Summary Report for 2010-2014 Southwest Jemez Mountains Collaborative Forest Landscape Restoration Project (CFLRP) Monitoring Program: Natural and Cultural Resources Sections

Summarized from the 2015 “All Hands” meeting held in Santa Fe, New Mexico, March 2015

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Summary Report, 2010-2014

Southwest Jemez Mountains Collaborative Forest Landscape Restoration Project (CFLRP) Monitoring Program: Natural and Cultural Resources Section

Introduction: This summary report represents the cumulative results of the Southwest Jemez Mountains CFLRP monitoring program. The report is structured around the objectives listed in the original Forest Landscape Restoration Act passed by Congress in 2009. The results presented have been contributed by the collaborating groups of the CFLRP, based on their annual presentations at the most recent "All Hands" meeting (for this report, March 2015).

CFLRP Direct Objectives: As defined in the Forest Landscape Restoration Act (PL 111-11, Sec. 4003(c)), the natural resources monitoring program objectives are to evaluate the degree to which restoration actions:

(1) contribute toward the restoration of the structure and composition of pre-fire-suppression old growth stands,

(2) reduce the risk of uncharacteristic wildfire, and/or maintain or re-establish natural fire regimes,

(3) improve fish and wildlife habitat, including endangered, threatened and sensitive species,

(4) maintain or improve water quality and watershed function, and

(5) prevent, remediate, or control invasions of exotic species.

The success of the project's restoration actions will be determined based on the magnitude and direction of observed project-induced changes in the natural resource variables listed below. Restoration treatment effects and degree of success will be distinguished from normal "background" spatial and temporal variability through a carefully-designed network of replicated monitoring plots and untreated "control" areas.

Climate conditions during the SWJM CFLR Project. As part of the monitoring program, we monitor meteorological conditions at 10 weather stations located through the project area (Fig. 1). These data are essential for interpreting the observed responses of flora and fauna. Data from these stations are "live" Valles Caldera on the internet at the following address: http://www.dri.edu/vallescaldera/ .As a representative of the climate during the project period through spring, 2015, we include below the data for the Valle Grande Headquarters weather station.

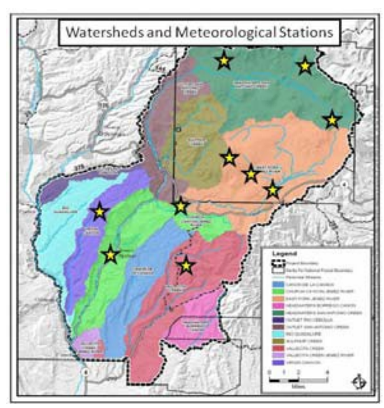


Fig. 1. Map of weather stations in SWJM CFLRP

Monthly precipitation during 2014 was very low during the winter of 2013-2014, but followed a record wet September in 2013 (see Fig. 2). Spring 2014 was just about on average, and the summer monsoon was overall average in total amount, though June was wetter than average and August was dryer than average. Precipitation (mostly as snow) through the winter of 2014-2015 has been somewhat above average (based on data from 2003-2015), a result of the weak El Niño event that has been occurring over this time period.

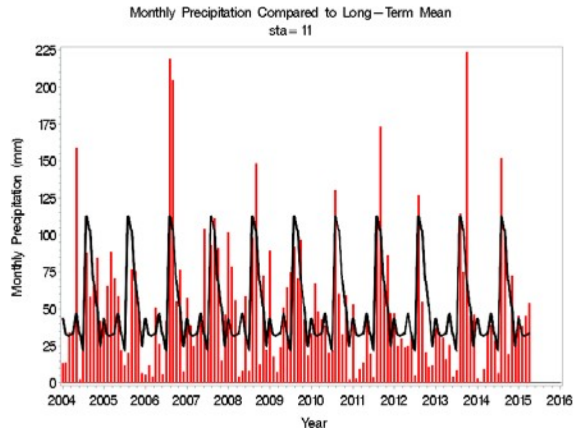


Figure 1Fig. 2. Monthly precipitation (red histograms)

Mean monthly temperatures in 2014 were mostly below average during most months; however, temperatures during the winter/spring of 2014-2015 were above average (Fig. 3).

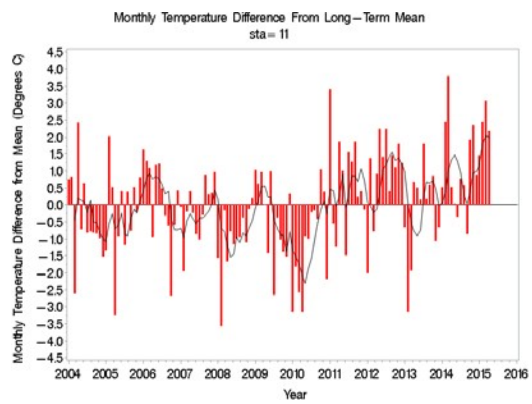


Figure 2ig. 3. Monthly temperatures (red histograms) compared to long-term mean (black line) at the Valle Grande weather station.

Soil moisture conditions in 2014 were generally average through most of the year, but were very dry in August (Fig. 4). Moisture then increased to about average by November/December, 2014.

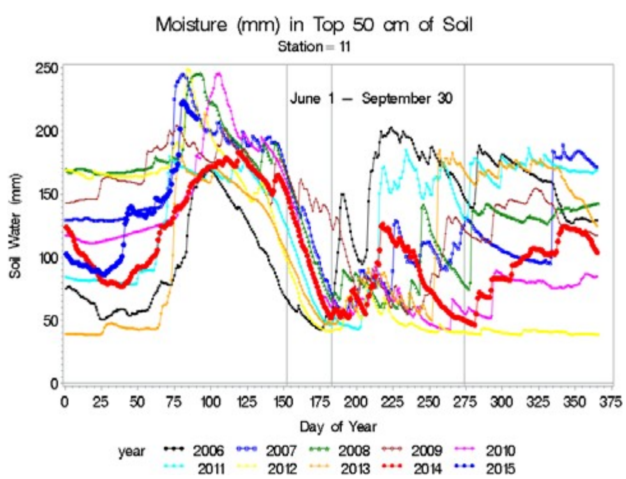


Fig. 4. Soil moisture levels (mm water in top 50 cm of soil). Note moisture spike in September, 2013 (orange line, day 260), and generally good soil moisture through midsummer of 2014 (dark red line), but drying out by early October. Soil moisture then improved during November and December, and has since achieved relatively high levels in the spring of 2015 (heavy dark blue line).

The following sections describe each *direct objective* of the CFLRP project (as listed in the Act), with the monitoring program's approach (from the original SWJM CFLRP proposal to USDA), measured variables, collaborating groups, and results to date (through 2014):

Objective 1. Restore the structure and composition of pre-fire-suppression old growth stands.

Monitoring approach: For each site (forest stands) to be restored, whenever possible, we will assess the historic stand structure (density and age-class distribution of trees and understory vegetation) and composition (tree species by age classes and densities) using data from stump fields, aerial photographs, and logging records. We will measure current forest stand conditions (tree species, sizes, spatial distributions, understory woody and herbaceous vegetation, dead and down woody debris) prior to restoration treatments, develop restoration prescriptions for thinning/burning to achieve long-term desired outcomes, and re-measure these same variables immediately after treatments. We will conduct periodic (3-5 year intervals) stand assessments for tree structure and composition. We also will conduct annual measures of herbaceous and woody understory fuels to monitor successional change of vegetation and development of fine fuel loads (measures to include plant species cover, height, and aboveground biomass). We will use these data to determine future schedules of prescribed/natural fire use for maintaining long-term forest restoration processes. An important component of this monitoring effort is to identify non-native/invasive plant species for potential control and/or eradication actions.

Collaborators: Valles Caldera Trust, Santa Fe National Forest, USGS, Bandelier National Monument, Jemez Pueblo, Santa Clara Pueblo, The Nature Conservancy, NM Forest & Watershed Restoration Institute (Highlands University), USFS Rocky Mountain Research Station, WildEarth Guardians, Forest Guild, New Mexico Department of Game and Fish, New Mexico State University's USGS Wildlife Coop Unit.

Results: *Forest stand structure and fuel loads:* The original assessment of the forest structure and fuel loads to develop the strategy for restoration were derived from Common Stand Exams (or comparable sampling) conducted across the project area (Including the Santa Fe National Forest (SFNF) and the Valles Caldera National Preserve (Fig. 5). The results of these assessments formed the basis for the CFLRP proposal. As the CFLR project continues to develop and treat ever-larger areas of land, a second post-treatment assessment using Common Stand Exams and Fire Monitoring Plots will be conducted in the treated and burned areas (Note: At this point in time, there is insufficient treated areas to warrant a contract for the field sampling; we anticipate that after the 2015 work season, we will have sufficient treated acres to justify a post-treatment inventory contract). From these data, we will have forest stand information to assess changes in Stand structure and fuel loads. *Herbaceous plant cover and Diversity:* Grass and forb (wildflower) cover and species Richness/diversity are being recorded at representative sites In the major treatment areas (thinned and

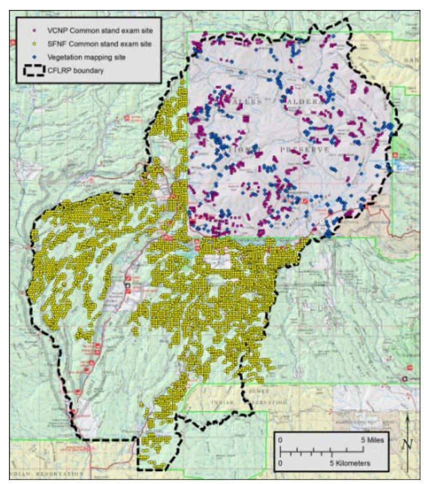


Fig 5. Map of CSE plots.

burned forest stands). Herbaceous vegetation is measured using replicated point-intercept line-transects during pre- and post-treatment time periods in both treated sites and untreated (control) sites. Sample locations are often situated near the perimeter of treatment areas, so that treatment sites and control sites are geographically close and share the same slope, elevation, aspect and soil types. Repeat photo points are established at all sites.

Thinning monitoring has been conducted on areas of Banco Bonito (Fig. 6), going back to years before the CFLRP and continued during recent years. Results show an increase in plant species diversity following thinning for 4 years in forest stands, but only a slight increase in open meadows (Fig. 7). After the initial response, the plant community diversity leveled off until the prescribed fire in the fall of 2012; diversity and plant cover dropped in 2013 but then quickly recovered in 2014. Plant responses post-fire were apparent in repeated photos (Fig. 8).

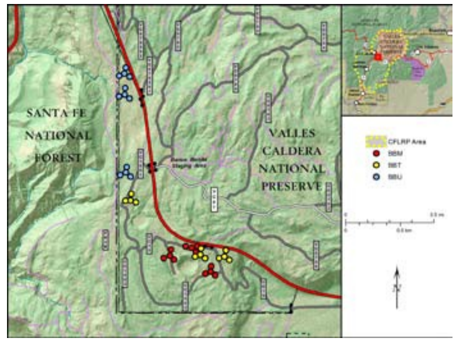
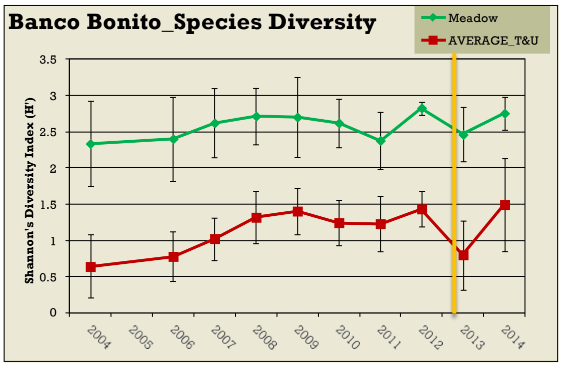


Fig. 6. Plot locations on Banco Bonito



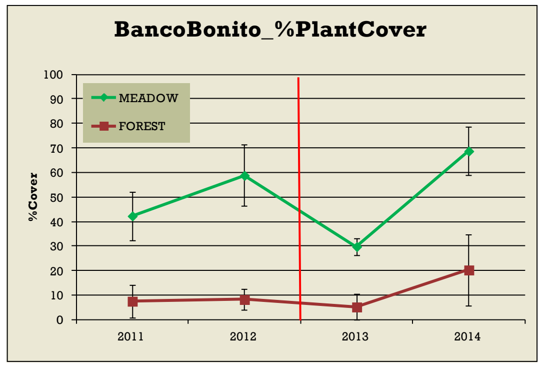


Fig. 7. Left: Plant diversity following thinning in forest habitat and meadow grassland, 2004-2014. Gold vertical bar indicates time of prescribed fire in late 2012. Right: Plant % cover at same sites (red line indicates fire).

Fig. 8. Paired photo of thinned forest (left) after thinning but before prescribed fire, and (right) after fire

A second region with post-thinning plant monitoring data is located in ponderosa pine forest adjacent to Redondo Meadow. This was a very dense stand of second-growth pine and was thinned in 2010. The site had near zero herbaceous plant cover and low diversity under the closed canopy forest. Cover and plant diversity began to increase in 2011, but then the site burned (understory, low-severity burn) in the Thompson Ridge fire in 2013. Within two years, plant cover had increased to 40-85% and diversity had increased from <0.75 to > 2.0 (Fig. 9, and Fig. 10).

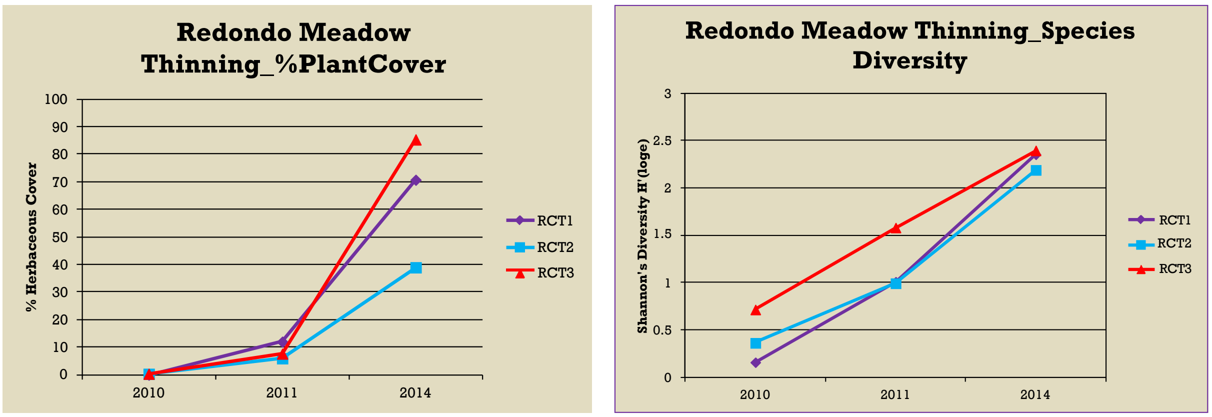


Fig. 9. Changes in plant cover (left) and diversity (right) in thinned (2010) and burned (2013) ponderosa pine forest.

Fig. 10. Repeat photos of pre-thinned (left), post-thinned (center) and post-burned (right) in ponderosa pine forest.

In addition to intensively-measured monitoring sites (with line transect plant data), additional monitoring sites are tracked using repeat photo points. Photo points are recorded using high-resolution GPS, and are visited prior to treatment, immediately after treatment, and then periodically through time to track changes in the vegetation and fuels. Repeat photo points allow a larger constellation of monitoring sites across the landscape, and provide visual information to assess the anticipated site responses to treatment. If sites are not following the typical successional pathway at the rates expected, then biologists visit the site to determine what (if any) action needs to be taken using adaptive management. An example series of photos are presented in Fig. 11 below. Note the general increase in herbaceous plant cover through time, as documented in the intensively-measured representative sites.

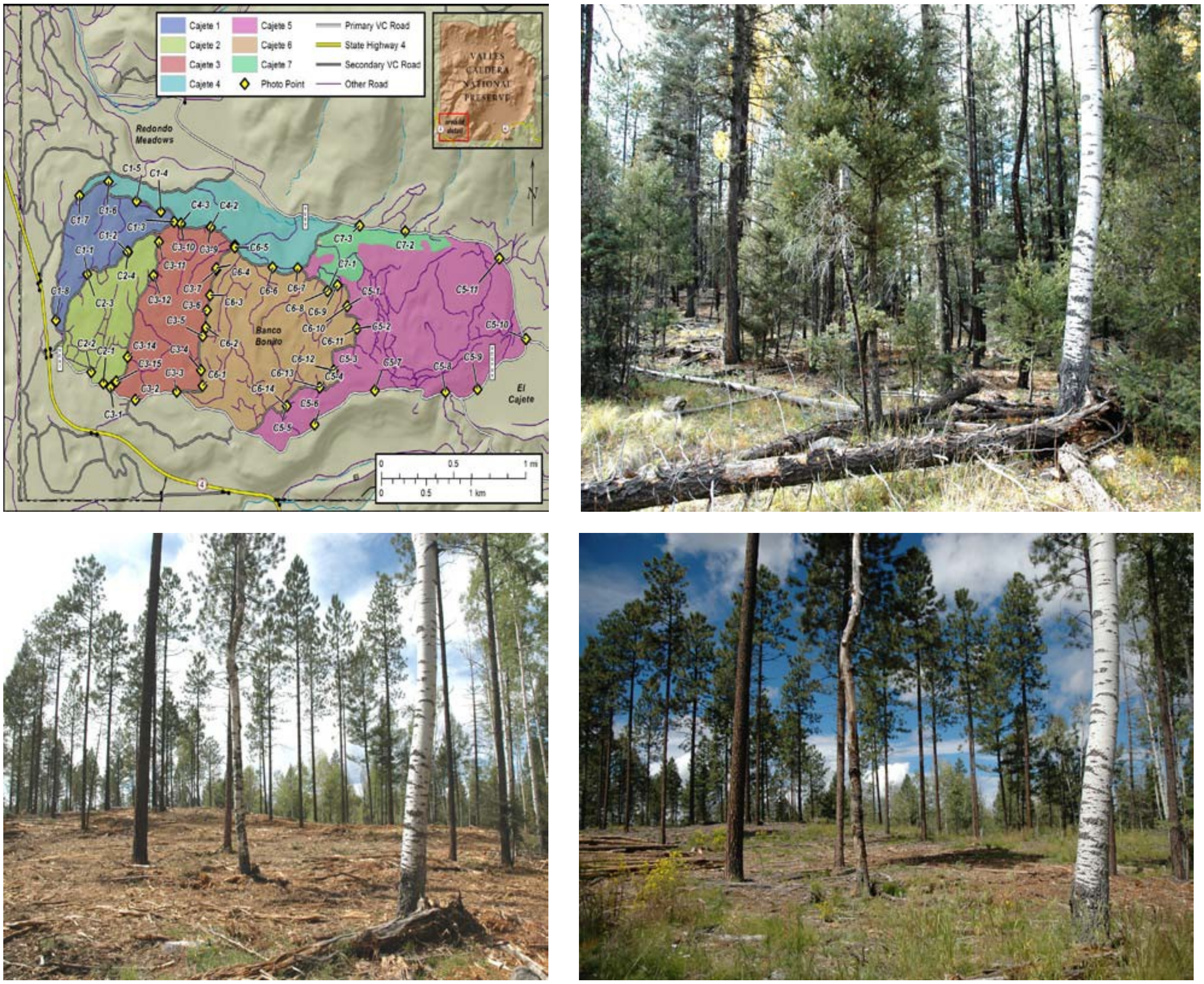


Figure 11. Upper left: Map of repeat photo points in thinning areas on Banco Bonito. Upper right: Example site prior to thinning. Lower left: repeat photo following thinning. Lower right: repeat photo 2 years following thinning.

Wildland fire projects with planned ignitions in un-thinned forest stands constitute another set of monitoring sites. The edges of planned burn areas sometimes are thinned as needed. Intensive monitoring sites were established along the periphery of the fires, with paired monitoring transects and photo points within the treatment area and outside the treatment area ("controls"). Measurements and photos are taken prior to the fire, and photos are taken immediately after the fire; then plant measurements are recorded in the late summer of the first post-fire growing season, and again periodically in subsequent years.

The San Juan and southern Paliza planned ignitions are being monitored using such a design, along with the Pino managed burn (an area within a planned prescribed fire area, but ignited by lightning and then allowed to burn). Fig. 12 shows the locations of vegetation monitoring sites for these prescribed and managed fires.

For the San Juan prescribed fire in fall 2012, 16 paired plots (16 treatment plots, 16 control plots = 32 plots total) were established along the periphery of the fire. These were sampled for herbaceous cover prior to the fire in 2012, and following the fire in the autumn of 2013 and 2014. Results indicated that herbaceous plant cover and diversity had not significantly changed from before the fire, and was statistically similar to the untreated control sites (Fig. 13). Litter cover and depth of litter decreased and bare ground increased, as expected following the fire (Fig. 13).

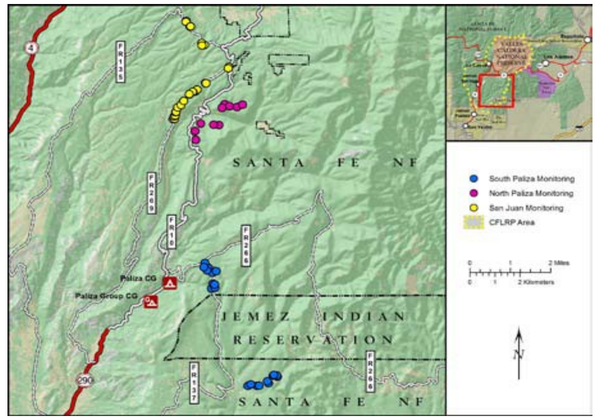
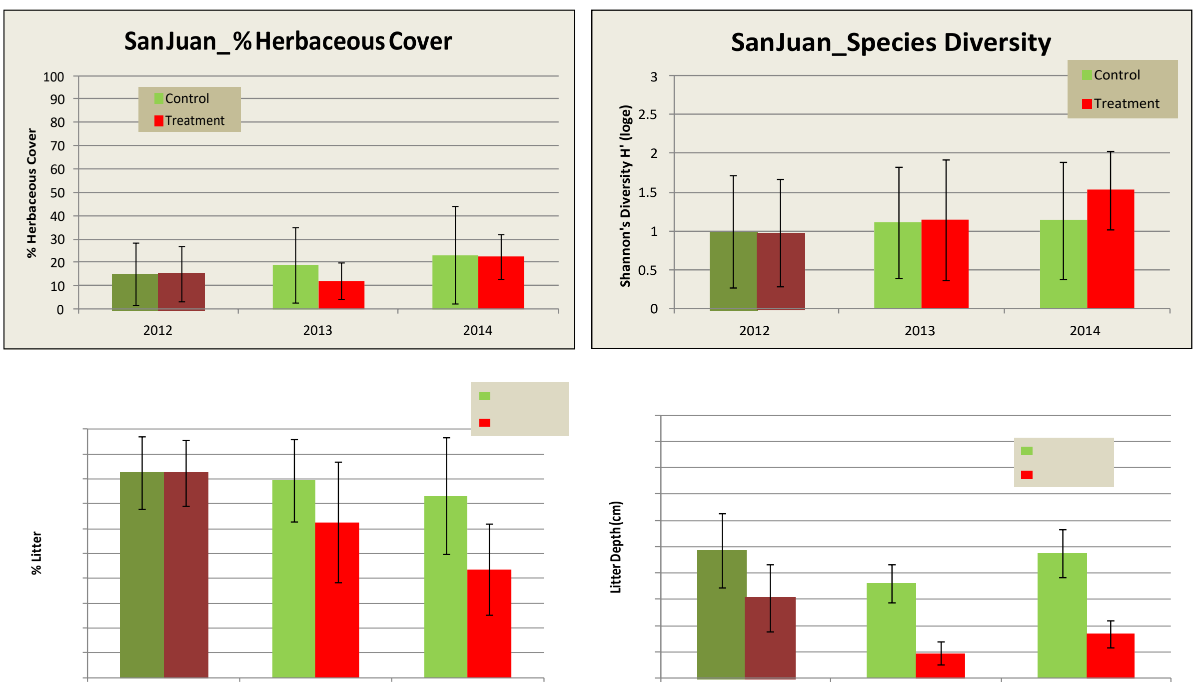


Fig. 12. Plant monitoring sites for the San Juan burn, the Pino burn, and planned Paliza burn.



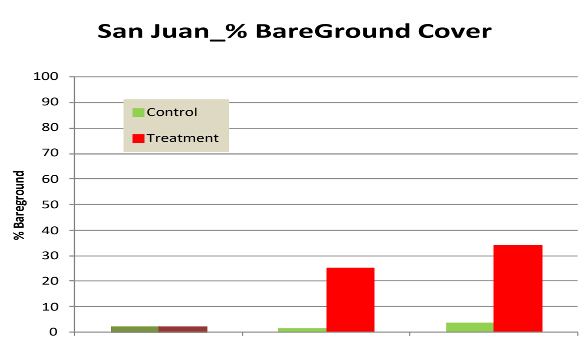


Fig. 13. Herbaceous cover and diversity, litter cover and depth, and bare ground cover after the San Juan Mesa fire.

Repeat photo plots also were established for the monitoring sites in the San Juan prescribed fire area. These photos were consistent with the line transect herbaceous plant data, showing minimal change in plant cover, but some forb species were starting to colonize (Fig. 14).

Figure 14. Repeat photos of monitoring site in the San Juan prescribed fire. Upper left: pre-burn site with high density of sapling ponderosa pine. Upper right:

In addition, the SFNF had contracted with the National Park Service, Bandelier National Monument, to establish a group of Fire Effects Monitoring Plots within the San Juan Mesa project area (Fig. 15). These were sampled prior to the prescribed fire, and will be re-sampled in the future to determine the fire's impact on stand structure and fuel loads. Initial visual surveys of the post-fire project area found higher-than-anticipated kill of mature ponderosa pines, potentially due to high heat generated from sapling pines and the thick layer of masticated materials on the forest floor. Possible root-kill from smoldering litter layers may have contributed to mature tree mortality.

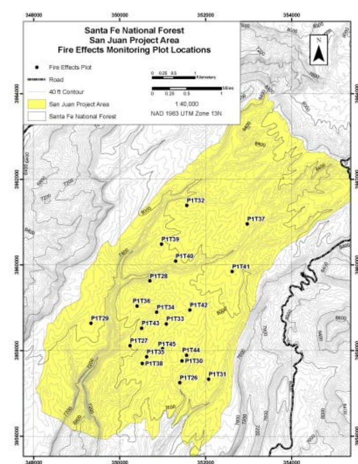


Fig. 15. Map of Fire Effects Monitoring Plots on San Juan prescribed fire.

Another planned ignition fire was the Paliza Fire, scheduled for burning in 2013/2014, but weather conditions prevented management ignition. However, a lightning strike during late summer 2014 in the northern unit of the planned burn area was allowed to continue burning as a managed fire; this was named the Pino Fire. Herbaceous plant monitoring plots had been established and sampled in 2013 (see Fig. 12 above), along with NPS Fire Effects Monitoring Plots (Fig. 16). The herbaceous monitoring transects will be sampled in summer, 2015, but repeat photographs of the sites indicated a moderate- to high-severity burn in some areas (Fig. 17). Future re-sampling of the Fire Effects Monitoring Plots will yield detailed information on changes in stand structure and fuel loads. The southern half of the Paliza project area is scheduled for burning in 2015; monitoring plots have been established and sampled in 2013, and will be sampled following the fire in 2016.

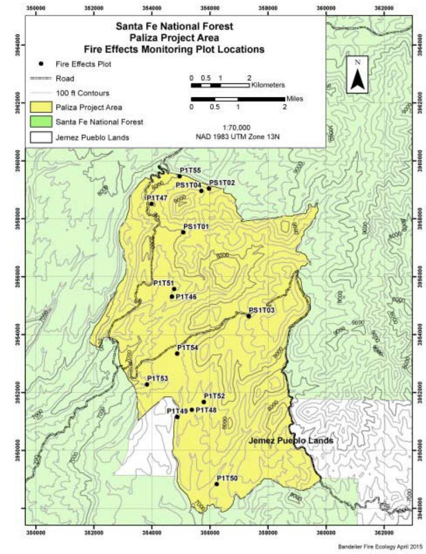


Fig. 16. Map of Fire Effects Monitoring Plots in the Paliza project area (the north half is in the Pino Fire area).

Figure 3Fig. 16. Map of Fire Effects Monitoring Plots in the Paliza project area (the north half is in the Pino Fire area).

The Las Conchas fire and the Thompson Ridge fire, both on the Valles Caldera National Preserve, were unplanned ignitions from wind-toppled trees striking live powerlines. We are monitoring sites impacted by both fires, along with unburned control sites (Fig. 18). Las Conchas post-fire results to date indicate that herbaceous cover quickly responds to stand-replacement fire. Forest sites sampled after the Las Conchas fire exhibit an average of 90% plant cover after 4 years of successional processes (2011-2014, inclusive), indicating that the former forest ecosystem has quickly shifted to that of a montane meadow (Fig. 19). Valle grassland sites recovered full vegetation coverage in the first growing season (i.e., by fall 2011), although species-specific changes in cover were observed, and continue to change in significant fashion in 2012-2014 with respect to species dominance.

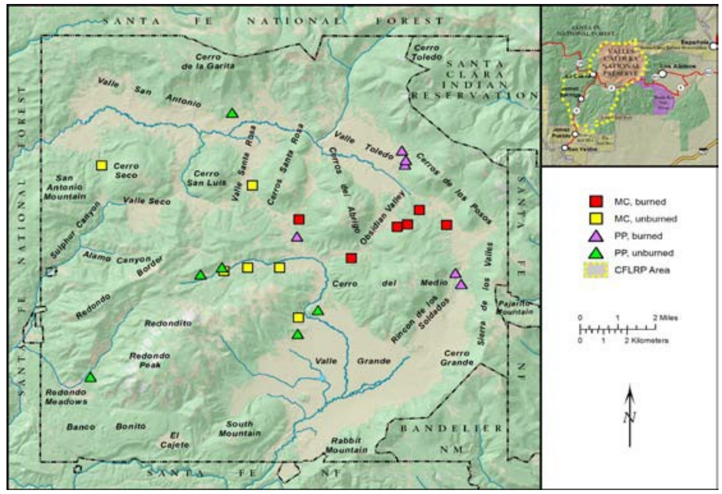


Fig. 18. Map of monitoring plots for Las Conchas Fire

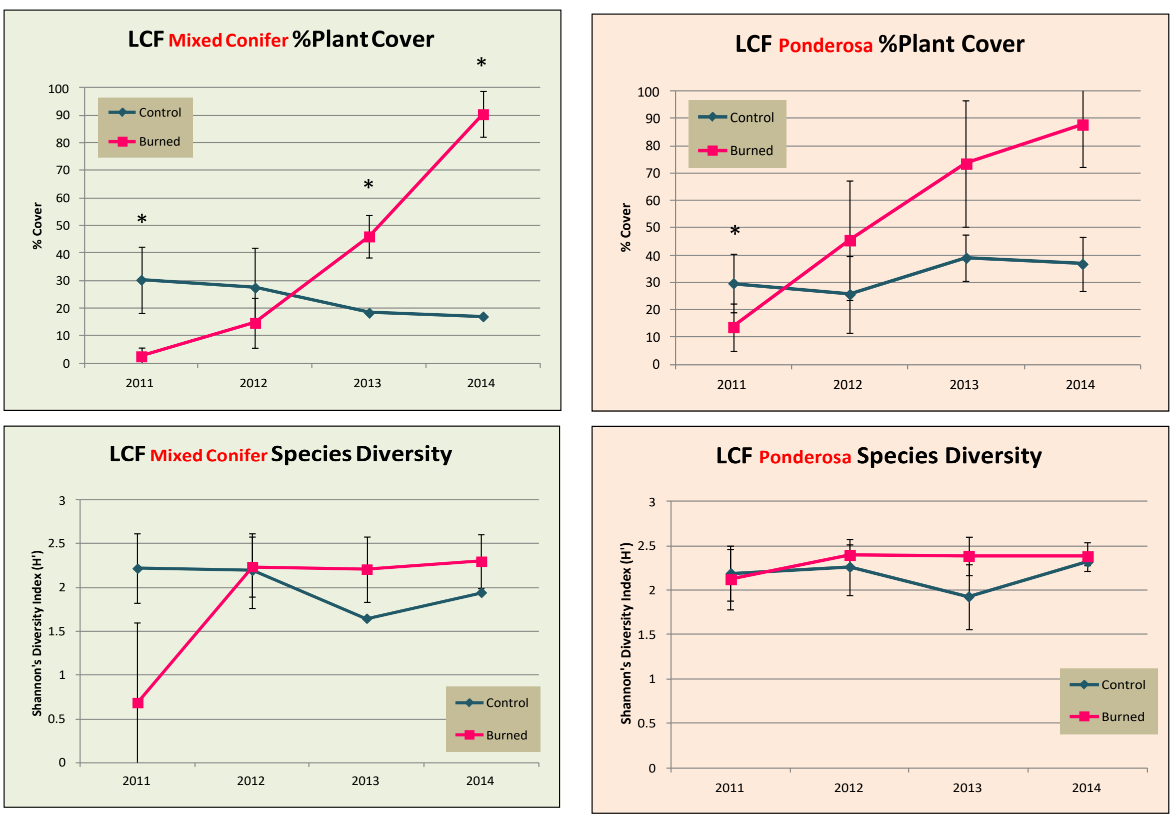


Fig. 19. Herbaceous plant cover (top) and species diversity (bottom) following the Las Conchas Fire in mixed- conifer forests (left) and ponderosa pine forests (right).

Repeat photographs of Las Conchas fire sites illustrate the rapid and extensive conversion of the former forest ecosystem to montane meadow ecosystem. An example time series of photographs in a mixed-conifer forest stand that had sustained a stand-replacing high-severity burn during the Las Conchas fire is shown below in Fig. 20.

Fig. 20. Herbaceous plant succession on a mixed-conifer site, 2011-2014, following the Las Conchas fire on the Valles Caldera National Preserve. Top left: Immediately post-fire, July 2011.

<u>Objective 2.</u> Reduce the risk of uncharacteristic wildfire, and/or maintain or re-establish natural fire regimes.

<u>Monitoring approach:</u> For the project area specifically, and the Jemez Mountains generally, fire histories based on tree rings and fire scars have been developed for both forests and grasslands (valles in the Valles Caldera National Preserve). These fire histories provide the basis for classifying historic fires as within normal ranges of fire areal extent versus "uncharacteristic." Fire model simulation runs have been conducted for the project area and Jemez Mountains, and these have been used to determine the fire behavior potential for existing forest conditions. As forest stands are sequentially restored over the coming decade, we will update the fire behavior conditions (using field collected monitoring data of fuel loads and stand condition) to determine the extent to which fire behavior potential is being reduced. In addition, during and after the restoration project, we will document the occurrence, areal extent, and vegetation impact of all natural and prescribed fires. We will then compare the estimated model results to the actual fire data to determine the realized change in fire behavior potential.

<u>Collaborators:</u> Valles Caldera National Preserve, Santa Fe National Forest, USGS, Bandelier National Monument, Jemez Pueblo, Santa Clara Pueblo, The Nature Conservancy, NM Forest & Watershed Restoration Institute (Highlands University), WildEarth Guardians, Forest Guild.

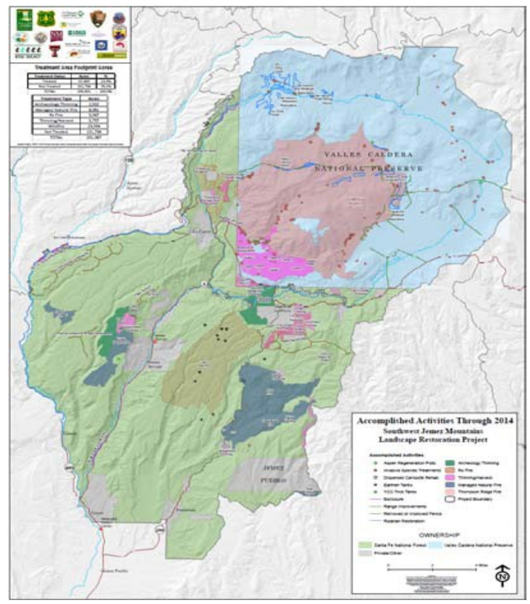


Fig. 21. Map of treatments in the SWJM CFLRP

<u>Results</u>**:** Assessments of changes in fire behavior potential have not been conducted as yet, but will be planned for after the summer of 2015 (when we'll have a substantial proportion of the project area treated by either thinning or fire or both). Fig. 21 shows the areas treated during 2010-2014 in the project area, and Fig. 22 displays the modeled risk of crown fire at the beginning of the CFLRP in 2010. Data using stand characteristics and changes in forest S-class will be incorporated into the GIS database for the area, and fire models will be re-run in the restored landscape. Since the beginning of the project, the area has sustained two large unplanned ignition fires: Las Conchas fire (~30,000 acres) and the Thompson Ridge fire (~25,000 acres). The Pino fire began as an unplanned ignition, but because it was within the perimeter of an area planned and prepared for a planned ignition, the fire was allowed to burn as a managed fire. Several planned ignition fires were conducted, including the San Juan burn and the Banco Bonito burn, along with numerous pile burns in areas that had been thinned. All of these fires have been recorded in the CFLRP GIS for future comparison to historic natural fire regimes.

In total, the following areas have been treated with the listed activity:

1. Archaeology Site Thinning: 800 sites, totaling 2,532 acres.
2. Managed Natural Fire: 8,081 acres.

3. Prescribed Fire: 9,947 acres.
4. Mechanical Thinning: 5,757 acres.
5. Beneficial Wildfire: 23,934 acres.

Total Treatment Footprint Acres: **47,665 (24% of project area)**

Unplanned ignition, suppressed: Las Conchas fire (high severity = 8,277 acres; medium severity = 7,784 acres; low severity = 4,202 acres; unchanged within fire perimeter = 9,755 acres). **Total burn area = 30,019 acres (14% of project area).**

The total acres within the project area that have been treated or impacted by the Las Conchas fire is 77,684 acres, or 38% of the project area. Several areas are scheduled for planned ignitions during 2015, including the VCNP's Banco Bonito thinned areas and the grassland of the Valle Grande, as well as the southern half of the Paliza unit on the SFNF. Once these areas have been treated, the CFLRP collaborative will undertake the post-treatment fire risk modeling exercise. Following that, we will compare the amount of canopy fire risk between the pre-treatment values (Fig. 22) and the new values following treatment.

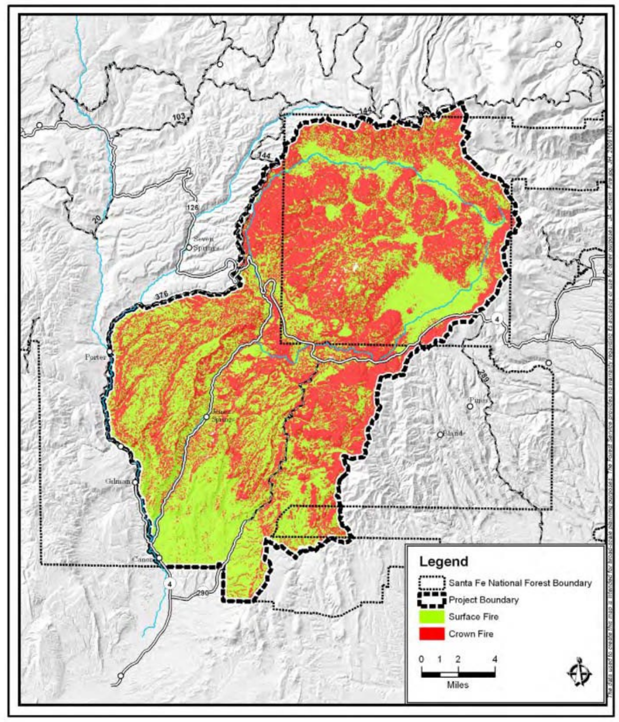


Fig. 22. Map of crown fire risk in the CFLRP project area in 2010 (pre-treatments).

Objective 3. Improve fish and wildlife habitat, including endangered, threatened and sensitive species.

Monitoring approach: In order to determine if the fish and wildlife habitat in the restored forest stands is improved, we will monitor the important wildlife populations with respect to use of the restored areas and the population, demographics, and survival within these habitats, and compare the observed variables to those from nearby untreated forest habitats. Whenever possible, we will collect pre-treatment data on wildlife populations in forest stands scheduled for treatment to strengthen the statistical inferences of the monitoring comparisons between treated and untreated forest stands. The important species of wildlife to be monitored, and the methods by which their populations will be monitored, include the following:

Large mammals: We have selected elk, mule deer, black bear, and cougar as the four most important "big game" grazers-browsers and predators to monitor, due to their economic importance, documented ecosystem impacts, and potential human-wildlife and livestock-wildlife conflicts (see CFLRP proposal, Section 13, for detailed explanation). If forest landscape restoration is successful in improving habitat for these species, we would expect to observe increased use of these restored forest habitats by each of these species for foraging/hunting, reproduction, and shelter. To monitor these species, we will deploy GPS radio collars to track their habitat use by season, and compare their relative usage of habitat types classified by level of restoration (e.g., untreated, newly thinned and/or burned, 1-year old restored sites, 2-year old…, etc.). Population numbers will be estimated using aerial surveys for elk and deer. Habitat quality will be monitored in randomly selected sites across the project area, with vegetation measurements (trees, shrubs and herbaceous plants) conducted to assess forage availability and nutritional content. Specifically, we will determine habitat selection and space use patterns of large mammals in relation to forest restoration treatments, and determine if and when mule deer, elk, black bear, and mountain lions begin to use treatment areas (including lag times following restoration activities for both plant succession and wildlife use, and differences in seasonal use by wildlife).

***Collaborators*:** New Mexico State University's USGS Wildlife Coop Unit, New Mexico Department of Game and Fish, University of New Mexico (Museum of Southwestern Biology), Valles Caldera Trust, Santa Fe National Forest, USGS, Bandelier National Monument, Jemez Pueblo, Santa Clara Pueblo, Rocky Mountain Elk Foundation, Pope and Young Club.

***Results*:** During 2010-2014, we have established 224 vegetation plots for habitat quality changes (118 plots on the SFNF, 106 plots on VCNP) (see map in Fig. 23). Results of forage (biomass) availability in thinned and untreated areas, and in burned and unburned areas, are shown in Tables 1, 2 and 3. Sites with open canopies had significantly more forage (kg/ha) than closed canopy sites, indicating that thinning and burning treatments to increase canopy openness will have the desired effect of producing more forage for ungulate species.

Fig. 23. Map of habitat vegetation plots in the CFLRP to assess habitat quality change for large mammals.

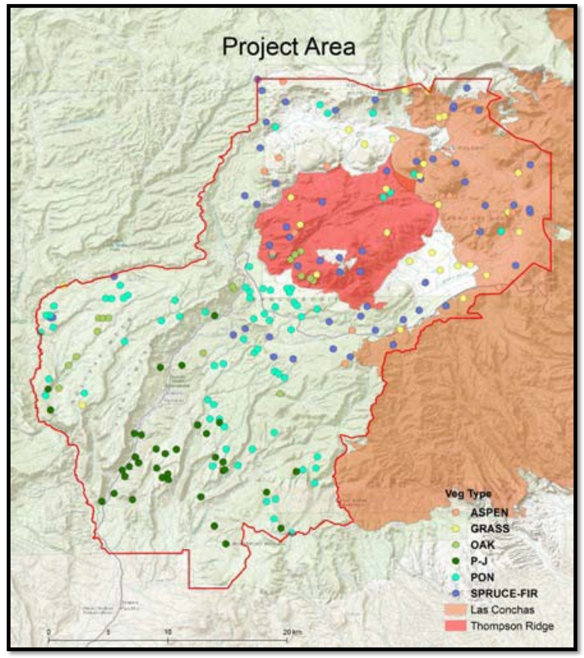


Table 1. Forage availability (kg/ha) in thinned and untreated sites in the CFLRP project area.

Thinned Area

Veg. type	Open Canopy	Closed Canopy
Mixed Conifer	Mean (SE)	Mean (SE)
Ponderosa	552.2 (241.0)	512.0 (94.0)
P-J	Na	168.8 (54.7)

Untreated Area

Open Canopy	Closed Canopy
Mean (SE)	Mean (SE)
667.7 (93.8)	453.2 (27.9)
517.7 (41.8)	556.4 (36.6)
542.0 (33.1)	319.4 (77.8)

Table 2. Forage availability (kg/ha) in areas treated with prescribed fires versus unburned sites.

RX Burn and Untreated

Veg Type	**Open canopy**	**Closed canopy**	**Open canopy**	**Closed canopy**
NA	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**
MixedConifer	NA	NA	**667.7** (93.8)	**453.2** (27.9)
Ponderosa	**849.1** (98.8)	**661.7** (122.3)	**517.7** (41.8)	**556.4** (36.6)
P-J	**782.2** (92.4)	**460.6** (69.9)	**542.0** (33.1)	**319.4** (77.8)

Table 3. Forage availability (kg/ha) in areas subjected to wildfire in the CFLRP project area.

Wildfire

Veg Type	**Open canopy**	**Closed canopy**
	Mean (SE)	**Mean (SE)**
Mixed Conifer	**1,494** (530.8)	**1,011.7** (91.4)
Ponderosa	**980.1** (270.6)	**823.5** (121.6)

GPS radio collars have been deployed on 39 black bears (11 currently collared), 23 mule deer (12 currently collared) and 80 elk (43 currently collared) to collect pre-treatment and early-years treatment effects on movements and habitat use relative to treatments. [Note: Only 4 mountain lions have had collars, so sample size is too small for statistical interpretation at this time]. Black bears have produced 34,013 locations within the project area; mule deer have contributed 20,214 locations, and elk have added 37,933 locations. Preliminary analysis has indicated that these species are not avoiding restored areas, and that mule deer are readily accessing areas on SFNF that have had prescribed fire treatments, and elk and black bear are utilizing new meadow areas created after the Las Conchas and Thompson Ridge fires (Fig. 24).

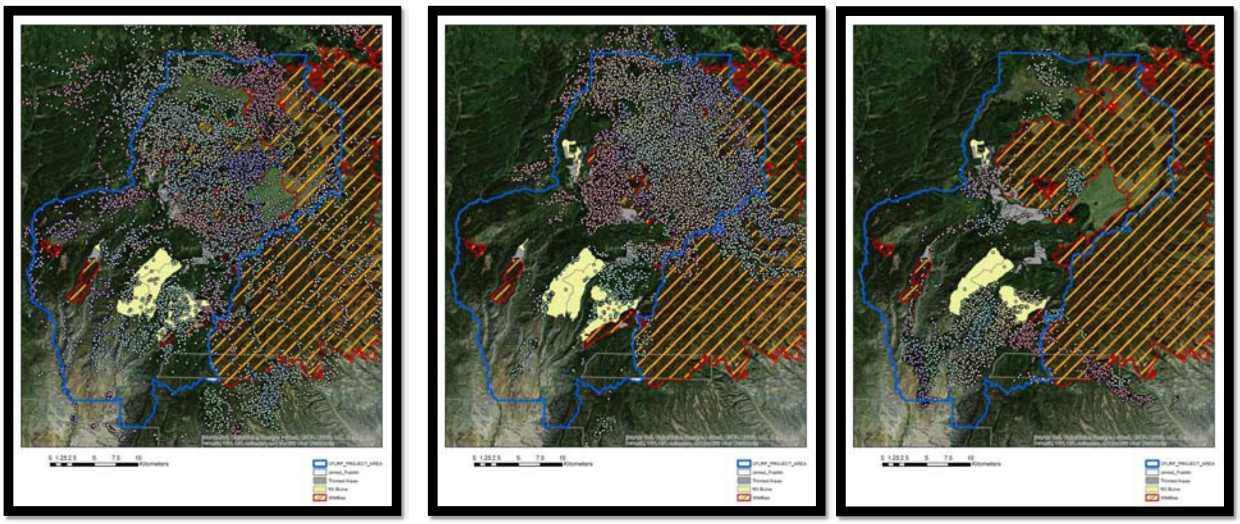


Fig. 24. Distributions of radio-collared black bear (left), elk (center) and mule deer (right).

Small mammals: The species selected for small mammal monitoring include all the resident rodents (including mice, voles, chipmunks, tree squirrels, ground squirrels, and the New Mexican meadow jumping mouse) and shrews. Small mammals (particularly rodents) are important as prey for protected raptors (Mexican Spotted Owl, Northern Goshawk), and as forest habitat is restored, we would expect to observe shifts in rodent populations with changes in habitat structure and food resources (plants and invertebrates). As riparian zones are restored with willow plantings and beaver recolonizations, we would expect to observe re-establishment (perhaps through deliberate reintroductions) of populations of the New Mexico meadow jumping mouse (a Federal endangered species). We will monitor for rodent populations using capture-mark-recapture methods (live traps that sample all these taxa simultaneously) in riparian zones and upland forest stands in both treated and untreated areas. Tree squirrels will be monitored using visual transect surveys and counts. Bats will also be monitored in forests, as treatments will likely alter bat shelter habitat, insect prey abundances, and habitat architecture (influencing night flights). Bats will be monitored using mist net live capture-release methods and sonic monitoring of bat calls (e.g., Anabat™ detection technology).

Collaborators: Valles Caldera Trust, Texas Tech University, USGS/New Mexico State University, New Mexico Department of Game and Fish, University of New Mexico (Museum of Southwestern Biology), Santa Fe National Forest.

***Results*:** Small mammals have been monitored on burned and unburned stands of mixed-conifer and ponderosa pine in 2012-2014 within the high-severity stand-replacement burn areas from the Las Conchas fire. Results have shown that fire affects species composition and abundances of some species. Tree-dwelling squirrel species were extirpated from burned forests, and chipmunks decreased while golden-mantled ground squirrels increased (Fig. 25). Deer mice showed no significant response to the fire. Montane voles and long-tailed voles, normally found in open meadows, had colonized the sites by 2014 (the 4th growing season after the fire) as a result of rapid herbaceous plant re-growth on these sites (Fig. 25).

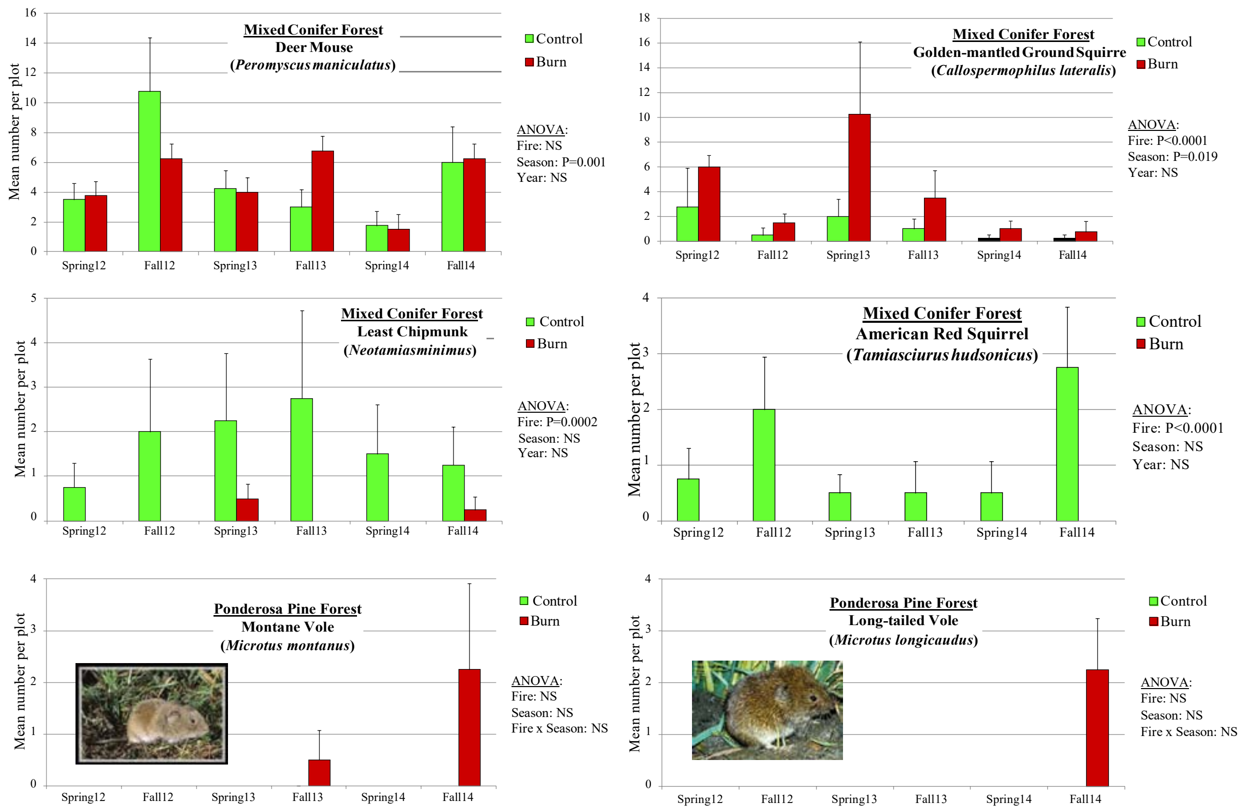


Fig. 25. Response of small mammals to the Las Conchas stand-replacing fire. Statistical results for Analysis of Variance (ANOVA) indicate level of significance.

Bats were sampled in Las Conchas burned and unburned forests in 2013 and 2014 by Nick Goforth, a graduate student from Texas Tech University. Fig. 26 shows the monitoring sites in burned and unburned forests. Goforth found that bats were more active in areas that burned at lower severities. There were no strong patterns observed between activity levels and vegetation type. Bats responded to variations in burn severities across the landscape that were at least 30 ha in size.

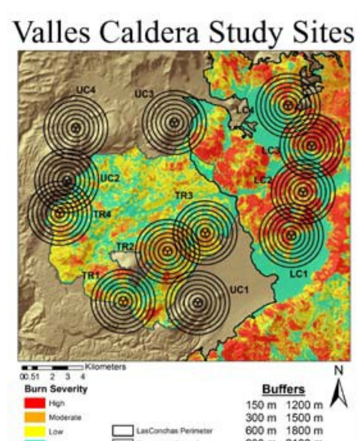


Fig. 26. Bat monitoring sites on the Valles Caldera.

Birds (raptors, game birds, song birds): Bird populations are expected to respond to forest thinning and burning due to changes in forest architecture, nest site availability, food resources and predator-prey relationships. We will monitor bird species composition and population densities and demographics. Federally-list species, such as the Mexican Spotted Owl, and other species of interest (e.g., Northern Goshawk) will be monitored using standard field protocols for those species. Song bird species will be monitored using variable circular plots (for species composition and densities) and mist net capture-release methods (for population demographics). Distributions and habitat use of selected birds (e.g., Merriam's Turkey) will be assessed by VCNP personnel as part of an on-going long term monitoring effort; this involves radio-telemetry data for movements, migratory routes, selection of nesting and roosting locations, and reproduction and mortality dynamics.

Collaborators: Hawks Aloft, Bandelier National Monument, Audubon Society, Valles Caldera Trust, Santa Fe National Forest, The Nature Conservancy, USFS Rocky Mountain Research Station, New Mexico Department of Game and Fish.

Results: Bird community species richness and abundances were monitored at 120 sites across the CFLRP project area (Fig. 27). In burned ponderosa pine, there was a significant increase in avian density in burned points (11.81 birds/site per sample) relative to control points (9.4 birds/site per sample). Although not yet significant, the data show a trend for increases in density among all burned points.

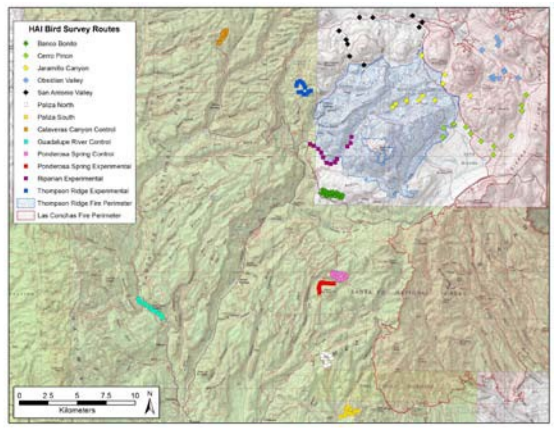


Fig. 27. Map of bird sampling sites.

In addition, breeding bird surveys were conducted by Bandelier National Monument personnel with Audubon Society volunteers (see route map in Fig. 28). Overall species richness has been declining, with a large decrease following the Las Conchas fire in 2011 (Fig. 29).

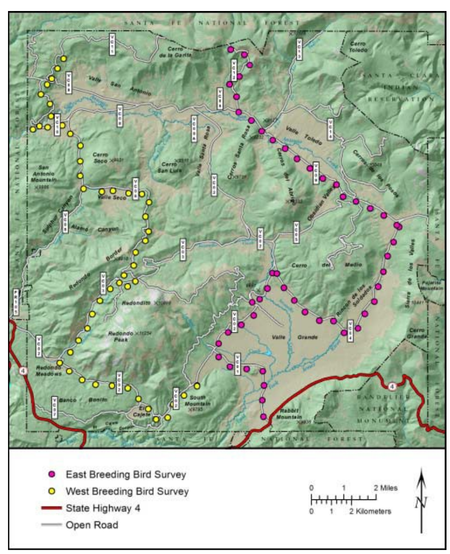


Fig. 28. BBS routes in VCNP.

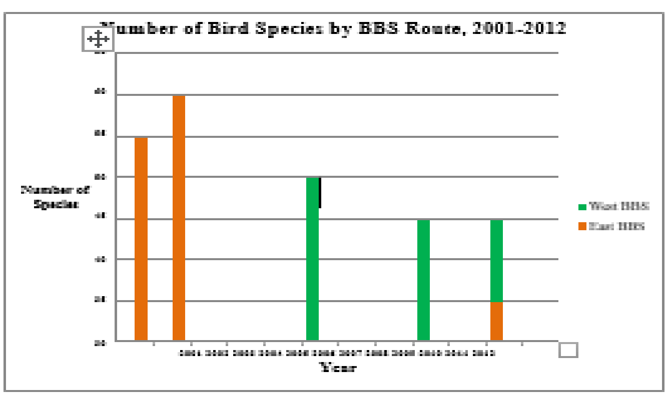


Fig. 29. Bird richness on BBS routes.

Surveys for Mexican Spotted Owls and Northern Goshawks were conducted prior to the CFLRP being started. In 2015, halfway through the CFLRP project, we will conduct recon surveys for Northern Goshawks in June, and in areas where we find hawks, we will return in 2017 for standardized grid surveys and attempt to determine nest locations. Surveys for Mexican Spotted Owls will be undertaken by Jemez Ranger District personnel in future years as treatments are undertaken in or near known nest sites; previous owl surveys on the Valles Caldera National Preserve yielded no individuals.

Reptiles and Amphibians: Reptiles will be monitored through opportunistic observations by field staff working on other projects (reptiles at high elevation are relatively rare, and low densities make systematic monitoring difficult and statistically weak). Amphibians, specifically the Jemez Mountains Salamander, and potentially the Northern Leopard Frog (following possible reintroduction), will be monitored using protocols currently being developed by a multi-party group of agencies and NGOs (all of whom are collaborators on the CFLRP project). Monitoring efforts will yield information on treatment impacts (thinning and burning) on salamander habitat and population numbers.

Collaborators: New Mexico Department of Game and Fish, The Nature Conservancy, US Fish and Wildlife Service, Valles Caldera Trust, Santa Fe National Forest, USGS, Bandelier National Monument, Jemez Pueblo, Santa Clara Pueblo, NM Forest & Watershed Restoration Institute (Highlands University), USFS Rocky Mountain Research Station, WildEarth Guardians, Forest Guild.

Results: The main species surveyed during the CFLRP thus far is the Jemez Mountains Salamander (JMS). Surveys were conducted through 2013, adding to the list of known occurrence locations. While standardized survey protocols have been developed by the JMS working group, there are still no accepted protocols for monitoring abundances or population trends through time. As a mitigation effort, the Valles Caldera National Preserve agreed with the U.S. Fish and Wildlife Service to conduct an assessment mitigation for microhabitat characteristics (soil moisture and temperatures) in areas that are treated with thinning and prescribed fire (in comparison with "control" sites that will be untreated). This effort will be undertaken in 2015 if administrative acquisition issues can be overcome.

In addition, in 2013 and 2014, the CFLRP re-introduced two populations of Northern Leopard Frogs in the Valles Caldera National Preserve. Monitoring surveys in both years found good numbers of individuals had survived, including some that had dispersed upstream into other parts of the watersheds. However, tests for chytrid fungus showed that some of the frogs were infected, but otherwise appeared healthy at this point in time. Further monitoring in 2015, the first anticipated year with mature breeding frogs, will provide a more detailed assessment as to the success of population establishment.

Fish: Restoration of upland forests via thinning and burning is expected to alter fish habitat, through an increase in the total stream discharge and potential changes in the water quality in perennial streams of the project area. This will lead to habitat changes for native and non-native fish species. Fish populations will be monitored biannually (spring and fall) using electro-shocking methods in permanently-marked stream reaches (Fig. 30). These data will provide monitoring data for fish species composition, densities and biomass.

Collaborators: Valles Caldera Trust, Santa Fe National Forest, USFS Rocky Mountain Research Station, New Mexico Department of Game and Fish, New Mexico State University's USGS Wildlife Coop Unit, New Mexico Trout, Trout Unlimited.

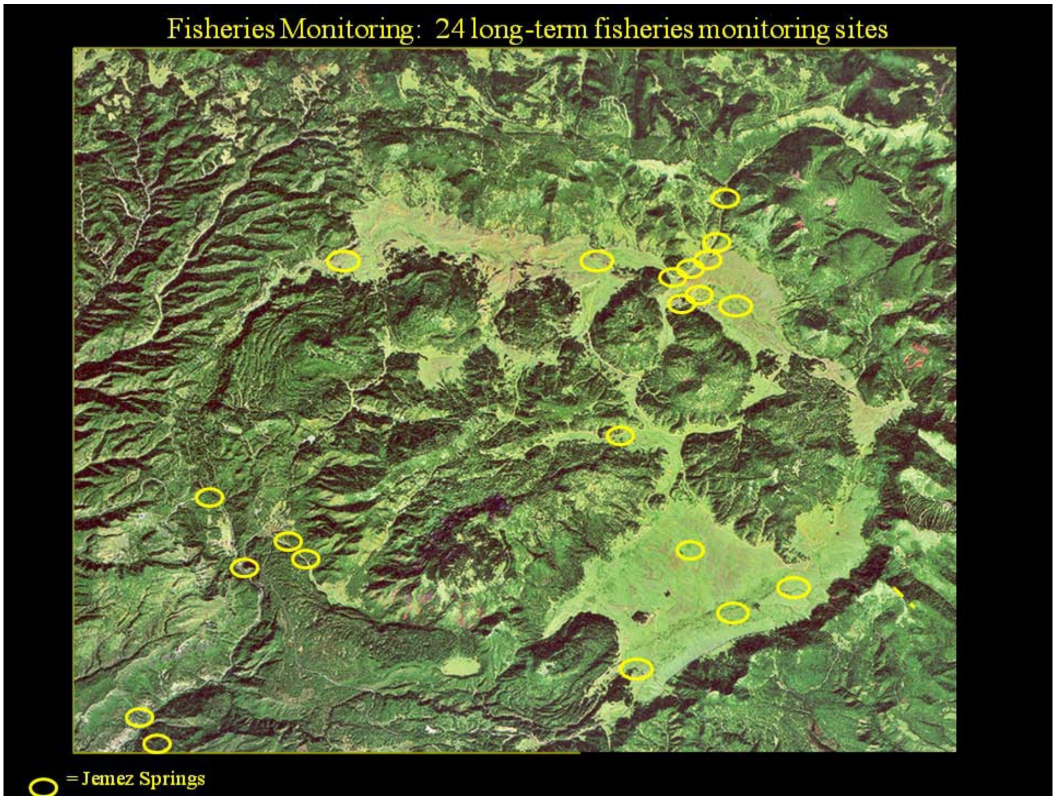


Fig. 30. Fish monitoring sites in the CFLRP Project Area (Jemez Springs and two sites in Vallecitos Creek not shown)

Results: The Las Conchas fire in 2011 proved to be the major "treatment" effect on fisheries within the watersheds of the Valles Caldera National Preserve, and the Thompson Ridge fire in 2013 had a major impact on the fish communities on the Jemez Ranger District. Long-term data on the Preserve's East Fork Jemez River illustrated the near-extirpation of brown trout and rainbow trout by the post-fire floods; similar impacts were observed on the Rio San Antonio in the Valle Toledo and the middle Valle San Antonio (Fig. 31). However, with the reduced abundances of predatory brown trout, the native non-game fish populations (typically the prey species of the piscivorous brown trout) began to increase. With the recovery of the trout populations, these native fish populations began to decline to pre-flood levels (Fig. 32).

Similarly, the post-fire floods from the Thompson Ridge fire had impacts on fish populations in the Rio San Antonio downstream of the confluence with Sulphur Creek/Redondo Creek near the La Cueva picnic area. Floods there caused declines in resident fish species, but these recovered within a year of the flood events (Fig. 33).

Vallecitos Creek contained only the non-native brown trout; due to fire and post-fire floods on the Paliza watershed, the brown trout population slowly declined between 2012 and 2014, finally going locally extinct in fall, 2014 (Fig. 34). This has provided an opportunity to restock the stream with native fish species.

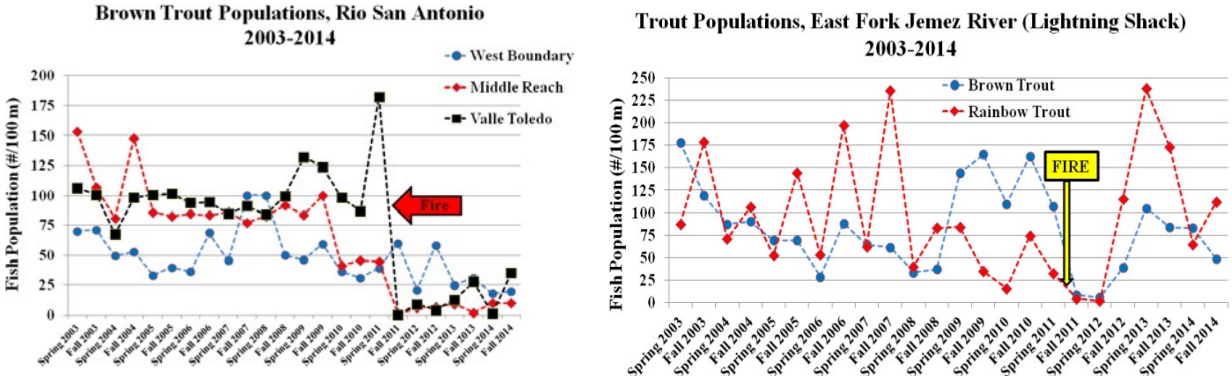


Fig. 31. Trout population data, 2003-2014, showing response to the Las Conchas fire in 2011.

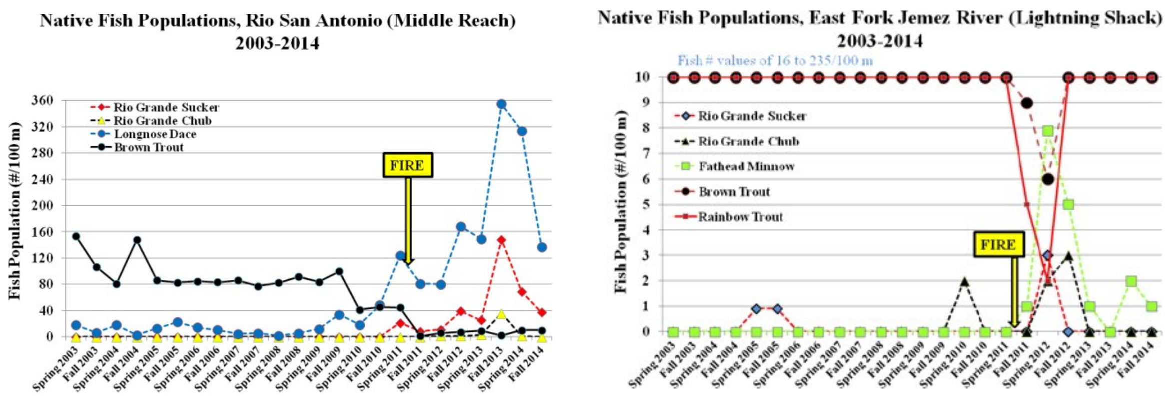


Fig. 32. Native fish population data, 2003-2014, showing response to the Las Conchas fire and loss of predatory brown trout in 2011.

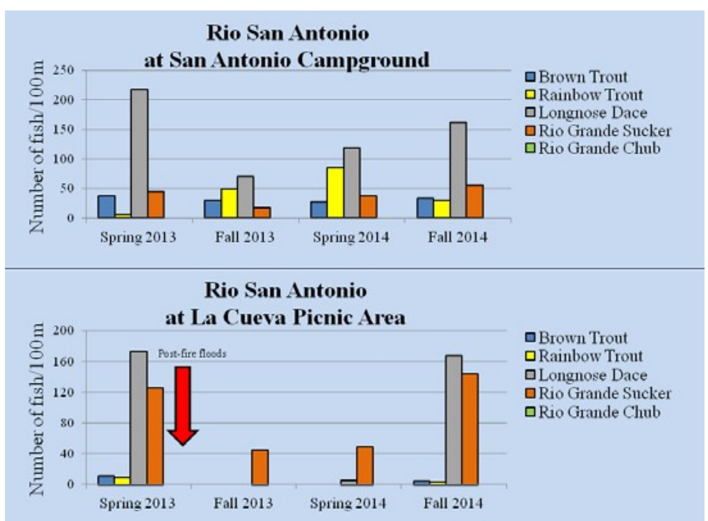


Fig. 33. Fish population data, 2013-2014, showing response to the 2013 Thompson Ridge fire. The San Antonio Campground site was upstream of the floods, and was the "control" site; La Cueva Picnic Area was flooded.

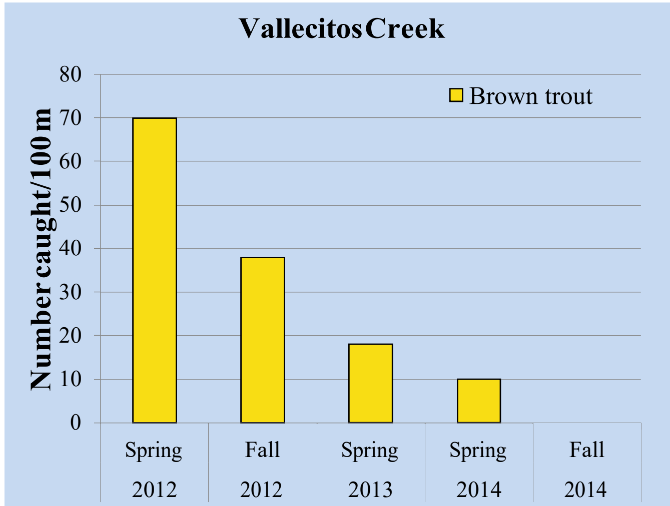


Fig. 34. Brown trout population data, 2012-2014 in Vallecitos Creek, exhibiting total extirpation from a series of flooding and channel scouring events.

Invertebrates: Forest restoration will change habitats for invertebrates, and is expected to increase the health conditions of trees and make them more resistant to pest insect attacks. In addition, increases in shrubs and forbs (wildflower species) on the more open, sunny forest floor, will alter habitat characteristics for beneficial insects (pollinating bees, moths and butterflies, and insect predators such as parasitoid wasps, spiders and beetles). We will monitor forest pest insects annually using aerial surveys (by USFS entomologists) and ground surveys in treated and untreated forest stands. Methods will include pitfall traps for ground-dwelling species, malaise traps and light traps for flying species, census rings for grasshoppers, pheromone-baited funnel traps for bark beetles, and hand- or net-collecting for particular target species (e.g., aphids, butterflies). Sampling data will permit estimates of species richness, diversity and relative abundances among habitats in restored and untreated stands.

Aquatic insect habitat is also expected to be altered by restoration actions (see fish habitat monitoring above). Aquatic insects will be monitored using Surber and/or Hess samplers to provide species composition, richness, diversity and density of aquatic invertebrates in streams.

Collaborators: USDA Systematic Entomology Laboratory, Smithsonian Institution, US Forest Service Region 3 [Forest Entomologists], Valles Caldera Trust, University of New Mexico (Museum of Southwestern Biology), USFS Rocky Mountain Research Station, New Mexico State University's USGS Wildlife Coop Unit, and Dr. Jerry Jacobi (consultant).

Results: Ground-dwelling invertebrates were monitored using pitfall traps in three different habitat types affected by the Las Conchas fires: mixed-conifer forests, ponderosa pine forests and grasslands (Fig. 35). In addition, pitfall traps were established and operated in the southern half of the Paliza burn area in 2013, covering both ponderosa pine and piñon-juniper-oak habitats. These latter traps were sampled through 2013, but the prescribed fire has not taken place as yet. These sites will be sampled post-fire as soon as the fire is implemented.

Results from the Las Conchas fire monitoring in grasslands showed various species-specific responses. We identified 8,849 grasshoppers and crickets (Orthoptera) comprising 18 species collected over 4 years (2011-2014). Orthopteran species showed three types of responses to grassland wildfire – 1) No response, 2) Short-term negative response, 3) Positive response. The most abundant species in grassland habitats (*Camnula pellucida*) was not significantly affected by wildfire. Many orthopteran species experienced a short term negative impact from the wildfire (Fig. 36), but the relative abundances of these species in burned areas had recovered by the first, second or third year after the fire. Seven species collected in grasslands were capable of becoming "pest" species, but only one pest species, the Mormon cricket (*Anabrus simplex*), showed a positive response to grassland wildfire. The number of Mormon crickets spiked in the year after the wildfire and have remained higher in burned grasslands even four years after the fire (Fig. 37). Overall, these findings suggest that orthopteran assemblages in grassland ecosystems are fairly resilient to wildfire. Species that are negatively affected will recover relatively rapidly, but species that benefit from wildfire may persist at elevated levels in burned grasslands for some time.

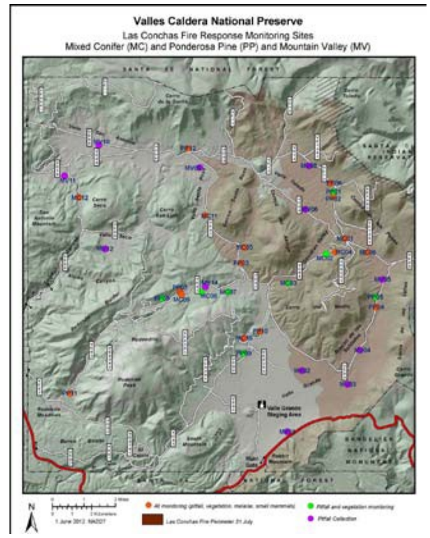


Fig. 35. Pitfall trap sites used to monitor surface-active invertebrates at burned and unburned sites following the Las Conchas wildfire in the Valles Caldera National Preserve

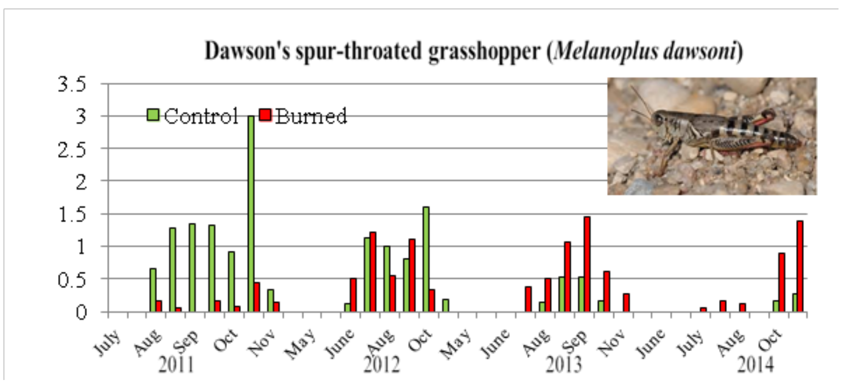


Fig. 36. Dawson's spur-throated grasshopper is a grassland orthopteran species that experienced a short-term negative impact from the Las Conchas wildfire.

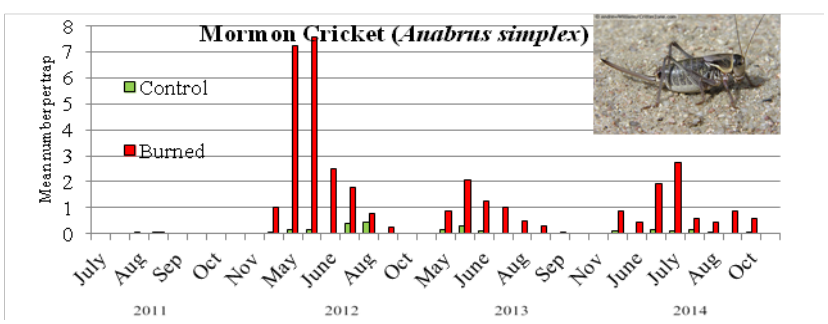


Fig. 37. The Mormon Cricket responded positively to the Las Conchas wildfire in grasslands on the Valles Caldera National Preserve and its numbers remained elevated in burned sites even four years after the fire.

In forests, we identified 7,193 orthopteran individuals comprising 13 species collected over 3 years (2011-2013) at mixed-conifer sites. Orthopteran diversity in mixed-conifer forests is lower than in grassland habitats and the camel cricket (*Ceuthophilus utahensis*) was overwhelmingly the dominant species. The camel cricket responded negatively to wildfire in severely burned mixed-conifer stands, but its numbers appeared to rebound in 2013--the second full year after the fire (Fig. 38). True grasshoppers (Acrididae) are not abundant in unburned mixed-conifer forests. By the second year after the fire, grasshopper nymph numbers were significantly higher in burned mixed-conifer stands (Fig. 39) indicating that the number of true grasshoppers are on the rise in burned forest sites. Severely burned mixed-conifer forests appear to be transitioning into a grassland-like habitat where grasshopper species are becoming more abundant and more diverse than in unburned mixed-conifer forests.

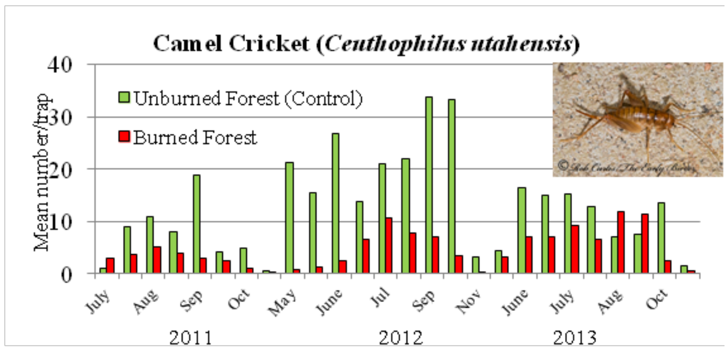


Fig. 38. The camel cricket was negatively impacted by the Las Conchas wildfire in mixed-conifer forests, but its numbers were well on their way to recovery by the end of the second year after the fire.

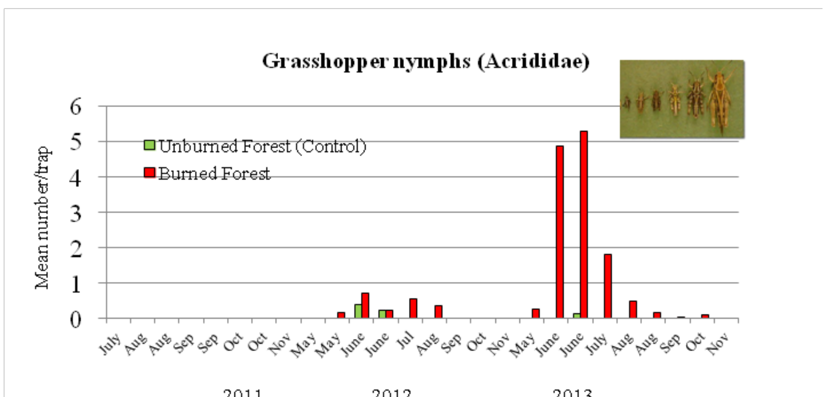


Fig. 39. True grasshopper nymphs began to appear in significant numbers in severely burned mixed-conifer forests about two years after the fire.

Our invertebrate data for orthoptera suggest that grassland orthopteran species that are negatively impacted by wildfire recover relatively quickly (within 1-3 years after the fire). Grassland habitats have been repeatedly subjected to wildfire throughout their history, and species existing in these habitats are apparently capable of withstanding periodic episodes of wildfire and able to persist. Moreover, the impacts of the Las Conchas wildfire on grassland habitats were probably no more severe than historic wildfire episodes on these grassland communities. The speed with which the Las Conchas fire passed through these grasslands precluded severe damage to soils or to dominant herbaceous species. Interestingly, grassland orthopteran species positively affected by wildfire (including one pest species) have managed to persist at elevated levels even several years after the fire.

Our data show that severely burned mixed-conifer forests appear to be transitioning into a grassland type habitat where true grasshopper species are becoming more abundant and more diverse than in unburned mixed-conifer forests. A dramatic transition in vegetation and corresponding invertebrate assemblages is underway in severely burned mixed-conifer forests; as the vegetation changes, the meadow/grassland fauna is coming along with the plants, and the anticipated meadow ecosystem is developing quickly.

Other groups of invertebrates are being identified and analyzed (e.g., spiders, beetles, millipedes and ants), and these taxa will provide additional insights into the impact of fire and restoration treatments on ecosystem structure and functioning.

Aquatic invertebrate communities in streams that had sustained post-fire flash floods exhibited reduced numbers of individuals (standing crop) and species (number of taxa) (Fig. 40). Other sites that were further from the flood impacts had less change in composition and abundances. However, even with the floods, the general indices for aquatic invertebrate assemblages indicated only a minor impact had occurred. Many of the taxa in high-quality streams were still present following Las Conchas.

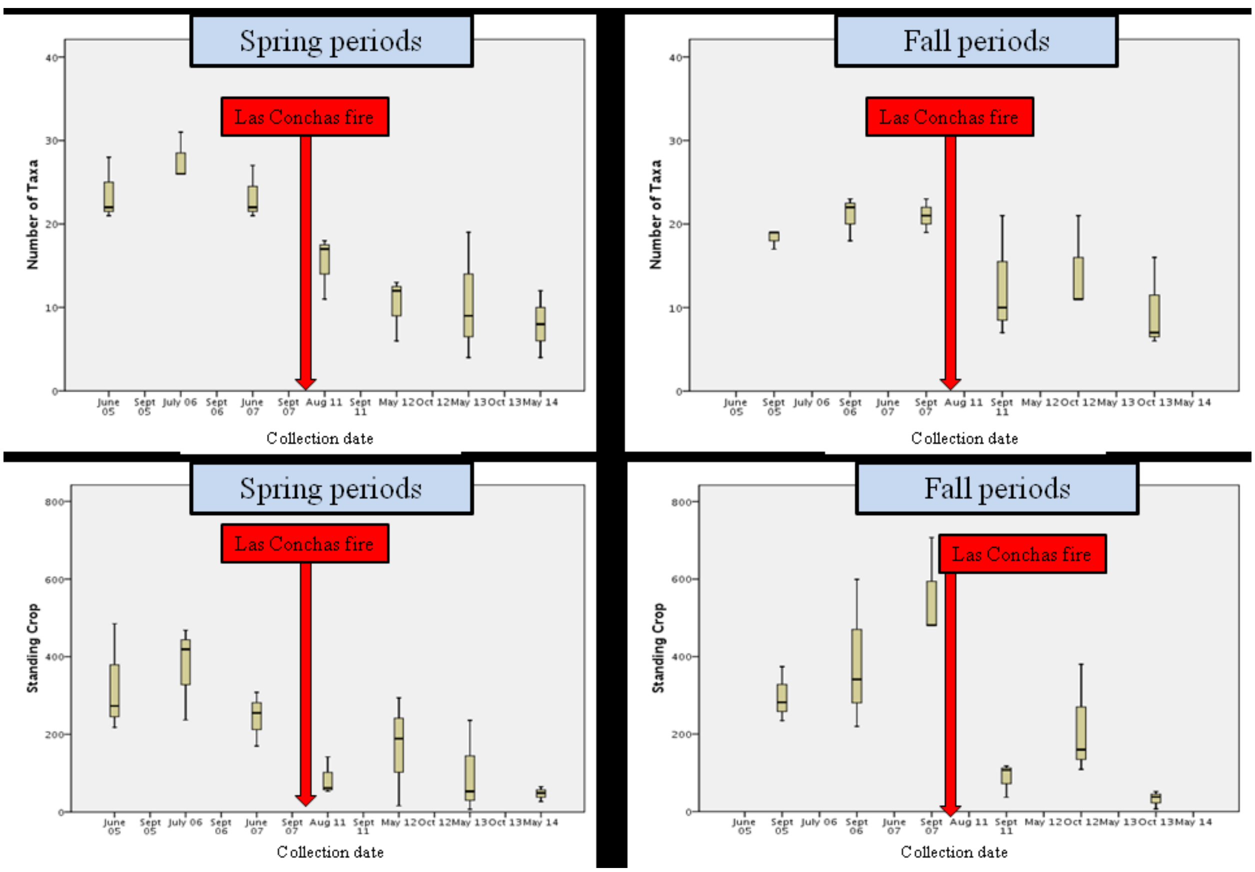


Fig. 40. Aquatic invertebrate responses to floods in Indios Creek following the Las Conchas fire

Objective 4. **Maintain or improve water quality and watershed function.**

Monitoring approach: As described in the proposal, we expect that restoration treatments of thinning and burning will improve watershed function by increasing stream discharge during spring snowmelt periods. In addition, water quality improvements may occur due to shifts in the type and extent of understory vegetation cover on watersheds (increased grasses and forbs). Restoration of willow and alder communities, including the reintroduction of beavers, along perennial streams should also improve water quality (especially temperature and turbidity). To monitor stream water quantity and quality during restoration treatments, we will install flumes and gauging stations for discharge monitoring, and water quality instruments (sondes) to measure water temperatures, dissolved oxygen, pH, conductivity and turbidity. We will use paired watersheds (treated and untreated) measured before and after treatments to determine the degree to which treatments have achieved the predicted increases in discharge and water quality. For watersheds that do not have sufficiently long data sets prior to treatment, we will use hydrology models to estimate discharge under current watershed conditions, and compare these estimates to the observed discharge amounts after forest restoration treatments. Soil erosion is expected to be reduced through increased vegetation cover on the watershed and stabilization of stream banks. Landscape-level soil erosion will be monitored through LiDAR data collected before and after the 10-year restoration effort. Pre-treatment LiDAR data were collected on the VCNP and SFNF during 2010, and will be repeated in 2019. Differences in soil erosion patterns and amounts in both treated and untreated watersheds will be computed.

Collaborators: Valles Caldera Trust, Santa Fe National Forest, USGS, New Mexico Environment Department, Jemez Pueblo, The Nature Conservancy, NM Forest & Watershed Restoration Institute (Highlands University), WildEarth Guardians, Arizona State University, University of New Mexico, New Mexico Tech, University of Arizona, Desert Research Institute.

Results: Stream water quality is measured using Sonde instruments for temperature, pH, conductivity, dissolved oxygen, and turbidity (Fig. 41). Stream water quality was greatly influenced by post-fire flooding from the Las Conchas fire and the Thompson Ridge fire. These fire effects were far greater than any impact we would have seen from watershed restoration activities. For example, the turbidity levels in the Rio San Antonio prior to the Las Conchas fire showed very low levels during the summers of 2008-2010; however, after the

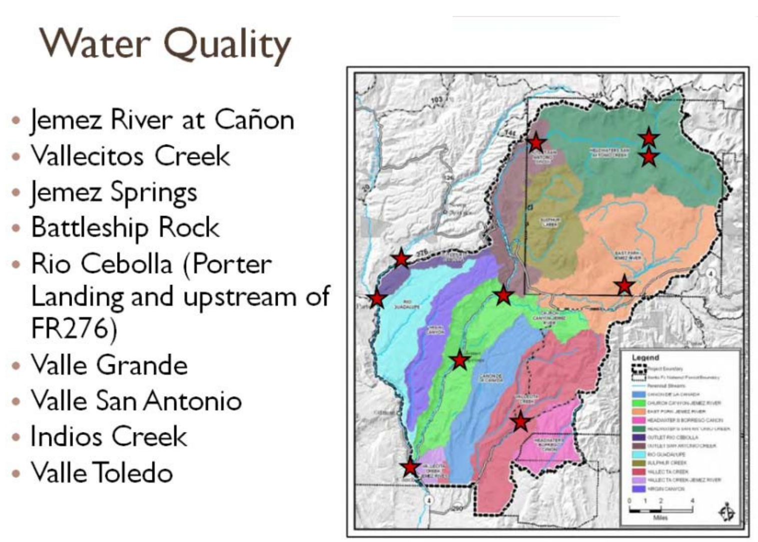


Fig. 41. Locations of water quality instruments (Sondes) in the CFLRP project area

Las Conchas fire burned the upper watershed, turbidity spikes occurred during every monsoon season in 2011-2014 (Fig. 42). Additional dynamics of other variables (dissolved oxygen, pH, conductivity) also occurred during each flood (Fig. 43). These changes led to large trout kills in the flooded areas, although the native fish species appeared to survive in good shape.

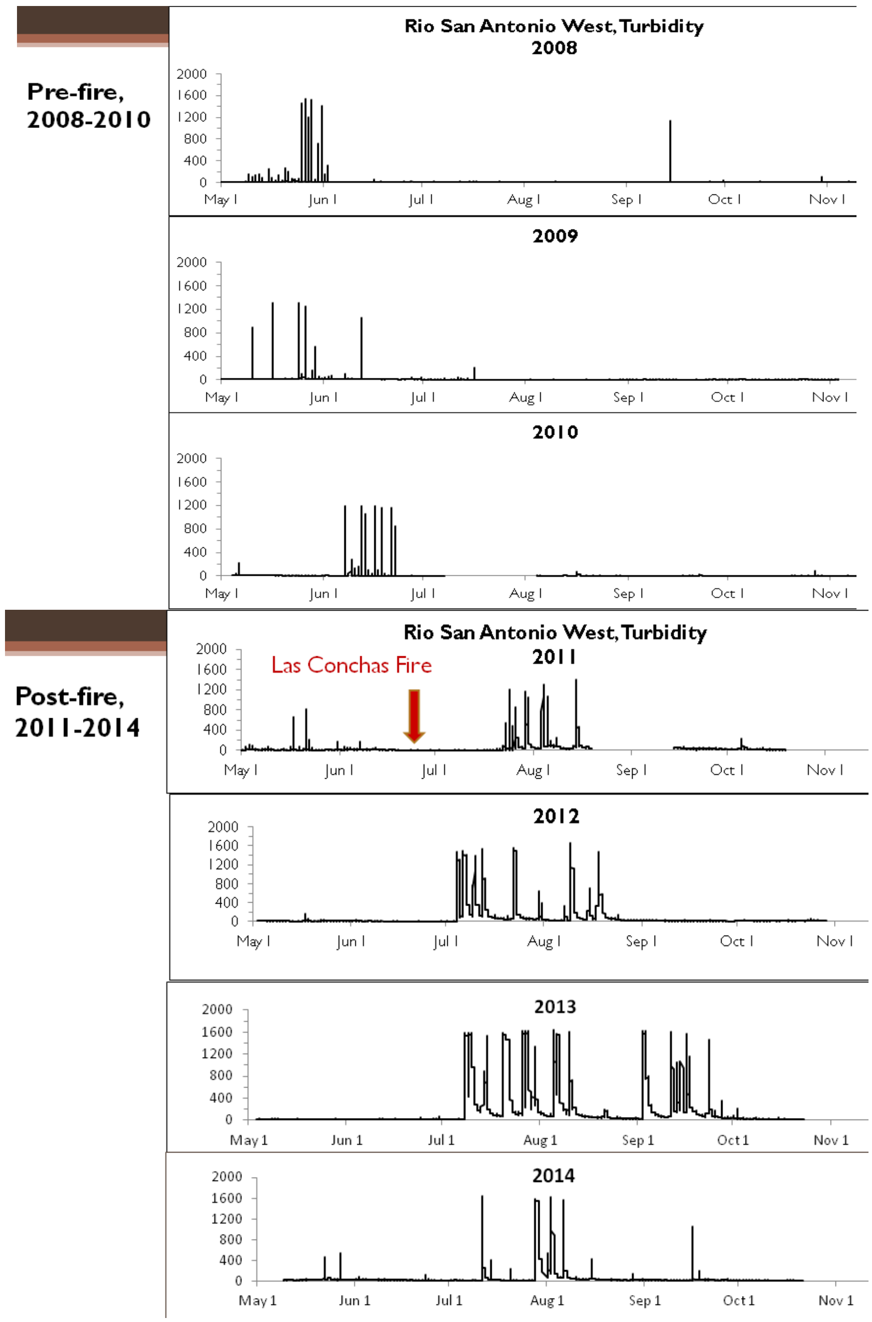


Fig. 42. Turbidity patterns in the Rio San Antonio during 2008-2014; note large turbidity spikes following the Las Conchas fire in 2011.

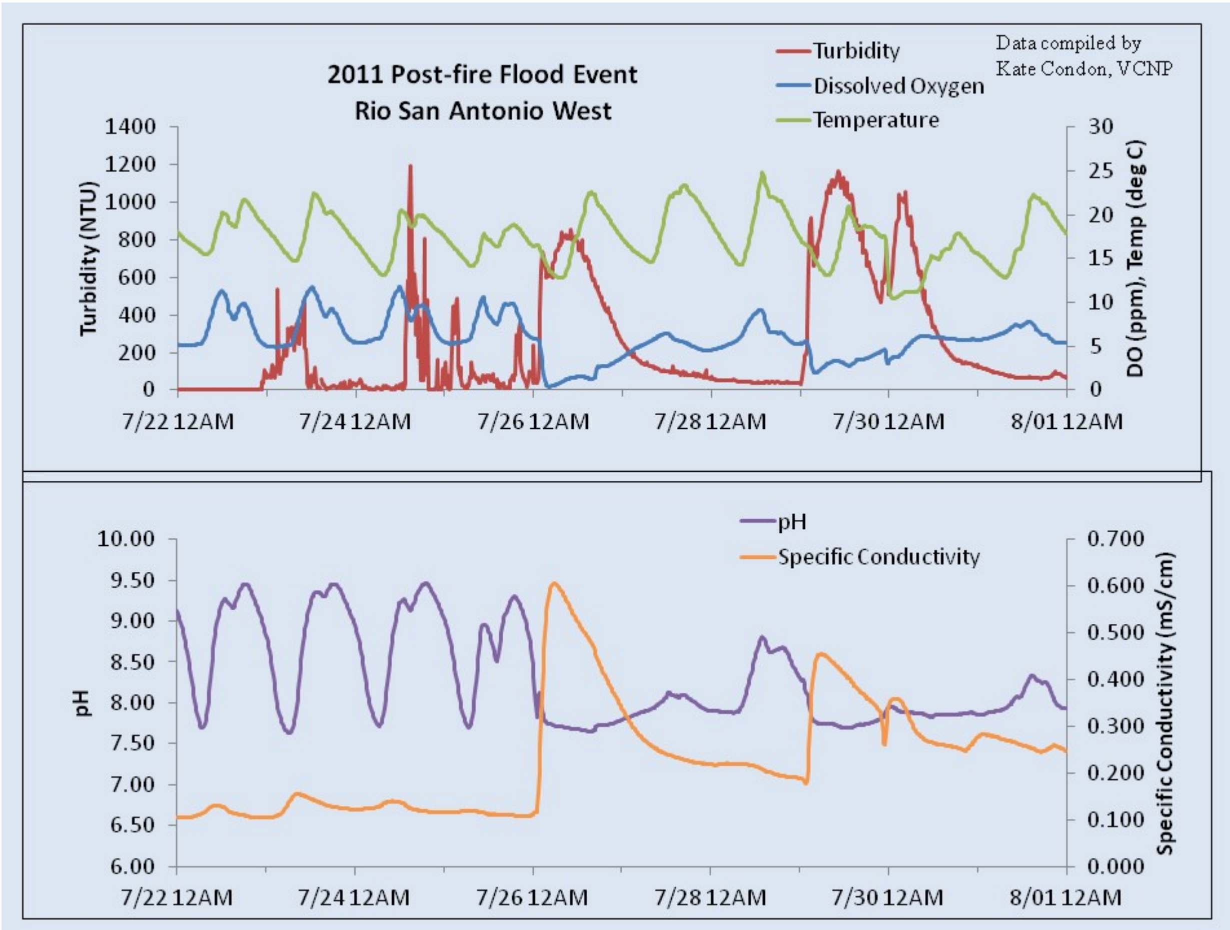


Figure Fig. 43. Water quality responses to flash floods in the Rio San Antonio during July, 2011, following the Las Conchas fire in 2011. Note the spike in turbidity on 26 July, accompanied by the drop in dissolved oxygen and pH, and an increase in conductivity

Stream discharge on CFLRP watersheds reflects the general drought conditions during the project thus far, with well-below average stream flows compared to the long-term average (Fig. 44). Future gauge and flume measurements will allow us to determine if watershed restoration will increase net water yield in streams following spring snowmelt.

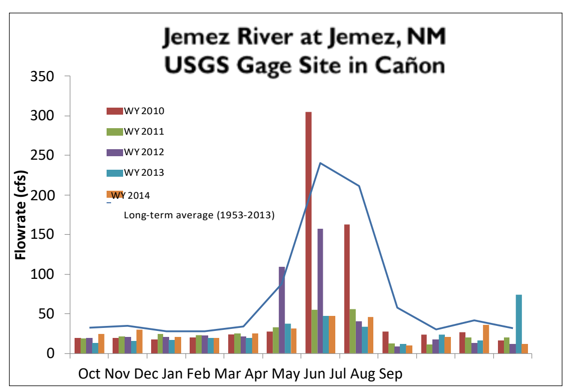


Fig. 44. Discharge by month of the Jemez River, 2010-2014, compared to the long-term mean.

Objective 5. Prevent, remediate, or control invasions of exotic species.

Monitoring approach: Invasive plants may become established in restored areas as a result of soil disturbances during restoration activities (e.g., machinery and vehicle tracks) or potential increases in human or livestock use of restored areas. Monitoring for invasive non-native species will be conducted continuously by project biologists during ongoing monitoring activities, and during special reconnaissance surveys specifically for invasive plants. Once identified by species and location, invasive plants will be subjected to control/eradication efforts according to existing NEPA-approved procedures (on VCNP). Continued monitoring of these sites will provide data on the degree of control success, and will generate information for future control actions as necessary.

Collaborators: Bureau of Land Management, Valles Caldera Trust, Santa Fe National Forest, USGS, Bandelier National Monument, Jemez Pueblo, Santa Clara Pueblo, The Nature Conservancy, NM Forest & Watershed Restoration Institute (Highlands University), USFS Rocky Mountain Research Station, WildEarth Guardians, Forest Guild.

Results: Invasive plant populations have been mapped and treated with herbicide during 2014 on the Valles Caldera National Preserve (see example of Bull Thistle in Fig. 45). Many new populations of non-native thistles, daisies and cheatgrass have been identified, and the CFLRP staff has been trained to deploy herbicide so that our efforts in invasive control will increase. Field crews document with GPS any new populations of invasive plants, and this information is passed along to the trained herbicide staff for treatments.

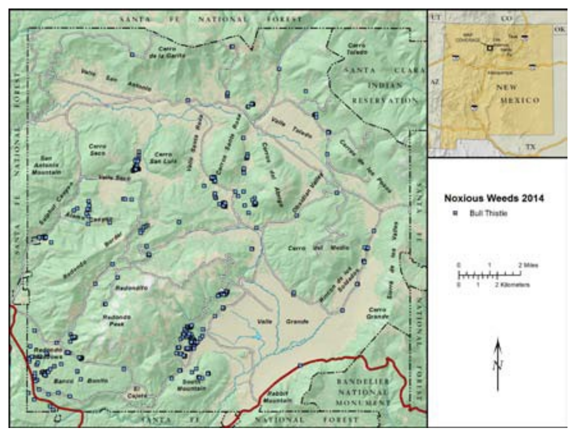


Fig. 45. Map of Bull Thistle locations.

Cultural Resources Monitoring

This section discusses the protection and preservation of cultural resources, an indirect objective of the CFLRP project.

Objective: Increase the resistance of cultural resources to natural and human disturbances.

Monitoring approach: Cultural resources include archaeological and historic sites and artifacts, cultural landscapes, and ethnographic values (i.e., tribal resource procurement areas, traditional cultural properties, and sacred sites). Across the project landscape, we use pedestrian surveys and site assessments to inventory archaeological and historic sites, and to account for potential effects as part of project planning in advance of implementation. Data are compiled across project areas to inform on broad patterns of changing human land uses over the past 10,000 years and to build baseline data to define and understand cultural landscapes. Tribal consultation and collaborations define values of concern for local and regional tribes and pueblos. Identification of resources, areas, and locations of tribal interest informs the preservation of traditional cultural properties and helps prioritize the sustainability of forest and riparian resources associated with traditional practices.

Specific objectives of CFLRP cultural resources inventory and monitoring are:

(1) to minimize fire effects by reducing fuel loadings on archaeological sites;
(2) to protect subsurface deposits by avoiding or controlling erosion and ground disturbance at archaeological sites; and
(3) to maintain forests and watersheds to assure continued engagement in traditional practices.

Both fire and restoration activities have the potential for alteration and disturbance of cultural resources. Monitoring efforts to-date have focused on standardizing the assessment of cultural resource fire sensitivity, fuel loadings, and erosion risks; prioritizing locations for archaeological protection actions; and developing effective site-treatment plans to minimize or avoid damage from fire and forest and watershed restoration treatment activities.

Collaborators: Valles Caldera Trust, Santa Fe National Forest, Jemez Pueblo, Santa Clara Pueblo, USFS Rocky Mountain Research Station Missoula Fire Lab, The Forest Guild, USGS, Bandelier National Monument, Joint-Fire Science Program, University of New Mexico, Earthwatch Institute, Vince Archer and Eric Moser (consultants)

Results :

Pedestrian inventory, site condition assessments, and site fuels treatments: Just over 20,000 acres of surveys have been completed since 2010. On the Valles Caldera National Preserve, areas include Banco Bonito; Valle Grande; Valle Seco and Mormon Canyon; and the San Antonio, Jaramillo, and Sulphur valley/wetlands areas. On the Jemez District of the Santa Fe National Forest, areas include Lakes North and South; Paliza Canyon; Cat and San Juan Mesas; and the East Fork of the Jemez River. On Jemez Pueblo, areas include Paliza, Canada de Cochiti, and Borrego Mesa. New or updated documentation has been completed at over 680 archaeological sites, and the collaborating agencies have developed and adopted a standardized protocol for assessing fuel-loading and other hazards. Pre-treatment site condition assessments serve as a baseline for monitoring and are used for planning and implementation of manual-removal of fuels at sites with surface cultural features (mainly field houses and pueblos). To-date, the SFNF has completed fuel-treatments at 800 sites, a remarkable number that likely is unprecedented in the northern Southwest region.

Post-fire and Rx fire monitoring: The Las Conchas and Thompson Ridge wildfires affected nearly 50% of the known sites in the VCNP portion of the CFLRP area. Post-fire assessments have proceeded slowly due to the scale of the affected area, but so far 60 sites have been revisited (mostly within the Thompson Ridge fire area). On the SFNF, post-fire work has been in areas of prescribed or managed fires, including the Stable Mesa, San Juan Mesa, Virgin Canyon, and Pino fire areas. Erosion monitoring installations have been placed at 20 locations for quantifying erosion outcomes both following wildfires and in advance of planned ignitions in locations ranging from Cerro del Medio, the Paliza Rx planning area, Valle Grande, and Banco Bonito. Installations include either erosion bridges or rectangular pin plots, with precipitation and soil moisture sensors paired with the latter at three locations on Cerro del Medio. Finally, the Rocky Mountain Research Station Fire Lab, funded in part by a research grant from the Joint Fire Sciences Program for the "ArcBurn" project, joined with SW Jemez CFLRP to do archaeological fire effects monitor during the San Juan and Pino fires. Data outcomes from burn periods include thermocouple temperature profiles, visual and infrared video, and fire effects observations on prehistoric artifacts and masonry. Outcomes assessments are already being used now to adjust on-site fuel-removal protocols across the SFNF Jemez Ranger District. Additional similar Rx burn monitoring is planned for sites in the Valle Grande and other areas of the Paliza planning area.