludes RGCT, last found in this drainage in 1950. Since then, German brown trout and other non-natives have replaced RGCT.

The wide variety of vegetative communities allows for a diverse complex of wildlife species. Periodic surveys and field visits by wildlife biologists have revealed the variety of wildlife species throughout the corridor. During certain times of the year, the river becomes a passageway for wildlife moving off the Preserve (e.g. Rocky Mountain elk). People have seen bear, elk, deer, mountain lion and bobcat within the WSR corridor. The WSR provides suitable habitat for a few species listed as federally threatened or Forest Service sensitive, such as Mexican spotted owl (threatened), Jemez Mountains salamander (sensitive) and northern goshawk (sensitive). Some uncommon species, such as the spotted bat and black swift, have been found within the WSR. (Santa Fe National Forest, 2002)

**Geology**

The 1.25 million-year-old Valles Caldera (15-mi diameter) is the centerpiece of the Jemez Volcanic Field in north central New Mexico. The singularity of the Valles Caldera begins (but hardly ends) with its geology. The volcanic pile underlying the Jemez Mountains of northern New Mexico has been active for at least the past four million years, and it is by far the largest and most powerful such formation in the region. The events that define the present landscape began approximately 1.22 million years ago, when a previous caldera, known to geologists as the Toledo Caldera, became the scene of renewed volcanic activity. A field of multiple volcanic domes within the caldera erupted, spewing vast quantities of ash and magma and making the area of the present Jemez Mountains a scene of sustained violence far greater than anything that has been recently observed on earth. Many Americans remember the eruption of Oregon's Mount St. Helens in 1980, which resulted in the rapid ejection and displacement of about 2.8 cubic kilometers of material, including landslides triggered by the eruption. By comparison, the eruptions that formed the Valles Caldera displaced some 292 cubic kilometers of the earth's crust and produced the titanic flows of superheated, liquid mineral that cooled to form the Pajarito Plateau. Ash that can be traced to the eruptions has been found as far away as Kansas.

The ejection of so much material left the subterranean innards of the former Toledo Caldera hollow and eviscerated. Devoid of structural support, the ravaged landscape fell in on itself, the floor of the land sinking to form the bottom of a giant, roughly circular bowl 13 to 14 miles across and bounded by a knife-edged rim of mountains. This collapsed volcanic field was the Valles Caldera, which remains today one of the best-exposed examples of caldera formation known to science. Although by no means the largest of the world's calderas nor the oldest or youngest, the landscape of the preserve is unsurpassed in the perfection of its expression of the caldera landform. This is one of many reasons for the preserve's great value for study and education.

The Jemez country's volcanism hardly ceased with the formation of the present caldera. The uplift of Redondo Peak, which towers above the center of the caldera, continued long after the eruption of the caldera. About 1.1 million years ago, new eruptions welled up to the northeast of Redondo, forming a mountain 1,200 feet higher than the surrounding caldera floor. This was Cerro del Medio, which separates what is today the Valle Grande from the Valle Toledo. About a hundred thousand years later a second cluster of mountains, Cerros del Abrigo, welled up, after which came a third, a fourth, and more eruptions, each spaced approximately one hundred thousand years apart, as the site of the eruptions moved at first counterclockwise around the northern and western interior of the caldera and later clockwise across the southern interior. Last in the sequence of volcanic events sculpting the interior of the Valles Caldera was the El Cajete eruption of 40,000 to 60,000 years ago, which deposited thick layers of pumice in and near the southern parts of the Preserve. Almost certainly there will be more eruptions in the future—the magma underlying the caldera lies only about three miles beneath the surface, rather than the seven miles typical throughout most of the world—but such eruptions probably will be far in the future. The presence of geothermal waters in and around the Valles Caldera serves as a reminder that this volcanic field is dormant, not extinct.

Water as well as fire has shaped the present landscape. At various times lakes have filled parts of the caldera, and the soils that formed from the sediments that collected beneath their waters help account for the famous grasslands of the valles. One of the lakes that formed within the caldera also shaped lands beyond its boundaries. About half a million years ago, the waters of a lake filling the Valle Grande breached the southern rim of the caldera, and once the breach began, the waters flowed faster the more they opened the breach, widening and deepening their channel and eventually becoming a violent, sustained, and stupendously erosive flood. The result was the formation of the Cañon de San Diego, the narrow, steep-walled canyon through which the Jemez River flows today.

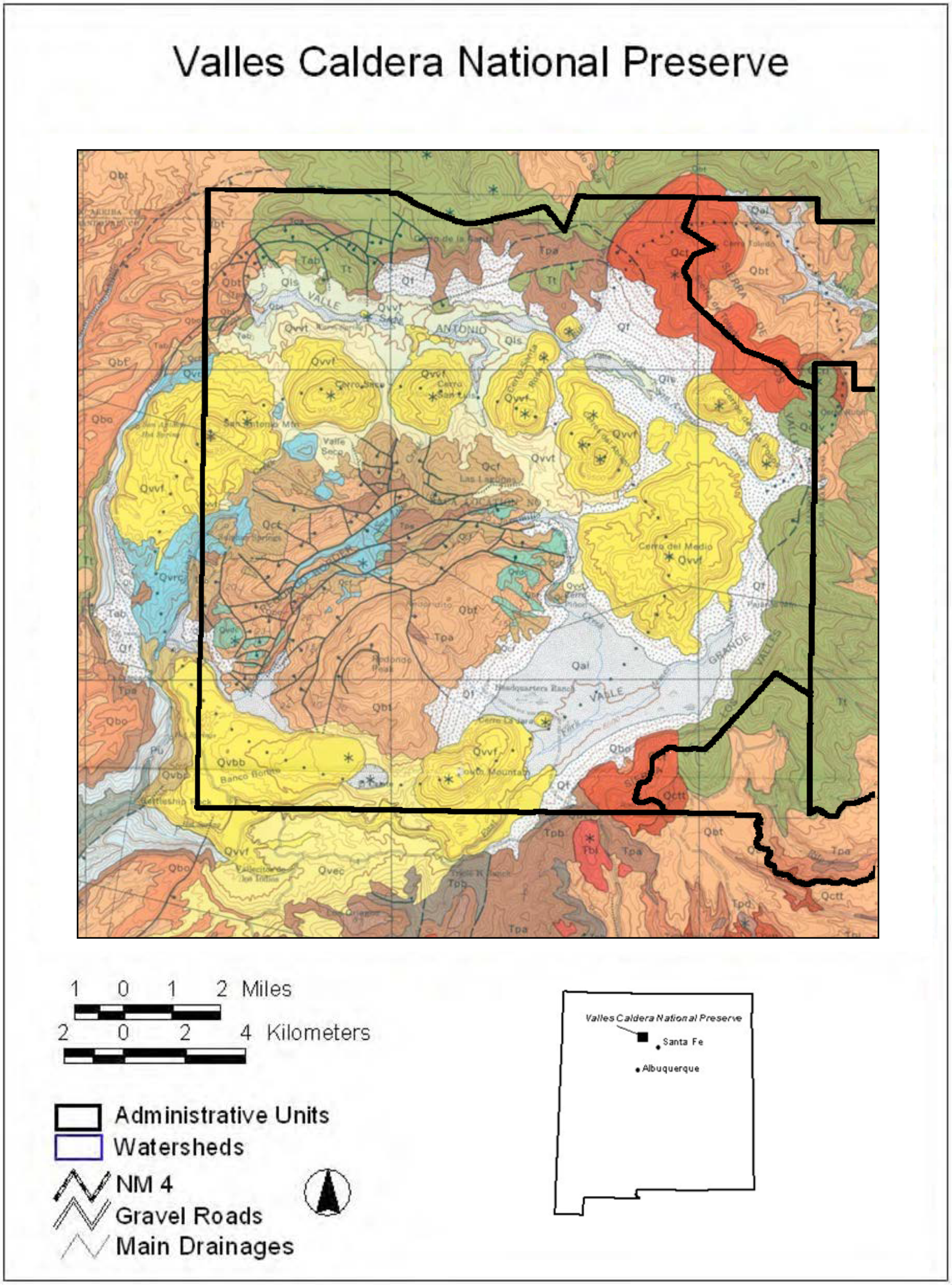



*Figure 4. Geology of the Valles Caldera National Preserve as mapped by Smith et al. (1970).*

*Table 1. Geologic map units of Smith et al. (1970) that occur on the Valles Caldera National Preserve*

| Map Unit | Map Unit Name | Description |
|---|---|---|
| Qvbb | Banco Bonito Member | (100-500 ft). Thick flow of porphyritic obsidian containing phenocrysts of quartz, sanidine, plagioclase, biotite, hornblende, and pyroxene. |
| Qal | Alluvium | (0-100(?) ft). Silt, sand, and gravel; mainly deposits of recent streams. |
| Qf | Fan Deposits | (0-100(?) ft). Coarse sand and gravel; mainly deposits of transient streams with steep gradients. |
| Qbo | Otowi Member | (0-600+ ft). Nonwelded to densely welded ash-flow deposits, characteristically containing abundant accidental lithic inclusions. As mapped includes 0-30 ft of basal, bedded, air-fall pumice. (Guaje Pumice Bed). |
| Qct | Cerro Toledo Rhyolite | Volcanic domes; mainly gray lithoidal rhyolite, commonly lithophysal, and subordinate obsidian, containing small sanidine and rare quartz phenocrysts. |
| Qctt | Cerro Toledo Rhyolite | Rhyolite tuffs and tuff braccias (0-200+ ft); includes hoy avalanche deposits from Rabbit Mountain center. |
| Qls | Tuffaceous Lake Sediments | (0-100+ ft). Thin-bedded clay, silt, and sand deposited in lakes within the Valles Caldera; commonly contain fossil leaf and other plant remains; interbedded with tuffs of the Valle Grande Member of the Valles Rhyolite. |
| Qvvf | Valle Grande Member (volc.domes and flows) | Volcanic domes and flows (200-2,500 ft). Predominantly porphyritic rhyolites containing major phenocrysts of quartz and sanidine with lesser plagioclase, biotite, hornblende, and pyroxene. |
| Qvvt | Valle Grande Member (tuffs) | Bedded rhyolite tuffs and tuff breccias (0-500(?) ft). |
| Qvdc | Deer Canyon Member | Rhyolite dome-flow, associated breccias, and bedded tuffs (25-100ft). Predominantly coarsely porphyritic lithoidal rhyolite typically containing abundant phenocrysts of sanidine and bi-pyramidal quartz. |
| Qcf | Caldera Fill | (0-2,500 + ft) coarse breccia, gravel, sand and silt deposited within the Valles Caldera. Predominantly volcanic detritus but locally contains large blocks of Paleozoic limestone and red sandstone. Some coarse breccia units represent landslide deposits from the caldera walls. |

| | | |
|---|---|---|
| | | Includes early-formed caldera lake sediments and some pyroclastic deposits. |
| Qbt | Tshirege Member | (50-900+ ft). Nonwelded to densely welded ash flow deposits, characteristically containing sparse to abundant cognate inclusions of hornblende-rich quartz-latite pumice, and sparse accidental lithic inclusions. As mapped includes 3-12 ft of basal, bedded, air-fall pumice. (Tsankawi Pumice Bed). |
| Tt | Tschicoma Formation | (0-3,000+ ft). Predominately coarsely porphyritic dacite, rhyodacite, and quartz latite containing pyroxene, hornblende, biotite, plagioclase, and occasionally quartz phenocrysts. Thick massive flows and domes. Associated pyroclastics mapped as part of the Puye Formation. |
| Tpa | Paliza Canyon Formation (andesitic) | Mainly hypersthene-augite andesites and subordinate olivine-bearing basaltic andesites. Flows, flow breccias, tuff breccias, and dikes, undivided (0-2,000 ft). As mapped includes some gravels of the Cochiti Formation. |
| Tab | Abiquiu Tuff of Smith | (0-1,200+ ft). Mainly white to light-gray tuffaceous sand and conglomerate; includes basal gravel member (60-300 ft), composed of Precambrian crystalline rock types, and a thin (5-25 ft) chert bed (Pedernal Chert Member of Church and Hack, 1939). The Abiquiu west of La Grulla Plateau consists only of the basal gravel and chert. Includes tuffaceous sediments of questionable correlation at the mouth of Santa Fe Creek Canyon. |

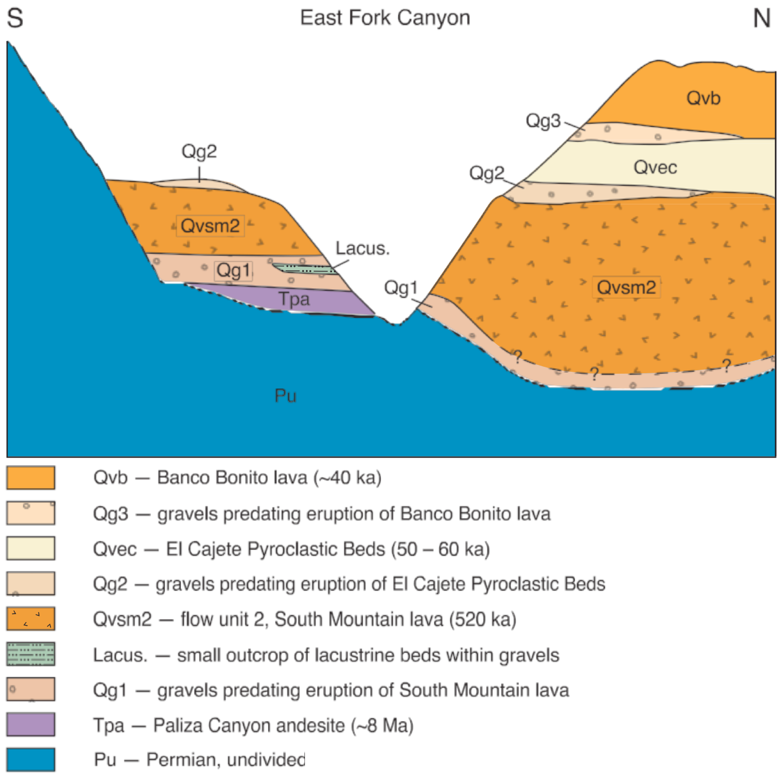



*Figure 5. East Fork Jemez River cut through the southwest caldera wall and the youngest moat volcanics.*

**Climate**

Average temperatures in the Preserve are 22°F (-6°C) in January and 60°F (16°C) in July. Temperature extremes range from a high of 84°F (29 C) in summer to -30°F (-34°C) in winter. The average annual precipitation in the Preserve is approximately 24 inches with over 50% from summer rains, typically monsoons. Snowfall occurs in the watershed from approximately December through March, and in many locations, because of high elevation factors especially in north-facing areas, roads are not passable until late April. (www.nps.gov/vall/planyourvisit/basicinfo.htm)

The New Mexico climate is historically variable with cycles of drought along with short-term storm events, conditions that are influenced by natural cycles such as el Niño/la Niña, the Pacific Decadal Index (PDO), and the Atlantic Multi-decadal Oscillation (AMO). Weather records dating back to 1914 indicate warmer temperatures and drier conditions on the Preserve over the past century. (Valles Caldera Trust, 2015) This trend is expected to continue.

***Climate Change.*** Scientists have identified the Southwest as a climate change hotspot—an area whose climate is particularly vulnerable to an increase in greenhouse gases in the atmosphere. (Diffenbaugh et al., 2008) Effects of climate change that are predicted for the Jemez Mountains and throughout New Mexico include (Enquist et al., 2008; NMOSE/NMISC, 2006; USGCRP, 2009) the following:

- Temperature is expected to continue to rise, resulting in increased evaporation and evapotranspiration.
- Precipitation is expected to be more concentrated and intense, so that increases in the frequency and severity of flooding are also projected.

- Streamflow is projected to decrease overall due to lower snowpack and higher evapotranspiration, and peak runoff will occur earlier and be diminished.

Additional stresses on wetlands due to increasing temperatures, evaporation, and intense precipitation events magnify the importance of protecting and restoring wetland resources. Wetlands provide buffering qualities to receiving streams. Wetlands also provide a mechanism for the subsurface hydrology to move slower through the system, and provide a barrier to moving sediment during flashy precipitation events.

Long-term climate data for the State of New Mexico suggest that the Jemez Mountains are warming at a faster rate than other regions of the state. (VCNP, 2018) Valles Caldera and the broader Jemez Mountains form an isolated sky island (rather than a mountain chain) that reduces migration options for many sensitive plant and wildlife species. Climate change vulnerability at Valles Caldera in recent decades has already been expressed through warmer temperatures and drought and an associated increase in risk for catastrophic wildfires such as the 2011 Las Conchas and 2013 Thompson Ridge wildfires, which, combined, burned approximately two-thirds of the Preserve. The 2011 Las Conchas Fire was particularly damaging, with large areas of high burn severity, high tree mortality, and profound post-fire erosion. (See Figure 6.) Assessment and adaptation planning is needed to understand the range of potential effects of climate change on uncharacteristic wildfire activity, ecosystem processes, hydrology, archeological resources, and biodiversity in this temperature-sensitive high-elevation environment. Possible threats include the following:

- Climate change could affect vegetation associated with traditional uses and practice.
- Historic building materials could be damaged by severe weather events, associated erosion, and rodents.
- Severe fire and post-fire erosion could affect cultural landscapes through changes in character-defining features including biota, cultural features, geomorphology, and hydrology.
- Climate change and insect outbreaks could impact native flowers and plants in the preserve.

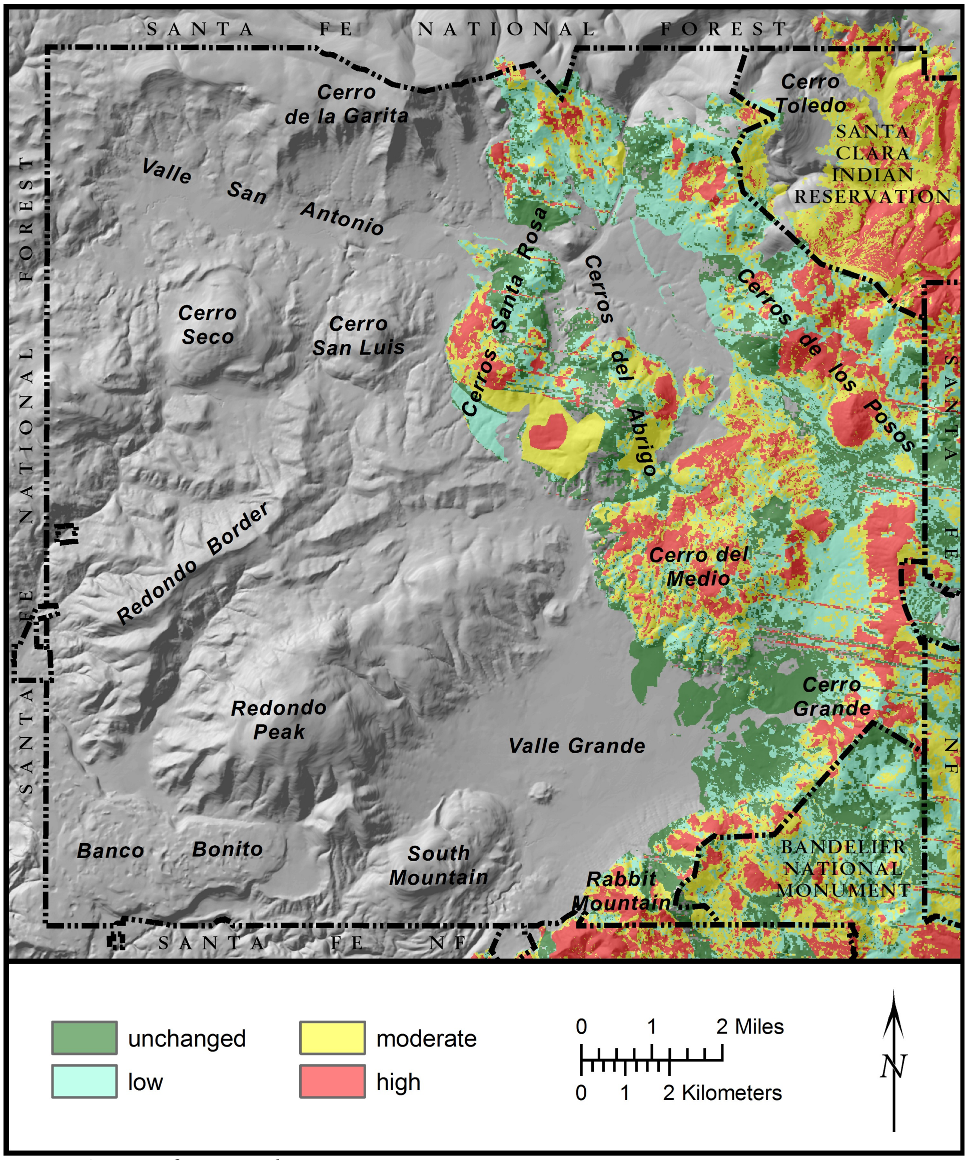


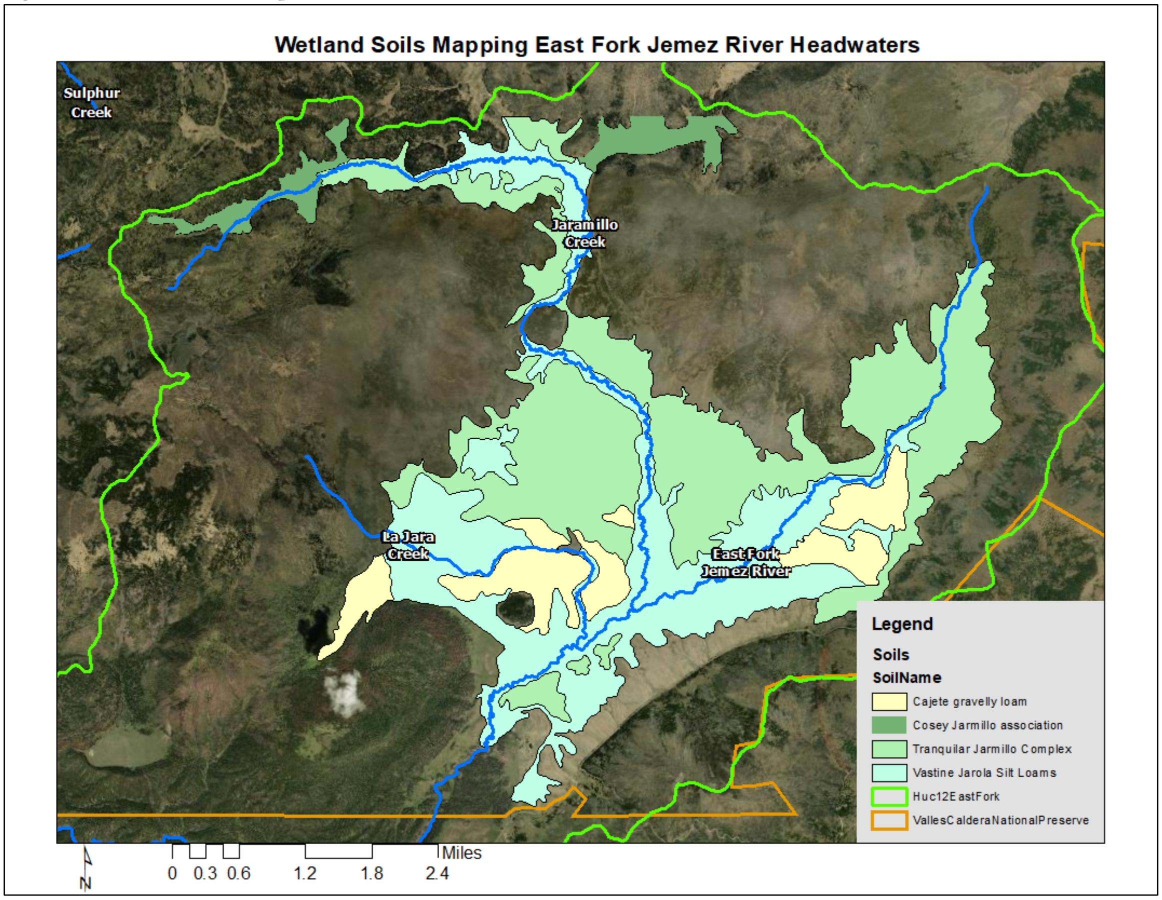

*Figure 6. Map of Las Conchas Fire, 2011.*

**Soils**

On the Santa Fe National Forest soils were inventoried as ecological units in the Terrestrial Ecosystem Survey (TES). This method considers soil genesis in an ecological context and combines the biotic and abiotic aspects of soils using climate and vegetation to form an ecological unit. Soil classification (USDA, 1975), properties (USFS, 1985), interpretations, and productivity are measured and inferred through the assessment by TES. Scientific planning for soil conservation and water management requires knowledge of the relationships among those factors that cause loss of soil and water and those that help to reduce such losses. (Renard, 1997)

The soils in the valley positions within the Preserve are an association of three dissimilar soils, which occur in a repeatable pattern that can be discerned over the landscape (soil association). The soils extend from adjacent to the aquatic sources up slope to a drier upland position. This mapping unit includes a hydric soil (*Cumulic Haplaquolls*, fine-loamy, mixed) near the stream, an adjacent alluvial soil (*Pachic Udic Haploborolls*, fine-loamy, mixed), and a coarser textured hydric soil on alluvial benches and bars (*Typic Haplaquolls*, loamy-skeletal, mixed). (NRCS, 1996)

*Figure 7. Wetland Soils Map.*



**Wetland Soils in EFJR**

The **Cajete** series consists of very deep, well-drained soils that formed in pumice on low hills, terraces, and mountain slopes. They have low runoff and rapid permeability. Slopes are 0 to 30 percent in elevations between 7,000 to 8,500 feet. The mean annual precipitation is about 18 inches, the mean annual temperature is about 44 degrees F., and the frost-free period is about 60 to 100 days. These soils play a crucial role in supporting various activities such timber production, livestock grazing, and wildlife habitat. Natural vegetation is ponderosa pine, white fir, mountain brome, Arizona fescue, and little bluestem.

The **Jarmillo** series consists of deep, well-drained soils that formed in alluvium, colluvium, and lacustrine sediment derived mainly from rhyolite and tuff. Jarmillo soils are on terraces that have slopes of 1 to 20 percent. The climate is subhumid continental with a mean annual precipitation of about 20 to 25 inches with moist winters and late summers and dry spring. The mean annual temperature is about 42 to 45 degrees F., and the frost-free period is about 70 to 100 days. Elevations are 8,000 to 8,800 feet. Jarmillo soils support grazing. The natural vegetation is Arizona fescue, bluegrass, pine dropseed, and sedges.

The **Tranquilar** series consists of very deep, somewhat poorly drained soils that formed in lacustrine and alluvial deposits on nearly level to moderate slopes on valley floors and on adjacent terraces. The sediments were derived mainly from rhyolite, tuff, dacite, and latite. Slopes are 1 to 15 percent. Elevations are 8,500 to 9,200 feet. The climate is subhumid continental with a mean annual precipitation of about 20 to 25 inches. During spring and early summer the water table is typically between 20 to 48 inches. The mean annual air temperature is about 42 to 46 degrees F., and the frost-free season is about 70 to 100 days. Tranquilar soils mainly support grazing. The native vegetation is Arizona fescue, bluegrass, pine dropseed, and sedges.

The **Vastine** series consists of very deep, poorly to somewhat poorly drained soils with low runoff that formed in mixed alluvium, and fine-loamy over sandy and gravelly alluvium derived from granite, gneiss, and mica schist. Vastine soils are on low stream terraces and floodplains with slopes 0 to 5 percent. The mean annual precipitation is about 7 inches and the mean annual temperature is about 42 degrees F. Typically the water table fluctuates with the height of the water in the adjacent streams. These soils are sometimes saturated in the spring. Water tables may drop as much as five feet in the driest parts of the year. These soils are used principally to support native pastureland and for irrigated meadows. Occasionally, some areas are used for small grains. Principal native plants are sedges, rushes, saltgrass, and other water-tolerant grasses and plants.

**Wetland Vegetation**

The wetland vegetation varies from carex species (Nebraska sedge, beaked sedge, beautiful sedge), grasses (hairgrass, Kentucky bluegrass, redtop, Arizona fescue, mountain muhly, and nodding brome), alder (thinleaf), and willow (Bebbs and scouler/mountain). This soil has a high re-vegetation potential.

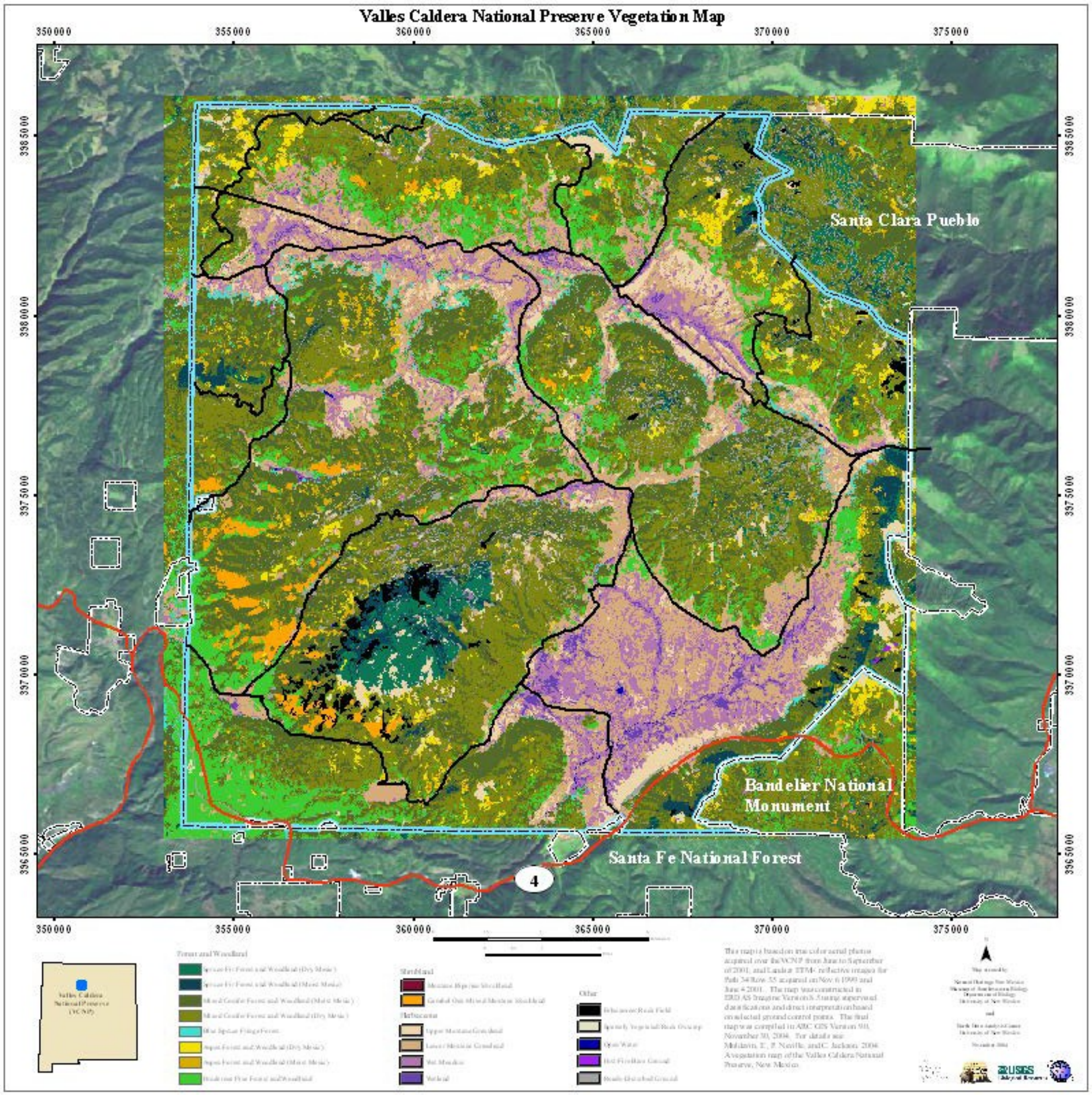



*Figure 8. Vegetation Map, Muldavin and Tonne, 2003.*

Riparian wetlands at Valles Caldera include the marshy meadows, fens, bogs, vernal pools, springs, and seeps that occur in the large, open, low-gradient landscape areas. About 8% of Valles Caldera's land area can be classified as wetlands. A variety of sedges (*Carex* spp.), cinquefoil (*Potentilla* spp.), rushes (*Juncus* and *Eleocharis* spp.), and longleaf pondweed (*Potamogeton nodosis*) comprise Valles Caldera's wet meadows.

According to Muldavin and Tonne (2003), the edges of the intermittent and perennial streams at Valles Caldera support a diverse layer of over 40 grasses and forbs, most of which are aquatic plants. The most common ones are Canada reedgrass (*Calamagrostis canadensis*), Fendler's waterleaf (*Hydrophyllum fendleri*), seep monkeyflower (*Mimulus guttatus*), Columbian monkshood (*Aconitum columbianum*), and Fendler's cowbane (*Oxypolis fendleri*).

Descriptions of the wetlands and riparian plant associations found in the Preserve are listed below.

**Rocky Mountain Wet Meadows and Wetlands**

Herbaceous vegetation of valley bottoms and swales dominated by grasses, rushes and sedges, many of which are either facultative or obligate wetland species.

*Table 2. Plant Alliances.*

| Plant Alliance | Primary Components | Secondary Components | Inclusions |
|---|---|---|---|
| Montane Wet Meadow | Tufted Hairgrass/Woolly Cinquefoil<br>Baltic Rush-Kentucky Bluegrass<br>Baltic Rush-Tufted Hairgrass Grassland<br>Kentucky Bluegrass-Common Dandelion | Tufted Hairgrass-Smallwing Sedge<br>Baltic Rush-Kentucky Bluegrass<br>Pine Dropseed-Baltic Rush | Arizona Fescue - Kentucky Bluegrass<br>Northwest Territory Sedge-Smallwing Sedge |
| Montane Wetlands | Northwest Territory Sedge-Smallwing Sedge<br>Woolly Sedge-Common Spikerush | Northwest Territory Sedge-Longstyle Rush<br>Water Sedge-Northwest Territory Sedge<br>Tufted Hairgrass-Northwest Territory Sedge<br>Kentucky Bluegrass-Common Dandelion | Tufted Hairgrass/Woolly Cinquefoil<br>Baltic Rush-Kentucky Bluegrass<br>Baltic Rush-Tufted Hairgrass Grassland<br>Narrowleaf Burreed Herbaceous Alliance |

**Grasslands**

Water as well as fire has shaped the present landscape. At various times lakes have filled parts of the caldera, and the soils that formed from the sediments that collected beneath their waters help account for the famous grasslands of the valles. (Valles Caldera Trust, 2003)

No feature of the caldera is more stunning than the sprawling, open grasslands that define its famous valles. Cumulatively these giant, sun-drenched spaces account for about a quarter of the area of the Preserve. Although at first impression these blankets of grass may seem uniform, the ecological communities found within them are actually quite diverse. Under the gentle light of early morning or late afternoon, the summer landscape of the Valle Grande reveals an intricately varied mosaic of countless shades of green, each hue and location reflecting a particular composition of grasses, forbs, rushes, and sedges at a particular stage of annual development. It is also important to note that the diversity of grasslands within the Preserve is not solely a phenomenon of the valles. Additional grassland types grace the slopes of the Preserve's mountains, even to the summits.

*Figure 9. East Fork flowing in the Valle Grande. (Photo courtesy of Valles Caldera Trust.)*

A number of useful approaches exist for evaluating the condition and health of grassland systems. One that is widely used compares existing vegetation to the vegetation that would be present under pristine conditions, uninfluenced by livestock grazing or other significant impacts caused by humans. By this measure, some of the Preserve's communities—notably certain of the bunchgrass meadows on the upper slopes of its mountains—are in excellent condition, but most of its valles rate only a grade of "high fair." This is because of the extensive presence of Kentucky bluegrass and other non-native species. These non-natives are pervasive throughout the mountain grasslands of the surrounding region, including wilderness areas.

Another way to appraise the grasslands of the Preserve is to evaluate their effectiveness in terms of watershed function: do they absorb and retain precipitation, do they hold soil in place and retain nutrients, and are they productive and diverse? By these criteria, the grasslands of the VCNP are among the finest to be found in the entire Southwest. The soils are by and large superb, and the vegetative cover, in general, is excellent. Nevertheless, significant areas are in need of improvement. The Valle Jaramillo, for instance, receives heavy and sustained impacts from elk, for which it is a key calving and nursery area, and parts of the Rincon de los Soldados are likely less productive than they could potentially be because the area underwent long-term use as a bedding ground for sheep both entering and leaving the caldera through Valle Pass (between Cerro Grande and Pajarito Mountain). Restoration of a more natural fire regime among the grasslands of the Preserve may help improve vigor and diversity in the future.

**Aquatic Communities**

The rivers and streams of the Preserve are its lifeblood. Their health is a major indicator of the condition of the Preserve in general. With minor exceptions, the headwaters of the streams that flow out from the Preserve are entirely contained within its boundaries, making the VCNP a self-contained watershed unit. With no other lands and no other land managers upstream from the VCNP, any changes in the quality of water leaving the Preserve or in the ecological condition of its aquatic and riparian communities are wholly attributable to the interplay of human activities, ecological succession, geology, climate, and other natural processes occurring within the Preserve.

The water-collecting basin of the Preserve contains a number of unique and uncommon aquatic and wetland features, ranging from warm and extremely acidic geothermal waters to numerous springs, seeps, and boggy wetlands. These water-rich environments, combined with the Preserve's many creeks and streams, provide a robust foundation for the ecological diversity and productivity that characterize the Preserve.

Aquatic insects were collected on the Preserve in 2003 and 2004 by Dr. Bob Parmenter and staff of the Preserve. In general, species were typical southern Rocky Mountain and southwestern fauna. One hundred and thirty-one species were collected, representing 46 families and 90 genera; 14 of these species were new state records. (Parmenter et al, 2007) *Trichoptera* was the most diverse order and seven species represented new state records, including *Agraylea multipuctata* (Curtis), *Hydroptila xera* Ross, *Ochrotrichia logana* (Ross), *Psychoglypha subborealis* (Banks), *Polycentropus gertschi* (Denning), and new species of *Neotrichia* (Morton) and *Helicopsyche* (von Siebold). Collections of the mayfly species *Cinygmula ramaleyi* (Dodds) and *Paraleptophlebia temporalis* (McDunnough) represented new state records. The aquatic beetles *Haliplus immaculicollis* (Harris), *H. leechi* Wallis, and *Ametor scabrosus* (Horn) and the *hemipterans Callicorixa audeni* (Hungerford) and *Gerris gillettei Lethierry* (Severin), also represented new state records. Small creeks fed by spring runs were the most diverse aquatic systems on the VCNP.

Approximately 27 miles of streams within the Preserve offer habitat suitable for trout, although part of this habitat is in need of rehabilitation. Fishing occurs on every major stream system. The Jemez River, East Fork Jemez, Vallecito Creek, and the Rio San Antonio fisheries are composed of naturally reproducing brown trout, rainbow trout, and a host of other native and non-native species.

The native Rio Grande cutthroat trout (RGCT) (*Oncorhynchus clarki virginalis*) is no longer present in the Jemez Mountains. In general, fishing pressure is considered to be relatively high in the Jemez Watershed, partly due to streams being easily accessible. The Jemez River, once hosted the largest populations of RGCT in the Jemez Mountains. Historically, the native fish assemblage throughout the East Fork was comprised of RGCT, Rio Grande chub (*Gila pandora*), Rio Grande sucker (*Pantosteus plebeius*), longnose dace (*Rhinicthys cataractae*), and fathead minnow (*Pimephales promelas*). The RGCT was last found in this drainage in 1950. Since then, German brown trout, rainbow trout, Yellowstone cutthroat trout and other non-natives have replaced RGCT.

A cultural report from 1892 states that the mountain streams fed "Los Valles" (Preserve) and that the streams "teem with mountain trout" (FS Files). This report predates fish stocking in the Jemez Mountains. The first recorded stocking in New Mexico occurred in 1896. (Sublette et al., 1990) The mountain trout that this report talks about can only be Rio Grande cutthroat trout.

**Riparian Communities**

Substantial uncertainties exist concerning both the historical species composition and the ecological potential of the caldera's streamside communities. Non-native Kentucky bluegrass is dominant in many riparian areas, and the potential for re-establishing the dominance of native species remains unclear. In addition, stream banks in the western United States are typically occupied by woody shrubs, especially willow, but relevant historical photographs of the VCNP, the earliest of which date from about 1906, show no such vegetation along its such vegetation along its principal streams. Whether or not woody shrubs existed along VCNP stream banks prior to the 1900s is unknown. At present, one rarely finds willow, alder, or other woody shrubs growing along the banks of the caldera's watercourses, and where these plants are found, they show the effects of heavy browsing by elk. Much of this browsing occurs in late winter and early spring, when the twigs of woody plants prepare for spring growth before the first grasses in the parks and meadows turn green. These woody stems offer rich nutrition at a time of year when other food is scarce, and the large numbers of elk in the caldera appear to exploit fully what woody riparian growth is present. Before elk were present in large numbers (they were reintroduced to the Jemez Mountains in 1947 and 1964), more than half a century of heavy early season grazing by sheep may have had a similar effect. It is possible that these pressures, augmented by decades of cattle grazing, removed woody riparian vegetation from part of its natural range within the caldera, but the limits of that range are by no means well understood. It may be that woody plants should not be expected to grow along certain stretches of stream, such as the EFJR through the Valle Grande, where the gradient is nearly flat and the soils fine textured and water saturated.

Species composition is also a cause for concern with Kentucky bluegrass (*Poa pretensis*) and Redtop (*Agrostis alba*) as a major component of the cover near and within the riparian area. Montane grasslands appear to have undergone significant modifications due to a 100-year history of grazing—including large herds of livestock and elk. Native grass species have been slowly replaced by exotic Kentucky bluegrass along with several exotic and weedy forbs. Under heavy grazing the exotic Kentucky bluegrass will displace native fescues and Parry's oatgrass, Although it is highly palatable, Kentucky bluegrass is not as productive when compared to native grasses (it is often semi-dormant during the summer months and sensitive to drought conditions). (*A Vegetation Survey and Preliminary Ecological Assessment of Valles Caldera National Preserve, New Mexico*, 2003) Though no single grazing system has been found to recover degraded riparian areas, changes in the level and timing of grazing both by domestic livestock and elk should be considered to address local vegetation conditions along and near banks as well as the road contribution of sediments into the system that has been depicted. Riparian utilization rates might be considered apart from upland species.

Monitoring vegetation resources is key in determining overall health of riparian areas. Areas of disturbance from past activities can contribute to added sediment contributions to adjacent streams by accelerated erosion if the path transferring the water to streams has inadequate buffering capacity by vegetation to catch the sediment. Vegetation management through various methods needs to ensure that sufficient effective ground cover exists to protect soils from accelerated erosion, and bank vegetation is comprised of those indigenous species that can protect banks from stream flow energies.

Woody riparian plants found in the Jemez Mountains such as thin leaf alder, Bebbs willow, mountain willow, and narrow leaf cottonwood offer increased bank stability and riparian structure. (Correll, 1972) Due to the low stream gradient woody plants might not be expected in the large open valleys but as stream gradient increases the expectation of woody species should increase. These species are evident just off the Preserve on National Forest System lands and offer variety to the riparian/wetland ecosystem. Woody riparian vegetation on the Preserve is limited to the higher reaches in the watersheds and dominated by a few mature plants. This limited extent may not offer support for riparian/wetland protection as a more climax community might offer.

*Figure 10. Example of a Properly Functioning Condition hydric meadow on the upper Jemez River. This area could be used as a baseline sampling area for comparing condition of other hydric sections of the Preserve.*

**Water Quality**

The East Fork has been listed on the Clean Water Act §303(d)/§305(b) Integrated List since 1998. On the **2022-2024 State of New Mexico Clean Water Act §303(d)/§305(b) Integrated List,** EFJR is not supporting High Quality Cold Water Aquatic Life because of turbidity (first assessed in 1998) and Aluminum and Total Recoverable Nutrients, first assessed in 2016. See TMDL below.

*Table 3. ES-3 Summary for East Fork Jemez (VCNP to headwaters) TMDL*

| | |
|---|---|
| NM Standards Segment | 20.6.4.108 |
| Waterbody Identifier | NM-2106.A_10 |
| Segment Length | 8.66 mi |
| Parameters of Concern | Plant nutrients |
| Uses Affected | HQCWAL |
| Geographic Location | Jemez USGS Hydrologic Code 13020202 |
| Scope/size of Watershed | 44 $mi^2$ |
| Land Type | Southern Rockies - 21 |
| Probable Sources | Wildlife other than waterfowl, dispersed rangeland grazing, watershed runoff following forest fire |
| IR Category | 5/5B |
| TMDL for: | $WLA_{TOTAL}$ + LA + MOS = TMDL |
| Total Phosphorus | 0 + 0.11 + 0.02 = 0.14 lbs/day |
| Total Nitrogen | 0 + 1.44 + 0.25 = 1.69 lbs/day |

*Table 4. Water sampling was done in 2015 and Nutrients and Metals were still a problem.*

| Station Name | Assessment Unit | TSS/TDS 1 | Nutrients 2 | Total Metals 3 | Dissolved Metals 4 | SVOCs 5 | VOCs 6 | Radio-nucleotides 7 | E.coli |
|---|---|---|---|---|---|---|---|---|---|
| East Fork Jemez below Las Conchas day use area | East Fork Jemez River (VCNP to headwaters) | 8/7 | 8/9 | 3/5 | 3/5 | 0/0 | 0/0 | 0/0 | 8/8 |

Although there are fewer cows in the Valle Grande these days, there are still a lot of elk, especially during hunting season. The Valle Grande is not a hunting unit, and the elk have figured that out! So they spend a lot of the hunting season in the Valle Grande. This may be a continuing cause of the nutrient problem. (TMDL for the Jemez River Watershed, 2016)

**Land Use**

**Prehistoric and Historic Land Uses of the Caldera.** People have used the Valles Caldera and much of the surrounding Forest Service land, for a variety of purposes and in a variety of ways for thousands of years, as far back as the end of the Pleistocene epoch, about 12,000 years ago. Although the Jemez Mountains are one of the most intensively surveyed landscapes in North America and possibly the world, the Valles Caldera, privately owned until July 2000, remains a relatively blank spot on its archaeological map. Recent work commissioned by the Valles Caldera Trust and later the Park Service, however, is beginning to enlarge our knowledge of the caldera's human past. Recent learning has shown that the Preserve's archaeological past appears to be richer and more complex than most area experts had expected. From evidence of seasonal encampments of large size and great time depth (repeated use over many decades or even centuries), to obsidian "quarries"—areas of tool use and manufacture—that are kilometers long and wide, to dense concentrations of "field houses" at the extreme upper limit of agricultural potential, the caldera offers a wealth of opportunity for improving our collective understanding of the region's distant past. (Valles Caldera Trust, 2003) With this abundance comes a great responsibility. The caldera's status as private land protected its archaeological resources from surface disturbance and collection. In few other places does one encounter so many important archaeological sites with their integrity so well preserved. Many of these sites have yet to be recorded, let alone evaluated.

The numerous archeological sites in the caldera provide evidence of thousands of years of human use of this landscape for hunting and gathering, seasonal habitation, and ceremonial pilgrimage. For millennia peoples were drawn to the caldera for its abundant high-quality volcanic glass called obsidian. It was used by prehistoric peoples as far away as eastern Nebraska, northern North Dakota, southern Texas, and western Mississippi.

**Traditional Cultural Landscapes and Tribal Connections.** The Valles Caldera, and the domes and peaks along its rim and within it, is of spiritual and ceremonial importance to numerous American Indian peoples in the greater Southwest region. Among these features, Redondo Peak (11,254 feet) is the highest point within the caldera and has served as a regionally significant geographic and cultural focal point and a pivotal sacred place for numerous tribal groups. These cultural connections are both contemporary and of great antiquity, and Valles Caldera continues to be part of the practices, beliefs, identity, and history of tribes and pueblos. This landscape is cherished by other communities as well and holds a special place in the heritage of regional peoples.

The land use history of the Valles Caldera National Preserve extends back in time thousands of years. Given the great length of time involved and the many culturally diverse communities—Native American, Hispanic, and Anglo-American—that have interacted with this place, it is not surprising that this history evidences tremendous technological and organizational variability in how people have used and constructed affiliations with the VCNP. Nonetheless, throughout this long history, the VCNP was, and continues to be, peripheral to major centers of residential settlement and areas of intensive economic land use.

The archaeological record is a principal medium for tracing the human occupation of the Valles Caldera before the arrival of European explorers in 1540 and the subsequent establishment of the Spanish colony in 1598. Using artifacts and other durable material traces that survive the ravages of time (e.g., obsidian debitage, chipped stone tools, charred botanical materials, a few fragments of animal bone, and the remnants of stone fieldhouses), archaeologists have constructed a history of land use by Archaic period hunters and gatherers (5500 B.C.–A.D. 600) and pre-Columbian Pueblo Indians (A.D. 600–1600), who are among the forebears of the people of the Pueblo of Jémez and the other Pueblo communities. (Anschuetz & Merlan, 2007)

Native Americans have used the Valles Caldera since time immemorial for hunting; gathering medicinal plants, wild grains, and other vegetal foodstuffs; and for the collection of useful materials such as obsidian. Human use of the caldera grew still more intensive with the introduction of domestic livestock to the region. Without exception, the pueblos of northern New Mexico took up raising sheep, goats, and cattle and made tending and use of those animals an integral part of their economies. The raising of domestic livestock, meanwhile, became even more central to Hispanic communities in the region, whose ranching traditions are probably the oldest, and possibly the most deeply felt, in America north of Mexico. These traditions contribute to the distinctive culture of northern New Mexico.

Historic structures and features on the landscape recall the caldera's use since before the 1800s for sheepherding and then cattle grazing, timber harvest, and other activities.

The powerful ties of the Hispanic villagers of the region both to the culture of ranching and to the lands of the caldera are a major reason the Valles Caldera Preservation Act instructed the Valles Caldera Trust to operate the preserve as a "working ranch." The Park Service still continues some grazing today.

**Twentieth-Century Uses**. Sheep and cattle grazing dominated the use of the caldera during the past century (under Frank Bond and Pat Dunigan), but they were by no means the only uses. Commercial logging operations gained strength after 1935, when a new road provided improved access to the Baca Location. These operations continued with growing intensity until 1972 and left a heavy imprint on the forests, soils, and watercourses of the preserve. A moderate amount of timber harvesting continued under Dunigan ownership until the family sold the property to the federal government in 2000.

The first well intended to assess the potential of the caldera for production of geothermal energy production was sunk in 1959, and since then approximately 40 wells have been drilled into the rocks and fluid reservoirs miles beneath the surface of the land. Half of these wells were drilled beginning in 1973 in an effort led by Union Oil Company, later in partnership with the Department of Energy and Public Service Company of New Mexico, to develop a geothermal plant generating at least 50 megawatts of electricity. By 1984, however, the caldera's resource was determined to be capable of supporting only a 20-megawatt generating station, and the project was terminated. Today the leveled and cleared drill pads that mark the location of the geothermal wells remain conspicuous features of Redondo and Sulphur canyons.

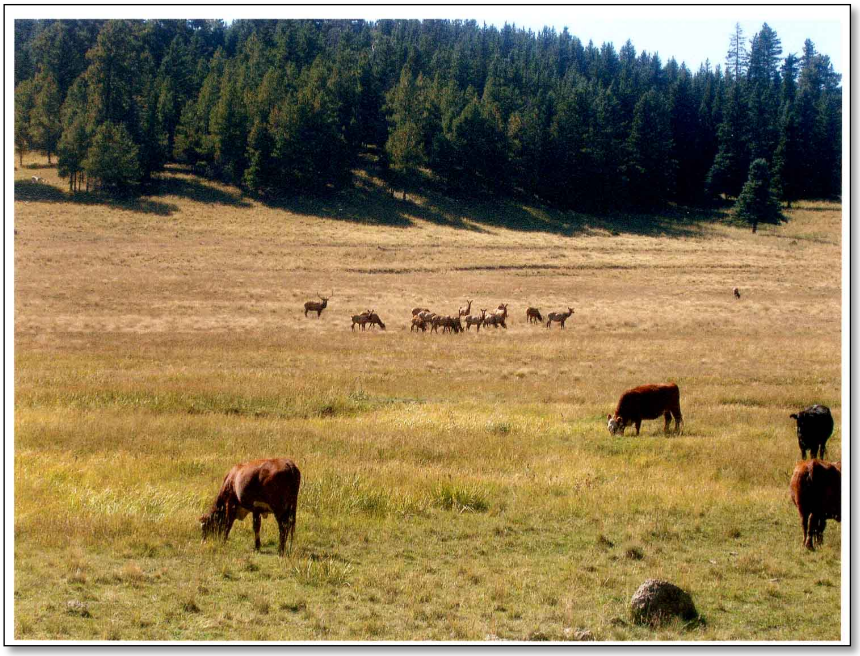


*Figure 11. Elk and Cattle grazing in the Valle Grande. (Photo courtesy of Valles Caldera Trust.)*

Other man-made features of the landscape include gravel pits, scattered through the preserve, that yielded materials for road construction within the Baca Location, and a pipeline that crosses the preserve by way of the Valles San Antonio, Toledo, and Los Posos, bringing natural gas to Los Alamos from the San Juan Basin of northwestern New Mexico.

As the elk population throughout the Jemez Mountains increased in the last decades of the twentieth century, the Dunigan family developed a vigorous and well-known trophy elk hunting program, for which they built an eight-bedroom hunting lodge a mile north of the Baca Ranch headquarters. They also successfully attracted the interest of filmmakers and advertisers, who set their stories and products amid the stunning scenery of the caldera. Today three significant movie sets remain within the caldera, one of which was used in the production of the motion picture *The Missing* in March 2003.

**The Valles Caldera National Preserve**

The Valles Caldera National Preserve was first established in 2000 as an unprecedented national experiment in public land management through which the U.S. Congress sought to evaluate the efficiency, economy, and effectiveness of decentralized public land management. The 15-year experiment continues to contribute to the national dialogue on the role of protected areas for long-term economic and environmental sustainability and innovative approaches to place-based and science-based adaptive management.

The Valles Caldera National Preserve was established as a unit of the Park Service when the enabling legislation adopted by Congress was signed into law on December 19, 2014. The purpose statement lays the foundation for understanding what is most important about the preserve. *Located in the Jemez Mountains of north-central New Mexico Valles Caldera National Preserve protects, preserves, and restores ecosystems and cultural landscapes within an outstanding example of a volcanic caldera for the purpose of education, scientific research, public enjoyment and use, and cultural continuity.*

The following significance statements have been identified for the VCNP by the Park Service.

- ❖ Valles Caldera possesses exceptional value in illustrating and interpreting massive explosive volcanic eruptions, caldera formation, and the functioning of active geothermal systems. Valles Caldera is one of the world's best examples of an intact volcanic caldera and is considered the worldwide "type locality" for caldera resurgence.
- ❖ Valles Caldera is a place where one can directly experience pre-agricultural heritage and reflect on inconspicuous cultural landscapes where hunting and gathering were practiced successfully for more than 10,000 years. Past peoples across the continent were drawn to Valles Caldera to utilize its rich geologic deposits of high quality obsidian for tools and weapons, making this location one of the most significant cultural obsidian sources in North America. To this day, the caldera is used by local pueblo and tribal peoples and is cherished by more than two dozen American Indian groups.
- ❖ The land use history of Valles Caldera encapsulates the story of early Spanish and Mexican settlement across the present-day American Southwest and the socio-political shifts that occurred when the territory was annexed by the United States at the end of the Mexican-American War in 1848. Previously known as Baca Location No. 1, Valles Caldera exemplifies the legacy of how the establishment, utilization, and changing ownership of Spanish and Mexican land grants transformed the Southwest.
- ❖ Valles Caldera's unusual setting—high elevation, caldera topography, unfragmented habitats, and key hydrologic role at the top of the watershed—presents a dynamic learning landscape for the scientific study and restoration of ecosystem processes that are recovering from three centuries of human disturbances and challenged by contemporary and future climate change.
- ❖ Valles Caldera's distinct topographic mosaic of expansive valley meadows, lush forested volcanic domes, meandering valley streams, and old growth Ponderosa pine groves are in striking contrast to the arid New Mexico landscapes at lower elevations.

The 2014 enabling legislation for Valles Caldera National Preserve provides direction concerning administration and general management, visitor access and other uses, ecological restoration, development of a science and education program, hunting and fishing opportunities, livestock grazing, tribal access to traditional cultural and religious sites, and protection of volcanic domes and other peaks in the preserve. These directives can be summarized as follows:

- Establish a science and education program that includes research and interpretation, supports ecological restoration and science-based adaptive management, and promotes outdoor educational experiences; may establish a science and education center in Jemez Springs, New Mexico;
- Continue livestock grazing to the extent that use furthers scientific research or interpretation of the ranching history of the preserve;
- Permit hunting, fishing, and trapping in accordance with applicable federal and state laws;
- Undertake restoration activities to improve the health of forest, grassland, and riparian areas;
- Place certain limits on the construction of roads and buildings and motorized access on the tops of volcanic domes and other peaks;
- Ensure the protection of traditional cultural and religious sites in the preserve and provide access to such sites by members of Indian tribes or pueblos for traditional cultural and customary uses.

**Threatened and Endangered Species–Vegetation and Wildlife**

The Jemez Watershed contains several unique species including Giant helleborine (*Epipactis gigantea)*, Bunchberry dogwood (*Cornus canadensis)* and Bog birch (*Betula glandulosa*). Sapello Canyon larkspur is the only sensitive plant species recorded within the Jemez Watershed. This is a New Mexico endemic found only at high elevations in the Jemez, Sangre de Cristo, and Sandia Mountains, and is listed by Natural Heritage New Mexico (NHNM) as a "Species of Concern." (NHNM, 2017) Bog birch, although a somewhat common species at higher latitudes of the U.S. and Canada is restricted in New Mexico to the Alamo Canyon wetland complex on the west side of VCNP.

Currently there are a few non-native plants on VCNP deemed noxious in the state of New Mexico. The Preserve has a program to eradicate these plants: Canada thistle (*Cirsium arvense),* Bull thistle (*Cirsium vulgare),* Musk thistle (*Carduus Nutans*), and Oxeye daisy *(Leucanthemum vulgare).* (VCNP, 2018)

*Table 5 is a list of state and federally threatened and endangered animal species in Sandoval County. Note that this list covers the entire county rather than just VCNP.*

(BISON-M, 2017) **Threatened and Endangered Species in Sandoval County, NM**

| **Common Name** | **Scientific Name** | **Status** |
|---|---|---|
| **Mammals** | | |
| Spotted bat | *Euderma maculatum* | State NM: Threatened |
| Pacific marten | *Martes caurina* | State NM: Threatened |
| Meadow jumping mouse | *Zapus hudsonius luteus* | Federal: Endangered<br>State NM: Endangered |
| **Birds** | | |
| Brown pelican | *Pelecanus occidentalis* | State NM: Endangered |
| Common black hawk | *Buteogallus anthracinus* | State NM: Threatened |
| Bald eagle | *Haliaeetus leucocephalus* | State NM: Threatened |
| Peregrine falcon | *Falco peregrinus* | State NM: Threatened |
| Arctic peregrine falcon | *Falco peregrinus tundrius* | State NM: Threatened |
| Neotropic cormorant | *Phalacrocorax brasilianus* | State NM: Threatened |
| Yellow-billed cuckoo (western population) | *Coccyzus americana occidentalis* | Federal: Threatened |
| Mexican spotted owl | *Strix occidentalis lucida* | Federal: Threatened |
| Broad-billed hummingbird | *Cynanthus latirostria* | State NM: Threatened |
| Costa's hummingbird | *Calypte costae* | State NM: Threatened |
| Violet-crowned hummingbird | *Amazilia violiceps* | State NM: Threatened |
| Southwestern willow flycatcher | *Empidonax traillii extimus* | Federal: Endangered<br>State NM: Endangered |
| Gray vireo | *Vireo vicinior* | State NM: Threatened |
| Baird's sparrow | *Ammodramus bairdii* | State NM: Threatened |
| **Fish** | | |
| Rio Grande silvery minnow | *Hybognathus amarus* | Federal: Endangered<br>State NM: Endangered |
| **Amphibians and Mollusks** | | |

| | | |
|---|---|---|
| Jemez Mountains Salamander | *Plethedon neomexicanus* | Federal: Endangered<br>State NM: Endangered |
| Wrinkled marshsnail | *Stagnicola caperata* | State NM: Endangered |

In addition to currently threatened and endangered species, several fish and wildlife species have been extirpated from their range in the Jemez Mountains or had their range significantly reduced over the last century. Extirpated species include Mexican gray wolf (*Canis lupus baileyi*), Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), Northern leopard frog (*Lithobates pipiens*), and American beaver (*Castor canadensis*). (Valles Caldera Trust, 2010)

## Wetland Inventory

The USFWS definition is: "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water."

**Wetland Mapping and Classification**

Deepwater Habitats Classifications are used for the National Wetland Inventory (NWI), which classifies wetlands by system. (Cowardin et al., 1979) Three systems are present in the Jemez Mountains area:

• The Riverine System includes deepwater habitats and mostly non-vegetated wetlands that are contained in natural or artificial channels. Either periodically or continuously, these channels contain flowing water that forms a connecting link between two bodies of standing water. Examples of the riverine systems include rivers, streams, creeks, arroyos, washes, or ditches.

• The Lacustrine System includes both wetlands and deepwater habitats. This system is defined by all the following characteristics: deep water that is situated in a topographic depression or in a dammed river channel; wetland areas lacking trees, shrubs, or persistent emergent vegetation; wetland areas consisting of emergent mosses or lichens with greater than 30 percent aerial coverage; wetland areas that exceed 20 acres; or wetland areas that total less than 8 hectares and, at low water, are deeper than 6.6 meters. Examples of these wetlands include lakes, reservoirs, or intermittent lakes, such as playa lakes.

• The Palustrine System includes all non-tidal wetlands that are dominated by trees, shrubs, emergents, mosses or lichens, and by all wetlands that occur in tidal areas where salinity due to ocean-derived salt is below 0.5 ppt. An estimated 95 percent of all wetlands in the U.S. are freshwater, palustrine wetlands. As a result, these wetlands will predominate in most wetland mapping efforts. No subsystems exist in the (P) Palustrine System. Examples of Palustrine wetlands found in the New Mexico project area include marshes, swamps, shoreline fringe, bogs, fens, or ponds.

In addition to the NWI system, other systems of wetlands classifications are commonly used to distinguish various types and characteristics between wetland resources. The SWQB Wetlands Program uses Brinson's Hydrogeomorphic (HGM) wetland classification (Brinson, 1993) for the Wetlands Action Plan process, because this classification system is the easiest to understand. The HGM classification system, based on geomorphic settings, water sources, and hydrodynamics, results in six wetlands classifications based on these three essential functions. (NMED, 2016)

**Slope wetlands** are normally found where there is a discharge of groundwater to the surface of the land. Elevation gradients may range from steep hillsides to gentle slopes. Principal water sources are usually from the return flow of groundwater, interflow from surrounding uplands, and precipitation. If groundwater discharge is a dominant water source, slope wetlands can occur in nearly flat landscapes.

Slope wetlands lose water primarily by saturation of the subsurface, through surface flows, and by evaporation. Springs are an example of slope wetlands in New Mexico. Slope wetlands are the most prevalent wetlands in the Jemez Mountains and in the EFJR.

NMED updated the National Wetland Inventory for the Jemez Mountains as part of ongoing efforts that will eventually provide updates for the entire state excluding tribal lands. Previous wetland mapping in New Mexico was sparse and dated. NMED contracted with GeoSpatial Services of Saint Mary's University of Minnesota to complete the Geographic Information System (GIS)-based mapping. A report entitled *Mapping and Classification of Wetlands in the Jemez Mountains, New Mexico* includes updated mapping and classification for VCNP. (Stark et al., 2016)

Wetlands for the project area were mapped and classified using on-screen digitizing methods established in GIS. Aerial imagery, combined with soils, topographic, hydrologic, and land cover data sets, was used as a basemap (Stark et al., 2016), the mapping performed by Saint Mary's University is consistent with the Wetlands and Deepwater Habitats Classification used for the National Wetland Inventory (NWI), which classifies wetlands by system. (Cowardin et al., 1979)

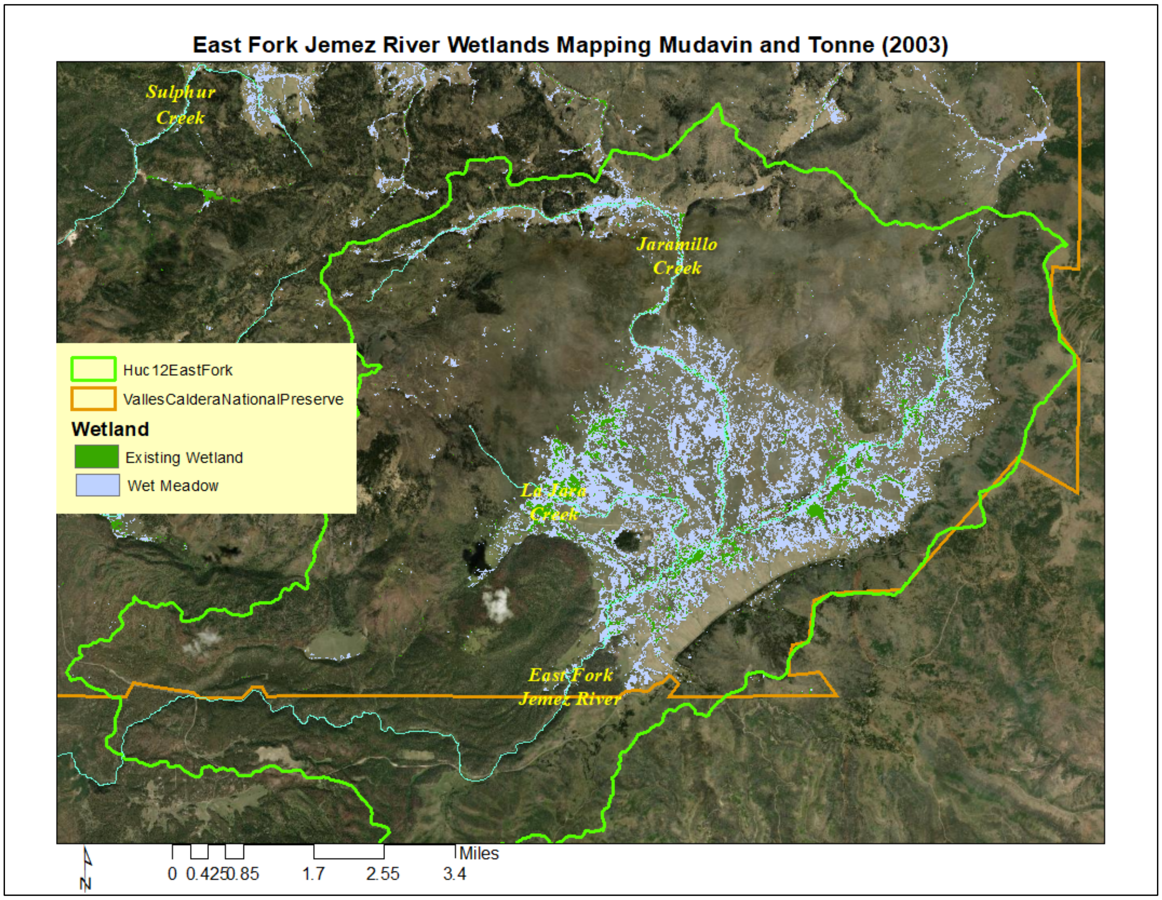



*Figure 12. EFJR Wetlands Map 2003.*

## Wetland Functional Assessment

Keystone Restoration Ecology (KRE) assessed 400 acres of wetland, wet meadow, and degraded wetlands downhill from Highway 4. This work was performed with an ArcGIS collector app, which allows for different basemaps for the same area. In the field, they were able to access the 1935 aerial photo, 1M contour lines, 200 pixel flowlines (EARTh™ model), and aerial ortho-photos. One hundred and fifty GPS points were taken during the assessment of different proposed restoration techniques.

The project area is fed by many small springs or seeps flowing out of the surrounding hillsides. The area has suffered from severe erosion in the past, leading to many large headcuts and deep gullies. These gullies have lowered the water table, which drains the surrounding slope wetlands and changes the vegetation to upland plant communities. KRE has developed a number of techniques and LIDAR GIS derivatives to assess erosion and restoration at a large scale (Erosion Analysis and Restoration Techniques). One of these involves the use of LIDAR hillshade, where a 1m pixel digital elevation model is used to create a false color hillshade so it appears to be 3-dimensional from above. On top of this hillshade, they have drawn "flowlines," which are modeled to begin at the outlet of 200 $m^2$ of micro watersheds. The colors in the map below show different sizes of watersheds in square meters. These lines allow us to locate fine-scale details of swales on the landscape where water can be diverted out of gullies back into sheet flow on former wetland surfaces without returning to the gully immediately. These lines act as a "fact check" for elevations that can be difficult to see in the field.

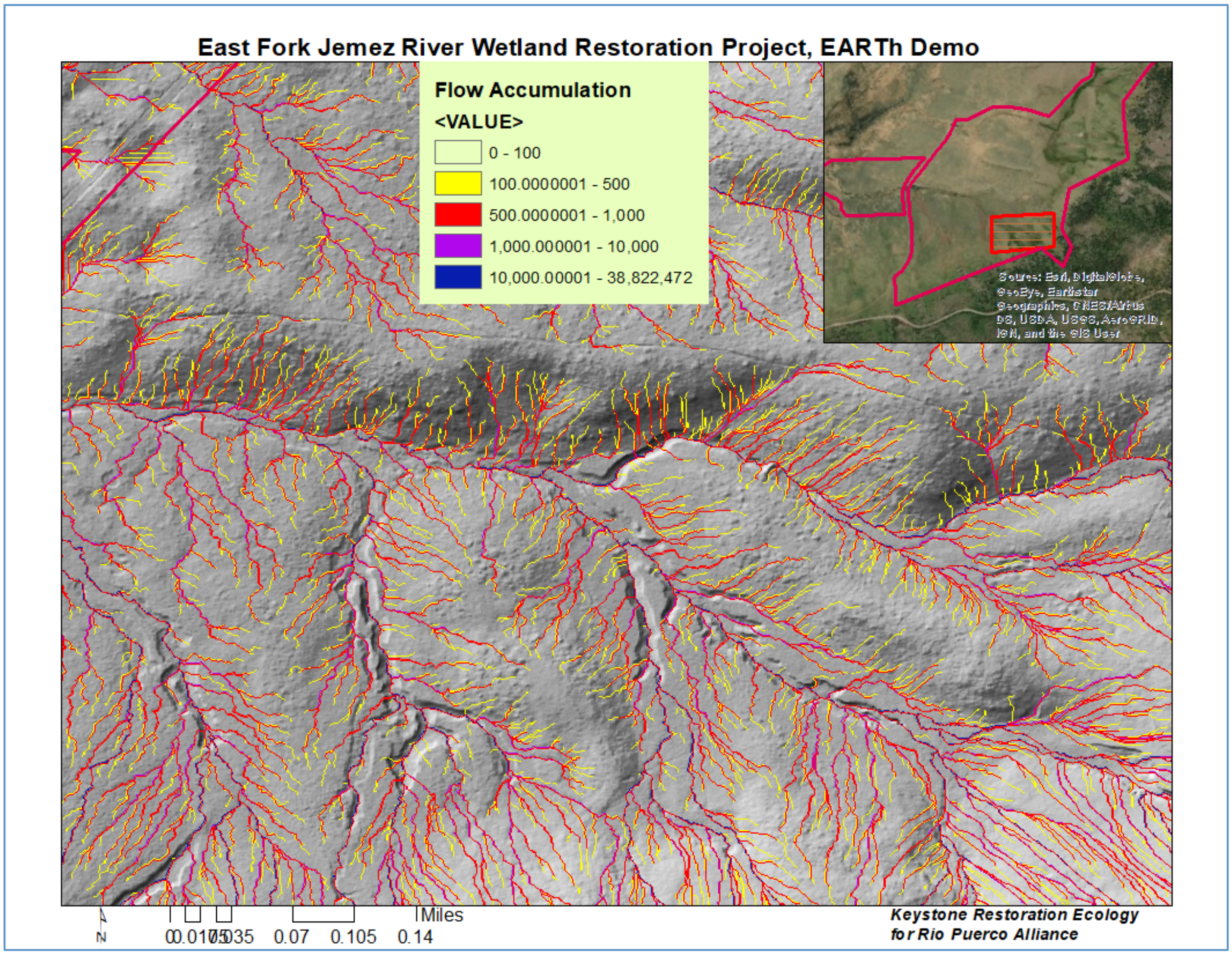
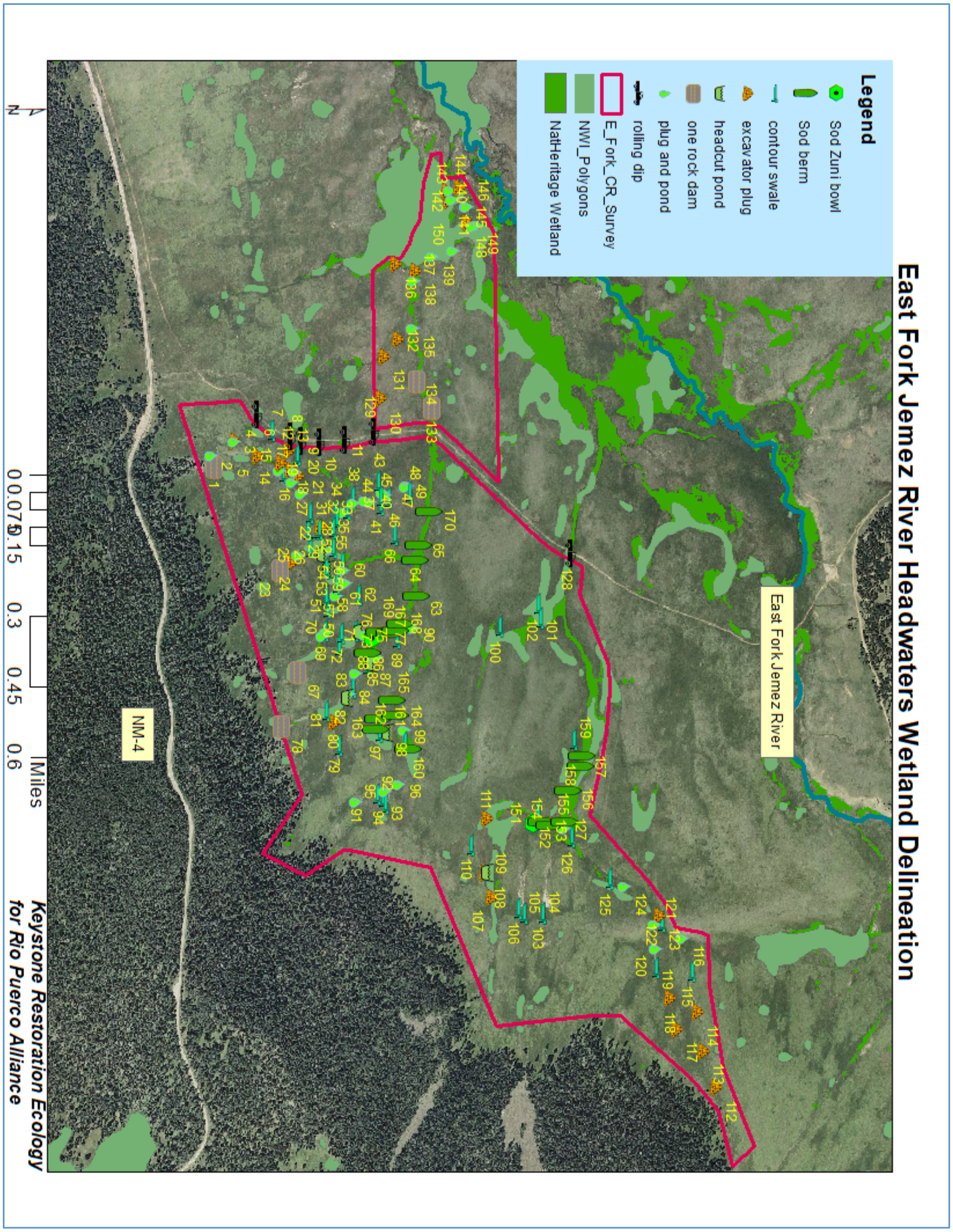



*Figure 13. EFJR EARThDemo. A close-up of some of the most eroded wetlands in the project area; see inset map for location. The gullies are 3-5 feet deep, and some headcuts are actively moving uphill into healthy, un-gullied wetlands.*

The 1,200-acre East Fork Jemez River demonstration project area has several spring-fed slope wetland areas. Vegetation in these areas, specifically Tufted Hairgrass (*Deschampsia cespitosa*), a facultative wetland (FACW) indicator species, suggests that wetlands were formerly more abundant. The project, while not yet complete, has already re-wet at least 30 acres of wetlands by constructing innovative treatments that redistribute runoff.

The design and installation of this project will increase the quantity and ecological functioning of wetlands, thereby helping mitigate effects of climate change in the watershed. These impacts have partially drained the wetlands, reducing their size and quality.




Continued drying and loss of the headwater wetlands results in diminished watershed health overall. Loss of headwater slope wetlands has negative downstream effects including increased erosion, sedimentation, fragmented wildlife habitat, loss of riverine wetlands/riparian vegetation, encroachment of upland vegetation, reduced base flows, increased nutrient loading, and warmer stream temperatures. Restoring headwater wetlands has significant positive downstream effects that buffer climate change by increasing the quality and quantity of downstream riverine wetlands, reducing stream sediment, nutrient loading, and temperature, supporting wildlife habitat, and regulating and increasing stream base flows. (QAPP)

## Wetland Threats and Impairments

**Livestock Grazing**

The EFJR valley is mostly montane grassland and easily damaged by misuse. Due to past grazing practices large portions of the uplands are drying out and soils are eroding. Sediment input from bank and upland erosion, exacerbated by poor road design, construction, and maintenance, has greatly diminished pool volume in the EFJR. The amount of fine sediment input from the erosion has begun to fill in much of the pool habitat. A little less than half of the river was meadow habitat, approximately nine miles. Due to past grazing practices, the side channels have been converted to dry sites due to channel degradation and loss of meadows. (Santa Fe National Forest, 2002) In the non-meadow high gradient mountain reaches, large woody debris is a large component in the development of side channels. When large woody debris jams are created in high gradient streams, the water is forced around these debris jams, often creating side channel habitat.

In the Valle Grande, there is a lack of quality stream habitat. The riffles continue for the majority of the length across the valley. These long riffles were broken at features such as side channels or tributaries for ease of estimating substrates, unstable banks, and widths. Valle Grande is truly a nine-mile long riffle with a few pools. The riffles throughout the entire river are dominated by a fine substrate. The amount of fine substrate is largely due to the delivery of fines from the Valles Caldera. Lack of pools means limited over-wintering habitat for fish and decreased thermal protection. Extensive damage caused by past grazing practices will continue to impact the wetlands until adequately addressed.

The introduction of non-native species in riparian areas has become a concern especially along the Lower Jemez River. Salt cedar, Siberian Elm, Russian olive, bull thistle, and musk thistle have been documented in riparian areas along the Jemez River, and thistle imported with cattle are a concern in this watershed. Once non-native species are introduced, they tend to out compete native plants and quickly take over an area. Loss of native vegetation can have devastating effects on wildlife species dependent upon specific plants. The non-native species also alter the effects of fire on riparian areas, as they tend to burn at higher intensities. (JNRA, 1997)

According to historical data, the grasslands within Valles Caldera National Preserve had a historical fire return interval of 3-12 years. (Falk, et al., 2011) Therefore, to mimic natural fire behavior to improve grassland health and forage quality for both wildlife and livestock, the NPS will seek to rest and burn the Preserve's grazing areas every ten years, during which time grazing will be suspended.

Beginning in 2021, NPS officials planned to rest the grazing areas and conduct prescribed burns in 2022. Because the park was not able to find a suitable window to conduct its prescribed burn in spring 2022, the park will seek to find a new burn window in spring 2023. If successful, the park will resume its grazing program during summer 2024 with applications for the two-year special use permit being requested in summer 2023. The NPS closely monitors the Preserve's grasslands to prevent overgrazing, and if conditions become too dry, the livestock program may be delayed or cancelled for the year.

Under NPS management, cattle numbers have been greatly reduced. However, past grazing management practices have degraded some areas of this watershed. The streams have erosion issues, not enough pools, and are too wide and shallow in places. Specifically, in the EFJR sub-watershed livestock and elk created countless trails that have captured water and funneled it directly down the path, eventually creating V-shaped gullies. These gullies are the demonstration sites for the already completed contour swales, sod bowls, and sod berms.

**Roads**

Roads are a huge barrier to natural movement of surface and subsurface water. Compaction by the roadway tends to force subsurface water to the surface, and roadway drainage features gather the increased surface flows to single point discharge sites. The result is drying out any down slope wetlands and erosion of new and natural drainage channels. This is particularly true with paved roads.

The VCNP is accessed by State Highway 4 and a system of National Forest and National Park Service roads. Highway 4 is critical access road from Albuquerque to Los Alamos. Highway 4 parallels the southern edge of the Valle Grande and the East Fork watershed with the western portion lying on the upper slope of montane grassland before moving into a forest environment in the eastern section. Highway 4 is a secondary highway, with the section across the VCNP meeting primary highway standards, meaning a "heavier and wider footprint" relative to the ecology of adjacent areas.

The roadway's impervious surface configuration (crowned, inslope or outslope) tends to concentrate surface flow to a common low point through ditches and gutters. On the upslope, small side drainages are captured and funneled to a common low point. Increased surface flow generally carries a greater amount of sediment to drainage structures.

Cross roadway drainage structures are expensive so the "fewer, the better" is the general design with little or no consideration given to what happens when flow leaves the outlet. While the outlet is normally in a natural channel, the concentrated flow erodes the channel; headcutting develops, side channels form, channels deepen, and any wetlands below the road begin drying out.

This activity is evident at many sites below the highway all through the Valle Grande. The greater water flows have eroded the channel, generally leading to eroded side channels and drying slope wetlands and sediment to the EFJR. KRE has completed some restoration on these sites under previous grants and a primary focus of the EFJR Wetlands project is to use these developed innovative treatments to demonstrate restoration on the EFJR headwaters.

The Baca Ranch headquarters was built on the northeast end of the Valle Grande on La Jara Creek because it was the best source of domestic water; potable and usable for irrigation of small pastures. Wagon trails through Vallecitos de los Indios, El Cajete, and South Mountain were probably the first access from the south but traces of old wagon trails near the present VC01 show probability of that location also. The present location is the shortest, driest and, with the equipment available in the early 20$^{th}$ century, the easiest route to build. Southeasterly slope winter sun exposure there also gave the earliest drying out for access than through other locations.

The VCNP is also served by a system of low-standard primary, secondary, and tertiary roads, the latter of which are project roads mostly built for logging.

Primary roads such a VC01 and VC02 were built for access to the ranchlands and are now considered low standard and built with little thought about drainage needs or about the effects on adjacent wetlands. As need arose, a culvert was placed in a wet area or washout, boggy areas were filled over and hardened and later widened for logging and cattle trucks.

Unfortunately VC01 to the crossing of the EFJR and just beyond was excavated on a bias to the contours, funneling water from upslope to roadway borrow ditches and concentrating flow to inadequately spaced dips and “getaway ditches.” Roadways were generally flat or out-sloped and often became the waterway. The result was muddy, eroding road surfaces, boggy areas with drying lower slope wetlands and eroding ditches. This condition can be contrasted somewhat with the location from the Staging Area to the Headquarters, which was built on contour.

VC03 was built mostly on contour along the northerly edge of the Valle Grande cutting through the rather dryer south facing lower reaches of the Jaramillo Creek watershed. Roadway excavation developed many small, perched meadows above the road and concentrated water flow onto the rather fragile wetland causing eroding drainage channels.

VC0401 was very poorly designed and cuts through, on a bias to the contours, the sensitive sloped wetland and riverine environment of the EFJR headwaters. Grades were too steep, culverts were too few and too small, maintenance inadequate and, during spring snowmelt and the monsoons, it became the channel and was boggy from end to end. KRE did some work on the road drainage under the EFJR demonstration project.

Poorly designed and constructed low-standard roads, with little or no culvert or other drainage structures, and poor maintenance, have led to poor distribution of runoff onto the wet meadows. Specifically, the EFJR sub-watershed has numerous gullies that are being exacerbated by erosion from trails created by livestock walking up and down the drainage channels. These trails captured water and funneled it directly down the channel, creating V-shaped gullies. These gullies are some of the demonstration sites for the contour swales, sod bowls, and sod berms.

Poorly maintained roads have contributed significantly to sedimentation and have degraded fish habitat. The increased fine stream sediment concentrations that result from poorly constructed and badly maintained roads has been associated with decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes.

The Jaramillo/East Fork Jemez River watershed road system was poorly designed, very difficult to adequately maintain and adds significant sediment to the streams. Major improvements to the drainage facilities of the road system would need to be undertaken to restore the watershed wetlands to pre-road ecology. In the past few years, the Valles Caldera Trust and the VCNP have begun to repair the main roads throughout the Preserve and restore habitat for riparian areas along main roads. Most of the major stream crossings have been improved under the direction of Mr. Bill Zeedyk to maintain the proper channel elevations, dimensions, and floodplain access. New culvert arrays were installed to provide sufficient flood capacity and to distribute large flows across the floodplain. In other places, rolling dips and other environmentally sensitive road drain applications have been installed to hydraulically isolate the roads from the natural drainages, allowing hillslope and swale runoff to continue along its natural historic route instead of being concentrated in road ditches and culverts. (Crane, 2023)

## Actions to Protect and Restore Wetlands

**Past Wetland and Riparian Restoration Projects:**

Los Amigos de Valles Caldera, Keystone Restoration Ecology, and the Rio Puerco Alliance have done several wetland restoration projects in the area of the East Fork in recent years. All were successful:

**Restoration of Slope Wetlands from Wildfire in the Valle Grande of the Valles Caldera National Preserve,** funded through the Wildlife Conservation Society. 2016-2018: $170,000.

**Restoring La Jara Creek from Damage from the Thompson Ridge Fire**, Valles Caldera National Preserve. Funded by NMED. 2016-2019: $160,000.

**Jaramillo Creek Wetland and Stream Restoration,** funded by the River Stewardship Program, NMED. 2021-2023.

RPA is currently working on **East Fork Jemez River Innovative Wetland Restoration Project Using Contour Swales, Sod Bowls and Sod Berms (EFJR),** CWA Section 104(b)(3) Wetlands Program Development Grant. 2018-2022: $191,490.

*Figure 15. Looking Northeast from Hwy 4 at EFJR slope wetland restoration project implemented in 2019. A series of plug in ponds, contour swales and sod berms slowly releases monsoonal rainfall to the wetland area. (Photo courtesy of Steve Vrooman.)*

**Land Stewardship Plan**

VCNP wrote a June 2014, Landscape Restoration & Stewardship Plan – Final Environmental Impact Statement in order to satisfy National Environmental Policy Act requirements for a broad spectrum of future restoration activities (VCNP, 2015). For riparian and wetland restoration, the plan includes the following:

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

- *Restoring streambanks and channels to address site-specific erosion.*
- *Planting trees and shrubs.*

• *Placing of rock or log and fabric dams, or using Zuni bowl techniques to protect and restore wetlands and mitigate ongoing erosion.*

- *Removing road and water control features to restore wetlands.*
- *Repairing or decommissioning earthen tanks and dams.*
- *Installing weirs or channel modifications to slow the development or reduce the consequences of meander cutoffs.*

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

NMED, KRE, and the Rio Puerco Alliance were able to get additional funding for work in Jaramillo and the East Fork in 2018.

*Figure 16. Looking North from Hwy 4 a series of plug and pond structures treats gully cutting through EFJR tributary slope wetland. (Photo courtesy of Steve Vrooman.)*

**Specific Wetland Restoration Actions for East Fork**

The East Fork Jemez River Wetland restoration project is administered by New Mexico Environment Department's SWQB Wetland Program and funded through the EPA's Wetlands Program Development Grant. The grant deliverables include the restoration of 400 acres of montane grasslands using wetland techniques that have been developed on the Preserve. The Rio Puerco Alliance is partnering with Keystone Restoration Ecology to assess and implement wetland restoration. A variety of techniques refined at the Valles Caldera National Preserve for wetland restoration are being used in this project including plug and ponds, sod berms, contour and diversion swales, sod bowls as well as other techniques.

**Overview.** The project area includes about 400 acres of north facing montane grassland in the Valles Caldera National Preserve of the U.S. National Park Service. The landscape is a series of Calderas created by multiple volcanic eruptions over millions of years, with the valleys at an elevation of about 8,600 feet and the mountain "rim" at about 10,000 foot elevation. We are working on the southern rim of the Valle Grande, the largest and most visible montane "Valle" on the Preserve.

*Figure 17. Westernmost tributary slope wetland treated in the EFJR restoration project with plug and pond, swales and one-rock dams. Large pond in left of picture created by road, which bisects the tributary before flow reaches the EFJR channel. (Photo courtesy of Steve Vrooman.)*

Slope wetlands are features created where there is a discharge of groundwater to a sloping land surface. They are typically incapable of water storage due to the slope contours of the landscape. The slope wetlands in the Valles Caldera appear to be expressed at a similar elevation contour along the entire project area. We believe that this may be due to an impermeable clay layer deposited by one of the large lakes created millions of years ago during the formation of the Caldera. This clay layer forces groundwater being carried in colluvial material to the surface, creating slope wetlands across many of the hillslopes. Elevation gradients may range from steep hillsides to gentle slopes. Principal water sources are usually groundwater return flow, interflow from surrounding uplands, and precipitation. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant water source. They lose water primarily by saturation subsurface and surface flows and by evaporation. Springs are an example of slope wetlands in New Mexico.

The area has been subject to heavy human uses such as road building, livestock trailing and livestock grazing over the last 150 years. Over 100,000 sheep were once summered on the high elevation meadows of the Valle Grande, causing enormous amounts of erosion due to reduction of vegetation cover. Slope wetlands are very susceptible to erosion due to the steep gradient of the wetland and the ground surface being held in place by wetland vegetation. Once this vegetation is eaten or dried out, it dies off and the land surface can erode very easily.

The goal of this project is to improve slope wetland form and function. Restoration techniques will fill gullied channels, raise the water table, arrest head-cutting, and restore 30+ acres of drained wetlands using innovative structures such as contour swales, sod bowls and sod berms. The project will demonstrate the effectiveness of these innovative water-slowing, spreading, and infiltrating structures. Design and implementation information about the new techniques will be shared with multiple agencies, landowners, restoration volunteers, and the public through a series of restoration workshops, guided tours, presentations and the distribution of a Technical Guide and fact sheet. The new techniques will be applicable to gullies in slope wetlands on gentle topographic gradients that have vegetation and soils characteristic of former wetlands. The contour swales, sod bowls and sod berms will work together in series to redirect and slow the flow of water at various locations along the flow path within a degraded channel: 1) upstream of a headcut, 2) at the headcut, and 3) downstream of the headcut. This project will also convene stakeholders to develop a Wetlands Action Plan for the 38,134-acre East Fork Jemez River watershed to guide future monitoring, restoration, management and protection in a coordinated and comprehensive manner.

**Contour swales** will be installed upstream of gully-forming headcuts. Machinery will be used to dig contour swales shaped concave-down, like shallow "frowns" on the slopes above the headcuts. The downslope edges of the contour swales will be deeper than the upslope edges. Stormwater runoff and snow melt will catch on the lower lips of the contour swales, then either infiltrate or be shunted off to the side slopes, thereby changing water flow directions and dissipating erosive energy. Contour swales will route the flow away from headcuts, onto former wetlands that were dewatered by the headcuts. Seepage through the contour swale will flow down the channel where it will then encounter the next innovative structure at the headcut.

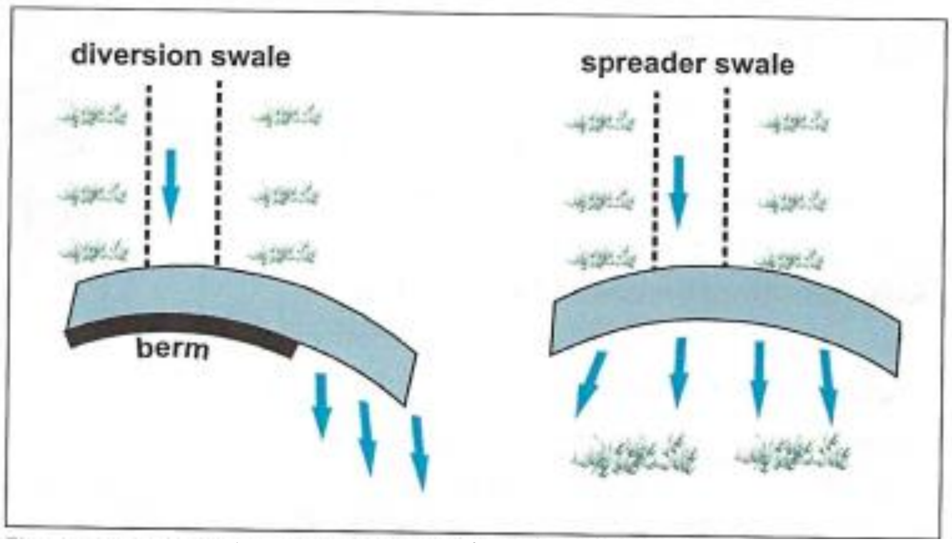



*Figure 18. Contour Swales. (Diagram courtesy of .)*

*Figure 19. A close-up of the plug and pond restoration structures as seen from Hwy 4. (Photo courtesy of Steve Vrooman.)*

**Sod bowls** will be installed as soft, absorbent treatment structures that fill a headcut. Sod containing wetland sedges will be stacked and layered from the base to the top of the headcut, forming the overall shape of a bowl. The sod bowl will fill the former headcut and the sedge roots will bind the sod in place. The layers of sod will create small terraces for the water to descend, each terrace dropping only a couple of inches along the soft, permeable, live sod. The sod bowls will work in concert with the contour swales installed upstream that will route some of the flow away from the gully, reducing the erosive energy of water within the channel.

*Figure 20. Sod Bowl. (Photos courtesy of Steve Vrooman.)*

*Figure 21. Sod Berm.*

**Sod berms** will be installed in series in the gullies downstream of the headcuts. The bottoms of V-shaped gullies will be flattened and smoothed with machinery and sod will be laid across the channel as low-height berms (approximately 3-6 inches high) oriented perpendicular to flow direction. Blocks of wetland sod will be harvested from wet meadows adjacent to the gullies as well as from the contour swales. The sod berms will create small rises at intervals as water moves down slope. The sod berms will provide grade control that slows and infiltrates water, and propagules for local native wetland vegetation to spread. Installation of the sod berms will render the valley form and width more suitable for sedge growth, thereby expanding wetland acreage within the former gullies, and catching sediment by increasing the roughness of the channel bottom. Structure designs will be based on the principles of natural channel design and will adapt and expand on structures developed and used in New Mexico for previous SWQB Wetland Program Development Grants (such as Zuni bowls for headcuts, one rock dams for water-slowing and worm ditches and *media lunas* for water-spreading). These structures are expected to lie gently on the land and become invisible after two or three growing seasons. This is especially appropriate for a high-profile area like the VCNP where people have opportunities to visit nature in a relatively pristine state without much human infrastructure. The structures will also be appropriate for situations where a landowner/land manager has access to machinery and wetland sod but not to other materials nearby. The techniques will also be scalable so they can be constructed with hand tools at smaller sites. Because this is a demonstration project, conceptual designs of the innovative restoration structures are subject to revision and improvement as the project develops.

Based on our discussions with the public (see below), we think that the next specific actions should be fixing the East Fork Jemez River channel cut-off and working above the current project in the Valle Soldades, doing much the same type of restoration we have been doing in the lower East Fork.

**Funding Sources**

We have been successful at receiving funds from the River Stewardship Program and from the Wetlands Program, and would hope that will happen again. We understand that there should be some federal money available soon for restoration and climate change, but we still have no information on that. In the past, Los Amigos was able to get money from Wildlife Conservation Society, so we will try there again.

*Figure 22. Same plug and pond structure from pg 44. The very top of the gully formation can be seen here. Darker lines are contour swales diverting water flow away from the headcut and spreading water to surrounding areas, sub-irrigating vegetation and reducing erosional forces. (Photo courtesy of Steve Vrooman.)*

## Public Involvement

We held a Stakeholders Meeting October 7, 2021 at the Preserve. With our contractor Keystone Restoration Ecology, we had 18 people, from RPA, Jemez Pueblo, Los Alamos National Laboratory (LANL), Trout Unlimited, New Mexico Trout, NMED, and Los Amigos de Valles Caldera. See the Sign in Sheet.

We went to three areas on the Preserve:

- The East Fork Headwaters in the Soldades area.
- East Fork Jemez River channel cut-off, near Hwy 4.
- The area south of VC02 road and downstream of La Jara Creek.

At each spot, we stopped and Steve Vrooman from KRE discussed the issues with the East Fork, our project on the East Fork, and invited comment from our attendees.

*Figure 23. Steve showing aerial pictures of the East Fork, current ones and those in 1935. (Photo courtesy of Jen Vrooman.)*

*Figure 24. Group discussing the presentation at VC02. (Photo courtesy of Jen Vrooman.)*

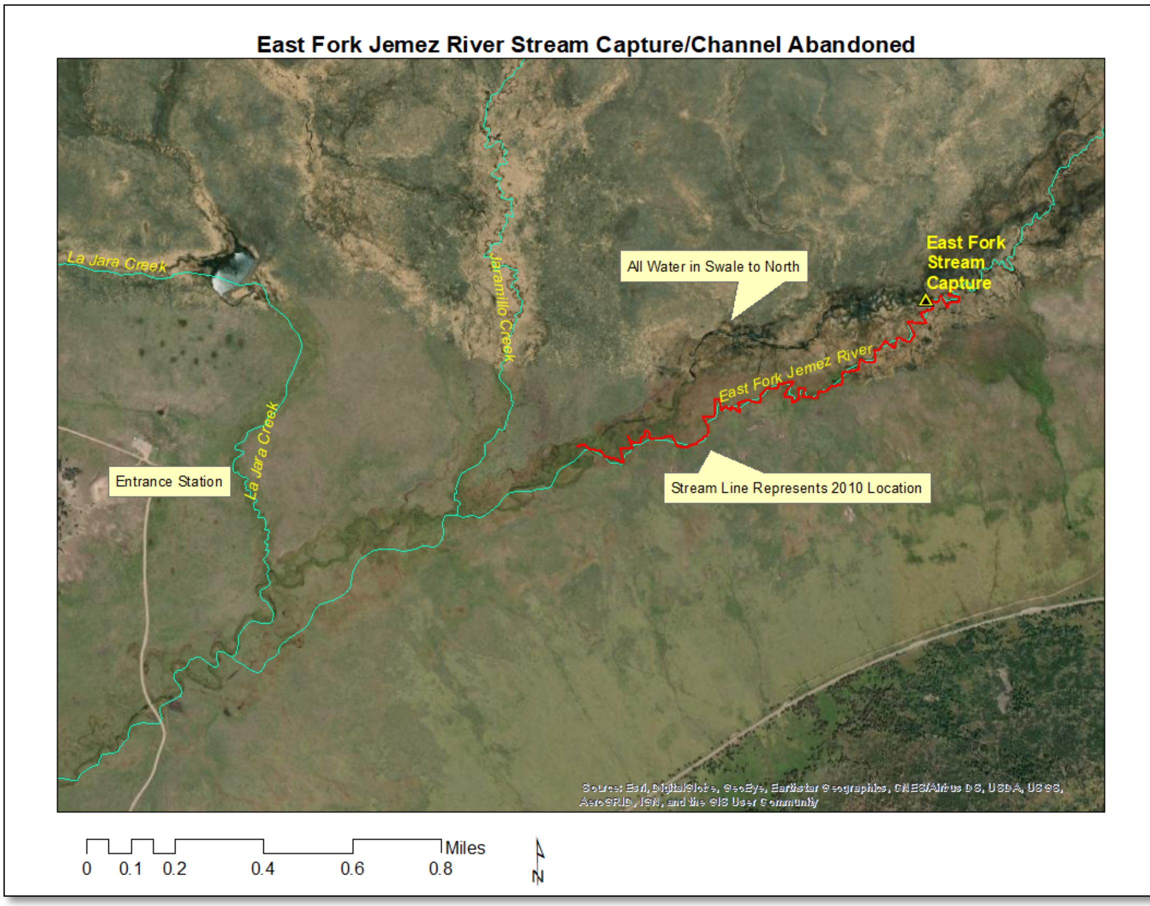
Anastasia Piliouras, from LANL, shared report data from their monitoring last year. To better charcterize the sites, they plan to expand the study in 2021 and 2022 focusing on specific increases in Carbon-sequestering at Nina's Spring. Preliminary data suggests that Nina's Spring may be sequestering more carbon than a relatively healthy nearby wetland area that was not restored.

Next steps could include:

- The use of soil horizon markings with feldspar (white mark) to track the deposition of biomass over time.
- Tracking sediments as turbidity is of concern in these streams.
- As discussed by Anastasia and Maryann McGraw from NMED, it would be helpful to better understand microbial activity and conduct long-term monitoring of soil moisture (currently have only one sample).
- Collection of biomass data would be helpful to sort vegetation data by different sites (wetland restored, not restored).

We also discussed the possibility of re-aligning the East Fork. There has been an area on the East Fork where the stream has been captured and moved to the north side of valle. The water is now all in a swale on the north side, and the East Fork (blue/red lines) is dry. (See photo below, Figure 25.) We were unaware of this until KRE was taking pictures and starting a wetland delineation in August 2021. This may have happened between 2011-2013, and may be due to the fire road cut by the firefighters for the Las Conchas Fire. Other possibilities include elk trailing, or fire deposition of sediment. It might take a lot more investigation of different time photos to determine a cause.

*Figure 25. EFJR Stream Capture.*




Reasons to do the re-alignment would include water quality increases, because there is a lot of sediment mobilized through the newly cut channel.

Reasons against the re-alignment may be that we would lose wetland.

A win-win would be to block the new channel so water backs up and then returns to flowing down the original channel. This would keep the new wetland but reduce the sediment source. Dr. Parmenter was inclined to think that splitting water like that seemed like a good idea.

We then moved on to the Soldades, and Jack Crane, Vice Chair of RPA, said he felt the headwaters really needed restoration treatment. He felt that the demonstration East Fork project needed to be repeated in the Soldades area.

## Conclusions

As we have noted, there are a number of potential future actions that should be implemented to continue to restore and improve hydrological functioning on the VCNP:

**Future Actions**

- **Soldades**. Repeat the EFJR demonstration project in the Soldades area.
- **East Fork Stream Capture**. We discussed this at the October 7, 2022 Stakeholder's Meeting, and it was decided that we should block the new channel so water backs up and then returns to flowing down the original channel.
- **Further Climate Change Adaptation**. More projects in the EFJR like the EFJR Headwaters project to build resilience against climate change.
- **Road Remediation**. Major improvements to the drainage facilities of the road system in the EFJR need to be undertaken to restore the watershed and wetlands to pre-road ecology.
- **Wildfire Flood Protection.** Plug and pond and other restoration structures could be utilized as a protective measure for post-fire flood management, or preventively, before a watershed burns.

In addition, we need to continue monitoring our finished projects and monitoring the East Fork Watershed to see what changes in climate may be forcing new projects. The VCNP has a continuing monitoring program, so we will continue to work with them to determine what needs to be done. We also need to strengthen outreach and engagement (see below).

**Funding Future Actions**

There are a number of possibilities for funding:

- State of New Mexico's River Stewardship Program
- EPA's Wetland Program Development Grants
- EPA's Water Pollution Control Section 106 grants
- EPA's Nonpoint Source Pollution 319 Grants
- EPA's Five Star and Urban Water Restoration Grant Program
- Department of Interior's North American Wetlands Conservation Act
- National Fish and Wildlife Foundation, Southwest Rivers Headwaters Fund
- Wildlife Conservation Society

**Outreach and Engagement**

1. We need to hold tours for the public and for restoration specialists to spread knowledge about need and processes for wetland restoration.
2. We need to continue engaging the Santa Fe National Forest, the VCNP, LANL, the tribes, and other stakeholders to develop partnerships and to learn new things about the needs of the EFJR.

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