Summary Monitoring Report 2021

Southwest Jemez Mountains Collaborative Forest Landscape Restoration Project (CFLRP) and Landscape Restoration & Management Program (LRMP): Natural and Cultural Resources

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Introduction

The Southwest Jemez Mountains Collaborative Landscape Restoration Project (SWJM CFLRP) and Landscape Restoration and Management Program (LRMP) on the Santa Fe National Forest and the Valles Caldera National Preserve, respectively, are long-term collaborative efforts to restore forest ecosystems at the landscape scale and improve resilience to major disturbances, including fire, insects and disease, and climate change. Lead partners include the Santa Fe National Forest (SFNF), Valles Caldera National Preserve (VCNP), US Geological Survey, Forest Stewards Guild, New Mexico Forest and Watershed Restoration Institute, New Mexico Forest Industry Association, Pueblo of Jemez, WildEarth Guardians and The Nature Conservancy. The entire SWJM Collaborative includes 39 organizations, agencies, tribes and universities (Table 1).

This summary report represents the results of the Southwest Jemez Mountains CFLRP and LRMP implementation and monitoring programs. 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 and LRMP based on their monitoring work through 2021, but primarily focusing on the implementation and monitoring undertaken during the Covid-19 pandemic of 2020 and 2021 during which time the annual “All Hands” meetings could not be held. The CFLRP/LRMP Collaborative is planning on resuming these in-person meetings in spring of 2023.

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,

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

(6) create local economic development opportunities.

Table 1. List of collaborating organizations for the Southwest Jemez Mountains Collaborative Forest Landscape Restoration Program

1. Bandelier National Monument, National Park Service
2. Forest Stewards Guild
3. Hawks Aloft, Inc.
4. Keystone Restoration Ecology
5. Los Alamos National Laboratory
6. Los Amigos de Valles Caldera
7. New Mexico Department of Game and Fish
8. New Mexico Environment Department
9. New Mexico Forest & Watershed Restoration Institute, Highlands University
10. New Mexico Forest Industry Association
11. New Mexico State Forestry Division (Energy, Minerals and Natural Resources Department)
12. New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology
13. New Mexico Trout
14. Northern Arizona University
15. Pueblo of Jemez
16. Pueblo of Santa Clara
17. Rio Grande Return
18. Rio Grande Water Fund
19. Rio Puerco Alliance
20. Rocky Mountain Elk Foundation
21. Santa Fe National Forest, U.S. Forest Service
22. Texas Tech University, Department of Natural Resources Management
23. The Nature Conservancy
24. Trout Unlimited
25. U.S. Bureau of Indian Education, Southwestern Indian Polytechnic Institute, Department of Natural Resources Management
26. U.S. Department of Agriculture, Systematic Entomology Laboratory/Smithsonian Institution
27. U.S. Fish & Wildlife Service
28. University of Arizona, Department of Soil, Water and Environmental Science
29. University of Maryland, Center for Environmental Science
30. University of Nevada, Desert Research Institute
31. University of New Mexico, Department of Biology
32. University of New Mexico, Museum of Southwestern Biology
33. USGS, New Mexico Landscapes Field Station
34. USGS, New Mexico Cooperative Fish and Wildlife Research Unit
35. Valles Caldera National Preserve, National Park Service
36. Village of Jemez Springs
37. Walatowa Timber Industries & TC Company
38. Wild Turkey Federation
39. WildEarth Guardians

The SWJM CFLRP has fostered partnerships with land management entities within the project area (Pueblo of Jemez and Valles Caldera National Preserve) as well as a number of NGOs to greatly increase the amount of on-the-ground work and monitoring that we have accomplished. Of particular note is the robust monitoring program coordinated by the Valles Caldera NP, supported by a combination of Forest Service and NPS funding. In addition to forest restoration and fire/fuels management, the Collaborative has greatly expanded restoration of streams and wetlands – partnerships with Rio Grande Return, Rio Puerco Alliance, Los Amigos de Valles Caldera, Keystone Restoration Ecology, the Pueblo of Jemez, Trout Unlimited, New Mexico Trout, The Nature Conservancy, the Forest Stewards Guild and the New Mexico Environment Department have in particular increased our capacity to conduct riparian and water quality improvements along streams and degraded wetlands throughout the project area.

The partnership between the Pueblo of Jemez and TC Company, the operator on the Stewardship Contract, to feed and operate the Walatowa Timber Industries mill, ensures that our restoration efforts produce forest products that support the local economy and provide jobs for residents of the Pueblo.

A unique facet of the SWJM project area is the prevalence of cultural sites, this being the ancestral homeland of the Pueblo of Jemez. We have treated vegetation/fuels on a vast majority of the known cultural sites (primarily ruins of field houses and pueblos) on the SFNF and the Preserve to protect them from damage due to wildfires. These efforts have additionally strengthened our relationship with the Pueblo.

While the authorized 10-year funding under the CFLRP program lapsed following the 2019 federal fiscal year, restoration and monitoring work continues with previously obligated funding, appropriated funds, and cooperator contributions, both financial and volunteer.

Chapter 1. Implementation Summary

SW Jemez CFLRP – Forest Service Update

Project implementation has continued throughout the project period, although the Covid-19 pandemic, the Mexican Spotted Owl injunction, and periodic fire restrictions played havoc with work schedules. Overall, restoration work in the project area on the Santa Fe National Forest (Table 1.1, Fig. 1.1) has accomplished 5,196 acres of thinning treatments with an additional 2,796 acres under contract, 14,797 acres of planned (prescribed) burns, and 9,093 acres of managed natural fires. In addition, 156 acres of stream and wetlands have been treated, along with 104 acres of invasive plants being treated.

Table 1.1. List of SFNF Implementation Projects 2010-present.

Project Name	Acres	Year(s) Treated
Thinning Fuels Treatments		
Jemez Falls Cut and Pile	90	2014
Los Griegos Cut and Pile	627	2015-2016
Vallacitos Cut and Pile	318	2017-2018
Holiday Mesa Mechanical Lop and Scatter	664	2018
Borrago Canyon Cut and Pile	82	2018-2019
Cat Mesa Cut and Pile	685	2019
East Fork Cut and Pile	117	2020
San Diego WUI	90	2020
Virgin Mesa Mechanical Lop and Scatter	135	2021
San Juan East Cut Skid Deck	171	2022
Broadcast Prescribed Burns		
San Juan Rx	7359	2012
Virgin North Rx	644	2015
Thompson Ridge Rx	238	2015
Virgin South Rx	621	2017
Stable Mesa Rx	1950	2017
Cebollita South Rx	1080	2018
Tent Rocks Rx	1310	2019
Stable Canyon Rx	1595	2021
Managed Natural Ignitions		
Virgin Canyon Fire	1706	2010
Guacamalla Fire	1558	2011
Bear Spring Fire	363	2012
Stable Fire	406	2013
Pino Fire	4284	2014
Canejos Fire	776	2019
Commercial Thinning Treatments		
Los Griegos Sale	143	2016
Pino West Task Order	1219	2017 - 2021
East Fork Task Order	360	2019 - 2020
Falls Task Order	178	2020
Cerro Pelado Task Order	317	2021 - 2022
Awarded Task Orders		
Paliza South	1067	2022
Cebollita	989	2022 - 2023
Redondo	740	2023 - 2024
Stream Restoration		
San Antonio Creek	120	2017 - 2021
Rio Cebolla	36	2018 - 2019
Invasives Treatments		
Lower Jemez River	82	2021
East Fork Oxeye Daisy	22	2021

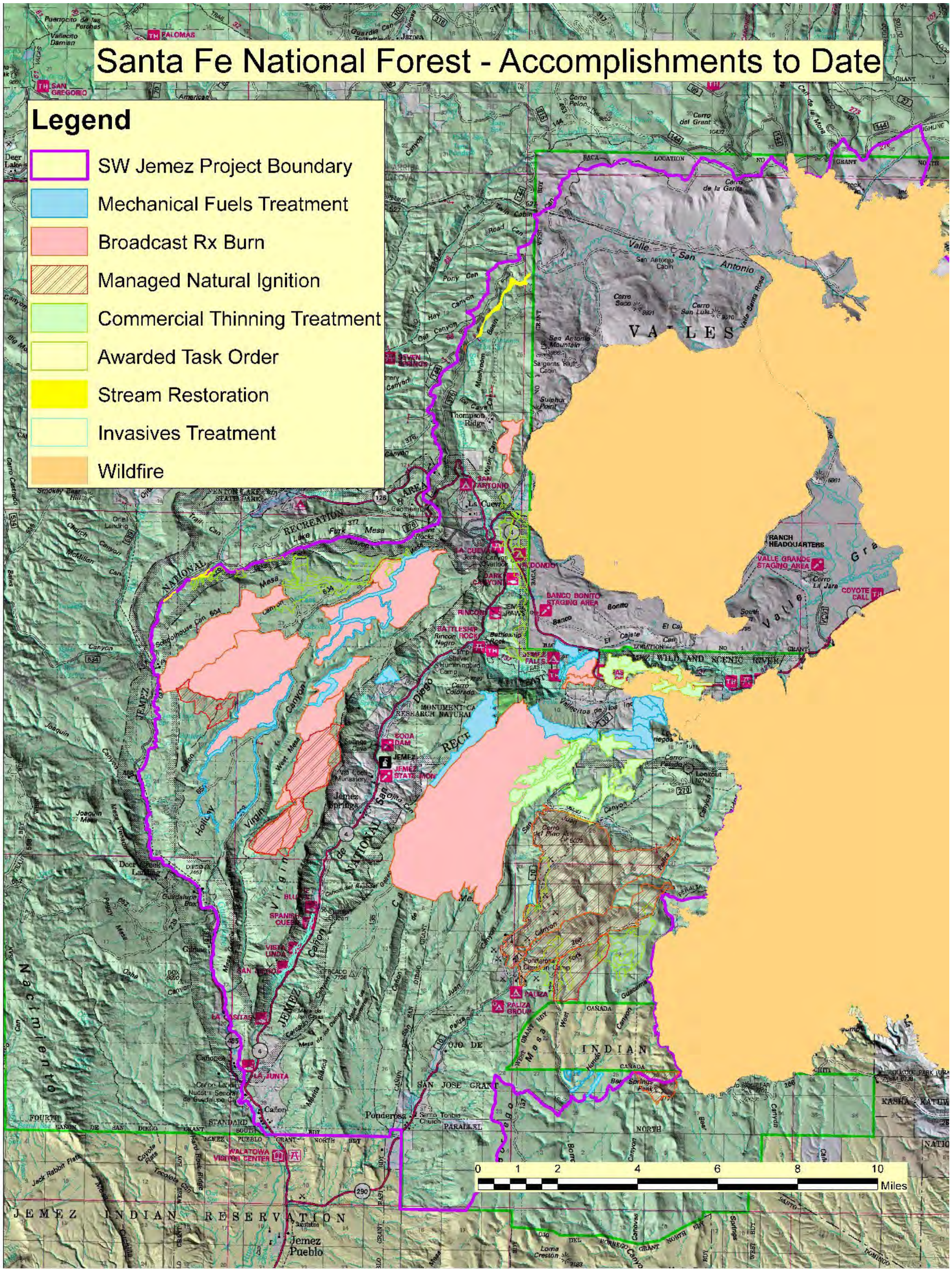


Fig. 1.1. Map of SWJM CFLRP implementation projects on the Santa Fe National Forest.

The East Fork and Falls Task Orders were completed in 2020, and the Pino West Task Order was completed in the fall of 2021. These treatments border on the residential areas of Bennet Lane and Sierra los Pinos, greatly reducing fire risk from Forest Service lands. In addition, more than 11 miles of road were decommissioned in and around the East Fork T.O., and 3.5 miles in Pino West. Thinning in the Cerro Pelado Task Order had just wrapped up when the Cerro Pelado wildfire burned through almost the entire treated area, starting on April 22nd. Preliminary observation of a limited number of the units was that fire behavior was affected by the treatments, dropping fire to the ground, but the extreme temperatures fueled by 50 mph+ winds has scorched the bases of the trees and will likely result in heavy mortality of a large percentage of the residual trees (Fig. 1.2).

Fig. 1.2. Cerro Pelado treatment unit following the wildfire. Note untreated stand in the background and surviving(?) trees the thinned foreground. The consumed log deck indicates extreme burn conditions.

In two locations on the West Mesas, we employed a novel technique using masticator to fell small trees and reduce slash without completely chipping them (“mechanical lop and scatter”) to thin and create holding lines for prescribed burns (Fig. 1.3). Also note that skinning the bark off of the tree boles allows for quick drying, minimizing the risk of bark beetle outbreaks from slash.

Fig. 1.3. Left: Mechanical lop and scatter on Holiday Mesa; Right: Masticator

A thinning project, San Juan East, has just been completed along Forest Road 10 on the eastern side of the District, where smaller trees have been thinned out and decked to provide a source of easily-accessible personal-use firewood (Fig. 1.4).

Fig. 1.4. Before and after photopoint, San Juan East cut/skid/deck

The use of fire was held up somewhat during the owl injunction, as well as during the height of the pandemic due to concerns around smoke complicating the effects of COVID. As conditions allowed, slash piles in the three previously mentioned task order areas were burned. Prior to the pandemic in 2019, the Tent Rocks broadcast burn obtained some excellent results on 1300 acres of Virgin Mesa, and adjacent to the community of La Cueva. This burn utilized the aforementioned mechanical lop and scatter holding lines to great effect.

Also in 2019, a lightning strike on Canejos Peak off of Forest Road 266 provided an opportunity to manage the fire for resource benefits. Unique to this project was the fact that the planned perimeter also included the previously awarded Paliza South Task Order. T.C. Company, the contractor for all of the Task Orders was supportive in allowing us to achieve our fuels management objectives prior to operating there.

A 2019 project in cooperation with NM State Forestry, NRCS, the Pueblo of Jemez, and homeowners in the Area 3 residential area north of Jemez Springs, thinned and piled fuels both on Forest Service and private land to reduce fire risk (Fig. 1.5).

Fig. 1.5. Thinned and piled fuels, and holding line for pile burning along Forest/private boundary

More recently, in September 2021, a 1,595-acre broadcast burn was conducted in Stable Canyon, on the west side of the West Mesas (Fig. 1.6). This is the first prescribed burn in a Mexican spotted owl protected Activity Center (PAC) and achieved excellent effects.

Fig. 1.6. Stable Canyon Broadcast Burn (credit A.Silva)

The stream restoration crew, transitioned from WildEarth Guardians to Rio Grande Return, has made excellent progress on the San Antonio Restoration Project, including a number of new beaver dam analogs (BDAs) and instream log structures, the extension of an existing exclosure, a new 10-acre exclosure, and control of sedimentation from the abandoned section of FR 376 (Fig. 1.7). This additional work was accomplished in part with a grant of $65K from the National Forest Foundation.

Fig. 1.7. Before and after images of stream restoration (BDA) in San Antonio Creek (credit R. Whittlesey, RGR)

A cooperative effort between Trout Unlimited, The Nature Conservancy, the San Diego Cattlemen's Association, and the Forest Service installed water wells on the uplands either side of San Antonio Creek (Fig. 1.8). The objective is to provide a source of water on the uplands to reduce the tendency of cattle to migrate into the canyon and the riparian area. Pipe and drinkers will be installed this season.

Fig. 1.8. Well site on the west upland of San Antonio Creek (credit A. Bishop)

Mexican spotted owl monitoring by Forest Service staff confirmed 10 (!) fledglings in 2020 and 3 in 2021 within the SW Jemez CFLRP footprint (Fig. 1.9).

Fig. 1.9. Adult Mexican spotted owl

Through an agreement with the Bureau of Land Management roads crew, storm-proofing and pipe barrier installation were conducted in Mushroom Basin in November of 2020 to reduce erosion and prevent unauthorized use of closed roads (Fig. 1.10).

Fig. 1.10. Pipe rail (in progress) and erosion control structure in Mushroom Basin

Archaeological site thinning continued over the last 3 years, also held up some by the owl injunction and Covid. This ongoing project removes fuels from around archaeological sites, mainly field house and pueblo ruins, to protect the fragile tuff rock from fire damage (Fig. 1.11). No treatments were accomplished in 2019 due to the injunction, and the pandemic halted the project in 2020. 154 sites were treated in 2021, bringing the total to around 1,500 sites since 2013. In addition, we have conducted fuels assessments on approximately 2,200 sites in this timeframe as well.

Fig. 1.11. Thinned archaeological site.

2021 saw some of our first invasive plant control efforts. The Pueblo of Jemez Forestry Crew cut and stump-treated Russian olive and salt cedar along the lower Jemez River, and an Ancestral Lands crew hand-pulled oxeye daisy along the upper portion of the Jemez, just above Jemez Falls (Fig. 1.12). Additional oxeye daisy was treated with herbicides around the Las Conchas Trailhead, where thick sod made hand pulling ineffective by Forest Service personnel.

Fig. 1.12. Ancestral Lands crew pulling oxeye daisy, and bagging the seed heads

Finally, boundary surveys were completed around residential Areas 1,2 and 3 north of Jemez Springs in 2021 (Fig. 1.13). This can facilitate future fuels treatments similar to what was completed adjacent to Area 3 in 2021. Some of the ground the surveyors covered and signed were extremely rough, very impressive!

<u>Future Implementation</u>: Planned activities in 2022 include thinning treatment of the 1,067 acre Paliza South Task Order. Prescribed burning is planned for Cat and Holiday Mesas, as well as pile burning in Cerro Pelado. Additional stream work in San Antonio (exclosures and riparian planting) will be conducted by Rio Grande Return, funded by NM Department of Game and Fish. Riparian invasive plant control by the Pueblo of Jemez will continue, and pending availability of funds, additional oxeye daisy and invasive thistle treatments via contract.

Fig. 1.13. Surveyed and signed Forest/private boundary above Soda Dam. Signs on opposite slope are circled.

SW Jemez Mountains LRMP – National Park Service Update

Valles Caldera National Preserve

During the period of 2019-2021, the National Park Service conducted 23 forest thinning projects covering 4,039 acres on Valles Caldera National Preserve (Fig. 1.14, Table 1.2). These projects brought the total thinned acreage during the CFLRP/LRMP to 9,444 acres. The overall strategy of the thinning actions on the Preserve has been to concentrate on forested areas that had not been partially burned during the 2011 Las Conchas Fire or the 2013 Thompson Ridge Fire (the yellow shaded areas in Fig. 1.14). In addition, the Preserve has focused on thinning the south-facing slopes of the forested domes within the caldera (as these are the warmer, drier aspects that tend to burn hotter during wildfires), as well as the Banco Bonito lava flow in the extreme southwest corner of the Preserve. Steeper slopes were thinned by hand crews using cut-and-pile or lop-and-scatter techniques, whereas flatter areas were thinned using mechanical equipment with removal of the logs to commercial forest products vendors (e.g., Walatowa Timber Industries at the Pueblo of Jemez, of Pete's Landscaping for firewood in Albuquerque).

During this same time period, the Preserve also undertook 9 planned burn operations totaling 6,274 acres: five of these were broadcast burns and four were areas of pile burns (Table 1.3).

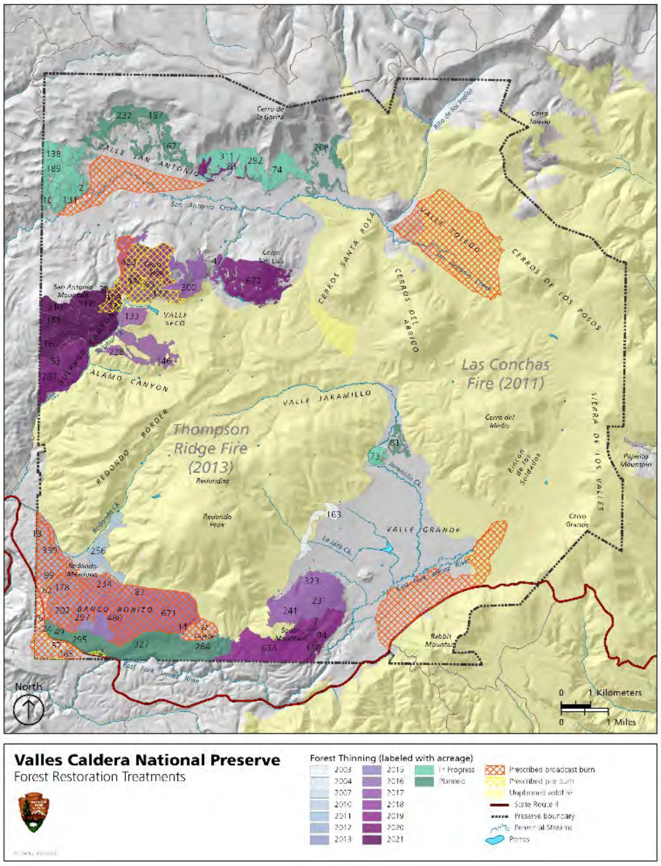


Fig. 1.14. Map of thinning and planned fire treatments on Valles Caldera National Preserve, 2010-2021.

Table 1.2. List of forest thinning projects on Valles Caldera National Preserve, 2010-2021.

Thinning unit name	Year	Acres	Thinning treatment	Fuel disposition
Redondo Block 2	2010	339	Hand	Cut and Pile
Redondo Block 3 So	2010	185	Mechanical	Haul Out
Redondo Block 3 No	2010	12	Hand	Cut and Pile
Redondo Block 1	2011	256	Mechanical	Haul Out
Redondo 1B	2012	99	Mechanical	Haul Out
Redondo 1A	2012	339	Mechanical	Haul Out
Cajete 2	2013	202	Mechanical	Haul Out
Cajete 1	2013	178	Mechanical	Haul Out

Cajete 4	2015	234	Mechanical	Haul Out
Cajete 3	2015	297	Mechanical	Haul Out
Cajete Unit 3-4 Prep	2016	13	Hand	Lop and Scatter
Cajete 5	2016	480	Mechanical	Haul Out
Cajete 7	2016	87	Mechanical	Haul Out
Cajete 6	2016	671	Mechanical	Haul Out
Seco 8	2017	177	Hand/Mechanical	Haul Out/Cut and Pile
Seco 5	2017	112	Hand/Mechanical	Haul Out/Mechanical Scatter
South Mountain	2017	231	Mechanical	Haul Out
Seco 4	2017	300	Mechanical	Mechanical Scatter
Seco 3	2017	238	Mechanical	Mechanical Scatter
South Mountain	2017	323	Hand	Cut and Pile
Seco 1	2017	133	Mechanical	Mechanical Scatter
Seco 2	2017	146	Mechanical	Mechanical Scatter
South Mountain A	2017	241	Hand	Cut and Pile
Seco 6	2018	63	Hand/Mechanical	Haul Out/Mechanical Scatter
Seco 7	2018	47	Hand/Mechanical	Haul Out/Cut and Pile
Valle San Antonio Prep	2018	2	Mechanical	Haul Out
South Mountain A	2019	94	Hand	Cut and Pile
South Mountain B	2019	634	Hand	Cut and Pile
Seco 9	2019	423	Hand	Cut and Pile
NW Corner Vet Crew FY20	2019	10	Hand	Cut and Pile
South Mountain A	2019	121	Hand	Cut and Pile
Hwy 4 Blowdown	2020	1	Hand	Cut and Pile
Banco RTRL	2020	11	Hand	Cut and Pile
Seco 9	2020	121	Hand	Cut and Pile
South Mountain A	2020	130	Hand	Cut and Pile
San Antonio Mtn South 8	2020	109	Hand	Cut and Pile
San Antonio Mtn South 2	2020	234	Hand	Cut and Pile
San Antonio Mtn South 1	2020	287	Hand	Cut and Pile
San Antonio Mtn South 3	2020	53	Hand	Cut and Pile
Cerro San Luis	2020	670	Hand	Cut and Pile
North Rim B	2020	11	Hand	Lop and Scatter
North Rim A	2020	83	Hand	Lop and Scatter
San Antonio Mtn South 5	2021	227	Hand	Cut and Pile
San Antonio Mtn South 4	2021	112	Hand	Cut and Pile
San Antonio Mtn South 7	2021	32	Hand	Cut and Pile
San Antonio Mtn South 4	2021	188	Hand	Cut and Pile
San Antonio Mtn South 7	2021	112	Hand	Cut and Pile
San Antonio Mtn South 6	2021	210	Hand	Cut and Pile
San Antonio Mtn South 3	2021	166	Hand	Cut and Pile
	TOTAL:	9,444		

Table 1.3. List of planned (prescribed) burns on Valles Caldera National Preserve, 2011-2021.

Fire name	**Year**	**Acres**	**Fire type**
Redondo Piles	2011	14	Rx piles
Redondo Piles	2011	12	Rx piles
Redondo Piles	2011	179	Rx piles
SW Banco	2012	339	Rx broadcast
North Banco Cajete 2	2015	202	Rx broadcast
North Banco Cajete 1	2016	178	Rx broadcast
North Banco Cajete 3	2016	244	Rx broadcast
North Banco Cajete Hwy South	2016	34	Rx broadcast
Valle Grande 2016	2016	1,251	Rx broadcast
North Banco Cajete 5-6	2018	1,164	Rx broadcast
Valle San Antonio	2018	845	Rx broadcast
Seco Piles	2018	240	Rx piles
Seco 5	2019	90	Rx broadcast
North Banco Redondo A+B	2019	379	Rx broadcast
North Banco Redondo A escarpment	2019	108	Rx broadcast
North Banco Cajete 4	2019	175	Rx broadcast
Seco 9 Piles	2020	422	Rx piles
Cajete Meadow Rx	2021	151	Rx broadcast
San Antonio Mtn 8 Piles	2021	109	Rx piles
Seco 9 Piles	2021	121	Rx piles
San Antonio Mtn 5 Piles	2021	16	Rx piles
TOTAL:		6,274	

The following summaries describe recent activities on the Preserve for various aspects of the CFLRP/LRMP implementation actions.

Summary of 2020 Projects:

Forest thinning activities accomplished in 2020:

- Cerro San Luis – 150 acres. Thinning now complete on Cerro San Luis (Total 670 acres).
- Cerro Seco – 124 acres. Thinning now complete on Cerro Seco (Total 1,840 acres).
- South Mountain – 129 acres. Thinning now complete on South Mountain (Total 1,796 acres).
- San Antonio Mountain – 1,016 acres of hand thinning. Thinning ongoing in 2021.
- North Rim Units A and B – 91 acres of hand thinning. Thinning ongoing in 2021.
- Northwest Corner 1 & 2 – No progress in 2020. Thinning ongoing in 2021.
- Banco Bonito RTRL – 11 acres of hand thinning. Thinning ongoing in 2021.

Biomass disposal – Prescribed fire – pile burn accomplished in 2020

- Cerro Seco - 400 Acres

Fire management – Handline preparation accomplished in 2020

- South Mountain – 0.7 miles, 1.3 miles remain to be prepared in 2021.
- Southwest Banco Bonito Rx handline complete.

Summary of 2021 Projects

Banco Bonito

Approximately 100 cultural resources sites totaling 29 acres were treated in 2021 by the Forestry Division of the Pueblo of Jemez. Activities are ongoing and should be completed in 2022.

Cajete Canyon

Forest treatment of 1,088 acres are scheduled to implemented starting in 2022. This covers four thinning units, and will be thinned with a combination of mechanical and hand-crew techniques. When these units are completed, the entire southwestern boundary of the Preserve will be thinned, and will be more resistant to high-severity crown fire.

Cerro Piñon

Hand cut-and-pile operations began on Cerro Piñon in 2021 with ~15 acres being treated and ~58 acres remaining. The unit is being thinned by the Forestry Division of Santa Clara Pueblo using cut-and-pile techniques.

Cerro Seco

The final 124 acres of piles were burned on Cerro Seco. All thinning and piled biomass disposal is now complete on Cerro Seco, with only the post-thinning understory broadcast burn left to implement; this planned (prescribed) fire is tentatively scheduled for 2023 or later. The Cultural Resources survey for this entire area has been completed.

El Cajete Meadow Rx

The NPS successfully completed a grassland prescribed fire to control ponderosa pine seedling encroachment and improve grassland condition in El Cajete Meadow in spring 2021.

North Rim Units A and B

The remaining 411 acres of thinning were completed in 2021 and all thinning has now been completed in North Rim Units A and B with activities ongoing to remove the remaining cut logs on the decks. The Preserve will continue tree removal and hauling activities from landings and existing logging roads as necessary to finish all activities on these units.

Northwest Corner Units 1&2

Thinning work on these two units has now ended with the termination (expiration) of the contract. Approximately 90% of the areas were treated with mechanical and hand-crew thinning (lop-and-scatter).

San Antonio Mountain Units 1 – 8

The final 458 acres of forest thinning on San Antonio Mountain were completed during November and December 2021 following the revised treatment prescription to retain > 60%

canopy cover and ≥ 120 ft^2 / acre in suitable mesic mixed conifer to better match the recovery habitat for Mexican Spotted Owls. All forest thinning completed in 2021 was located outside of the established 2021 provisional protected activity center of the two sub-adult owls that were observe in spring 2021; these birds have not been observed in 2022. All thinning is now complete on San Antonio Mountain. Additionally, 71 acres of piles located in San Antonio Mountain Unit 8 were successfully burned during a period of snow in February 2022.

South Mountain

No piles were treated in 2021. A total of 970 acres of piles with an estimated density of 70 piles/acre remain to be burned in 2022-2023.

Cultural Resources Surveys, 2019-2021

In support of the many LRMP activities on the Preserve, the NPS Cultural Resources team (including Preserve CR staff and the University of New Mexico's Office of Contract Archaeology) have conducted a number of field surveys to identify cultural resource sites. In general, project activities such as thinning and burning avoid these identified site locations, and specially-trained teams go in later to the CR sites and implement treatments to preserve and protect the on-site resources. Cultural Resource surveys during 2019-2020 are shown in Fig. 1.15, and a summary table shows CR work accomplished during 2010-2021 (Table 1.4).

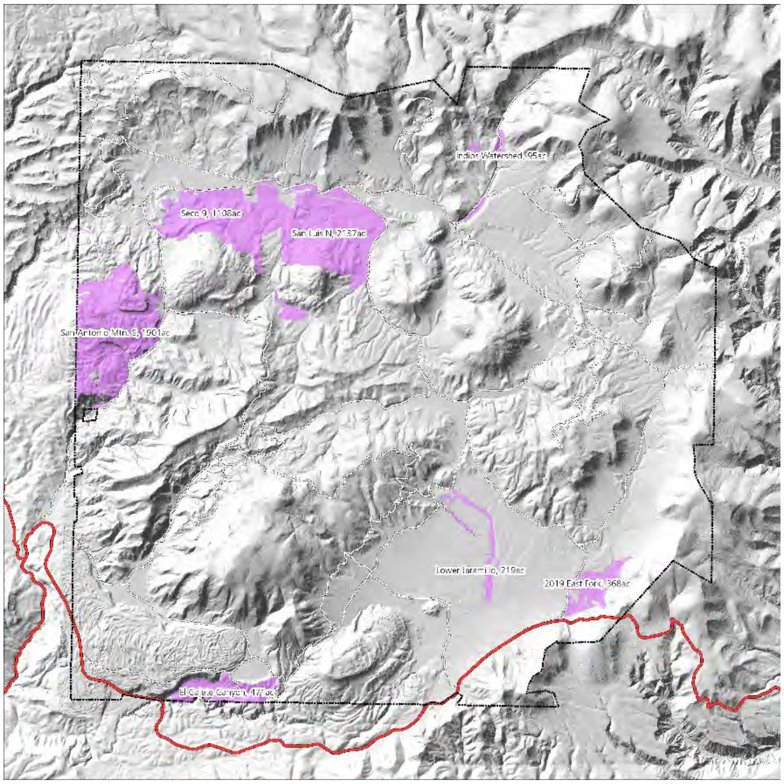


Fig. 1.15. Map of CR surveys on Valles Caldera National Preserve.

Table 1.4. List of Cultural Resource Activities on Valles Caldera National Preserve

VCNP CR Activity	2010-2018	2019-2021	TOTAL 2010-2021
Cultural resources inventory (acres surveyed)	19,790	6,299	26,089
Sites documented during inventory (# of sites)	334	71	405
Site assessments prior to forest & watershed restoration treatments (# of sites)	181	77	258
Protective treatment at CR sites (# of sites)	153	69	222
Post-fire monitoring for effects (# of sites)	92	0	92
Fire/Rx monitoring locations (# installations)	13 locations	No change	13 locations
Erosion monitoring locations	7 locations	No change	7 locations

Chapter 2. Climate Monitoring

Climate in the SWJM CFLRP/LRMP project area is continually monitored using Remote Access Weather Stations (RAWS). Data from this network of stations are collected and managed under an agreement with the Western Regional Climate Center at the Desert Research Institute at the University of Nevada, Reno; weather data can be found on the internet at the following link (Fig. 2.1):

https://wrcc.dri.edu/vallescaldera/

Weather data are uploaded hourly via the GOES satellite system, and displayed with an approximately 1-2 hour delay. The WRCC website includes a series of analytical software tools that can quickly provide summary statistics of the various parameters being measured at each station (Fig. 2.2).

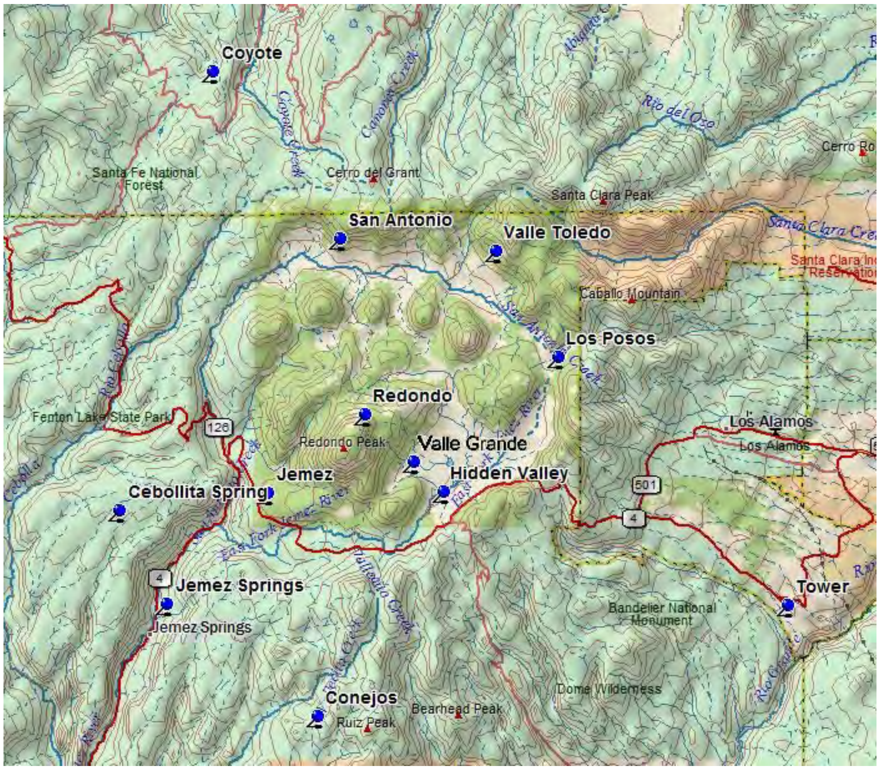
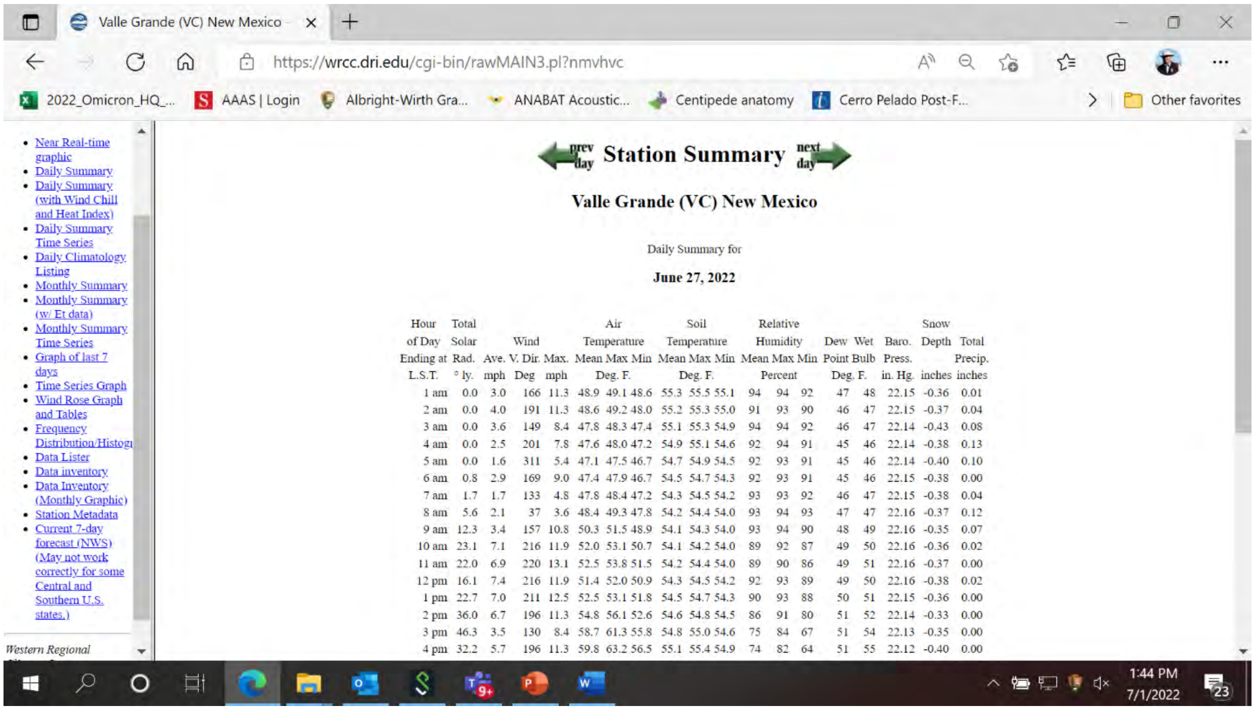


Figure 2.1. Map of RAWS station locations in the Jemez Mountains.

Weather stations were established throughout the project area in years prior to the SWJM CFLRP, and the network of stations was expanded in 2011 with the start of the monitoring program (Fig. 2.1).



Station Summary

Valle Grande (VC) New Mexico

Daily Summary for

June 27, 2022

Hour	Total				Air			Soil			Relative						Snow	
of Day	Solar		Wind		Temperature			Temperature			Humidity			Dew	Wet	Baro.	Depth	Total
Ending at	Rad.	Ave. V.	Dir.	Max.	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Point	Bulb	Press.		Precip.
L.S.T.	° ly.	mph	Deg	mph	Deg. F.			Deg. F.			Percent			Deg. F.		in. Hg.	inches	inches
1 am	0.0	3.0	166	11.3	48.9	49.1	48.6	55.3	55.5	55.1	94	94	92	47	48	22.15	-0.36	0.01
2 am	0.0	4.0	191	11.3	48.6	49.2	48.0	55.2	55.3	55.0	91	93	90	46	47	22.15	-0.37	0.04
3 am	0.0	3.6	149	8.4	47.8	48.3	47.4	55.1	55.3	54.9	94	94	92	46	47	22.14	-0.43	0.08
4 am	0.0	2.5	201	7.8	47.6	48.0	47.2	54.9	55.1	54.6	92	94	91	45	46	22.14	-0.38	0.13
5 am	0.0	1.6	311	5.4	47.1	47.5	46.7	54.7	54.9	54.5	92	93	91	45	46	22.14	-0.40	0.10
6 am	0.8	2.9	169	9.0	47.4	47.9	46.7	54.5	54.7	54.3	92	93	91	45	46	22.15	-0.38	0.00
7 am	1.7	1.7	133	4.8	47.8	48.4	47.2	54.3	54.5	54.2	93	93	92	46	47	22.15	-0.38	0.04
8 am	5.6	2.1	37	3.6	48.4	49.3	47.8	54.2	54.4	54.0	93	94	93	47	47	22.16	-0.37	0.12
9 am	12.3	3.4	157	10.8	50.3	51.5	48.9	54.1	54.3	54.0	93	94	90	48	49	22.16	-0.35	0.07
10 am	23.1	7.1	216	11.9	52.0	53.1	50.7	54.1	54.2	54.0	89	92	87	49	50	22.16	-0.36	0.02
11 am	22.0	6.9	220	13.1	52.5	53.8	51.5	54.2	54.4	54.0	89	90	86	49	51	22.16	-0.37	0.00
12 pm	16.1	7.4	216	11.9	51.4	52.0	50.9	54.3	54.5	54.2	92	93	89	49	50	22.16	-0.38	0.02
1 pm	22.7	7.0	211	12.5	52.5	53.1	51.8	54.5	54.7	54.3	90	93	88	50	51	22.15	-0.36	0.00
2 pm	36.0	6.7	196	11.3	54.8	56.1	52.6	54.6	54.8	54.5	86	91	80	51	52	22.14	-0.33	0.00
3 pm	46.3	3.5	130	8.4	58.7	61.3	55.8	54.8	55.0	54.6	75	84	67	51	54	22.13	-0.35	0.00
4 pm	32.2	5.7	196	11.3	59.8	63.2	56.5	55.1	55.4	54.9	74	82	64	51	55	22.12	-0.40	0.00

Fig. 2.2. Example screen view of RAWS weather data, showing list of variables in main hourly data table, and list of software analyses available (left column in blue font).

In addition to the RAWS network, a National Weather Service (NWS) station has been operating in Jemez Springs since 1914. The data from this station have been obtained from NWS and summarized for the period 1914-2021 to assess the degree of climate warming and precipitation patterns over the last 107 years.

Climate trend results

Atmospheric air temperatures from the Jemez Springs NWS station exhibited a statistically significant warming during the 20th Century and through 2021 (Fig. 2.3). The slope (rate of temperature increase) of the regression line indicated a 1.87° F increase in temperature over 100 years. This value is very close to the predicted temperature increase for our region of North America that was estimated by the Inter-Governmental Panel on Climate Change (IGPCC); as such, these data support the contention that the southwestern portion of the Jemez Mountains are exhibiting climate warming at a rate comparable to predictions by global climate models (GCMs) and that the forests in our project area are being subjected to climate trends that are similar to those of the American Southwest.

A more detailed analysis of these temperature data revealed that climate warming is occurring unevenly throughout the year. A month-by-month analysis of the 107-yr data set produced differences in rates of warming among spring, summer and winter months. The maximum rate of warming was observed during the month of June (4.5° F per 100 yr), whereas the months of October, November and December exhibited no temperature increase at all (Fig. 2.4).

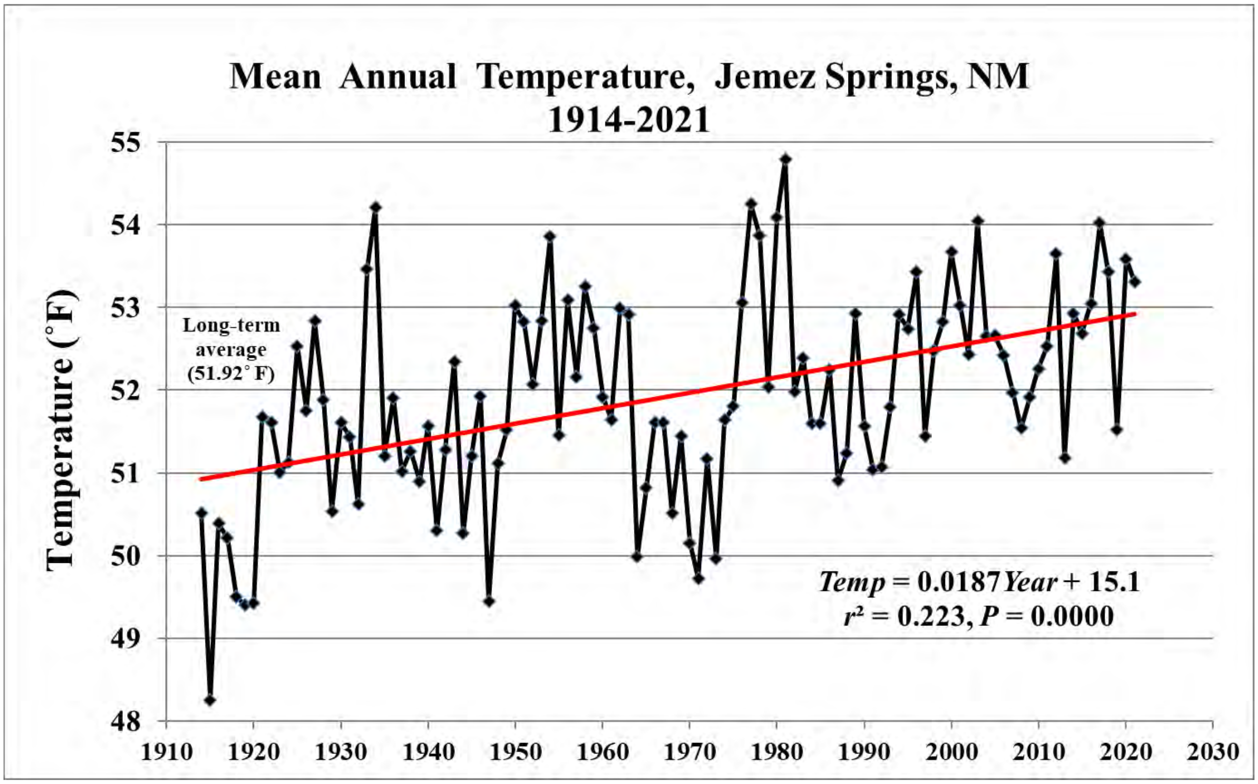


Fig. 2.3. Mean annual atmospheric temperatures recorded in Jemez Springs, 2014-2022.

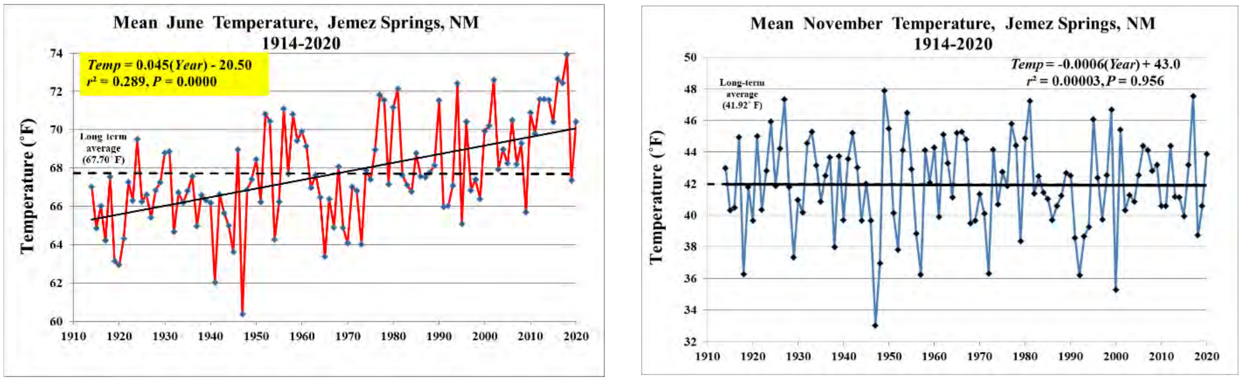


Fig. 2.4. Mean monthly atmospheric temperatures in June (left) and November (right) recorded in Jemez Springs, 1914-2020.

Precipitation patterns in Jemez Springs during this time period (Fig. 2.5) show considerable variation from year to year, but a statistical trend is evident – precipitation in Jemez Springs was above average during the 1920s and 1930s, and then entered the historic extended drought during the 1940s and 1950s. A particularly wet period began in the late-1970s and continued through the 1980s, with drought again returning in the 1990s through present-day. This pattern is aligned with the Pacific Decadal Oscillation (PDO), which influences long-term patterns of the jet stream that affects winter storm tracks in northern New Mexico. The periodicity for this oscillation is 20-30 years of above average precipitation followed by 20-30 years of below-average precipitation. If this pattern holds up, northern New Mexico should be emerging from the drought portion of this cycle sometime in the coming 5-10 years. All of the CFLRP/LRMP activities (2011-2021) have occurred during the drought phase of the PDO cycle, with only the year 2015 having above-average precipitation.

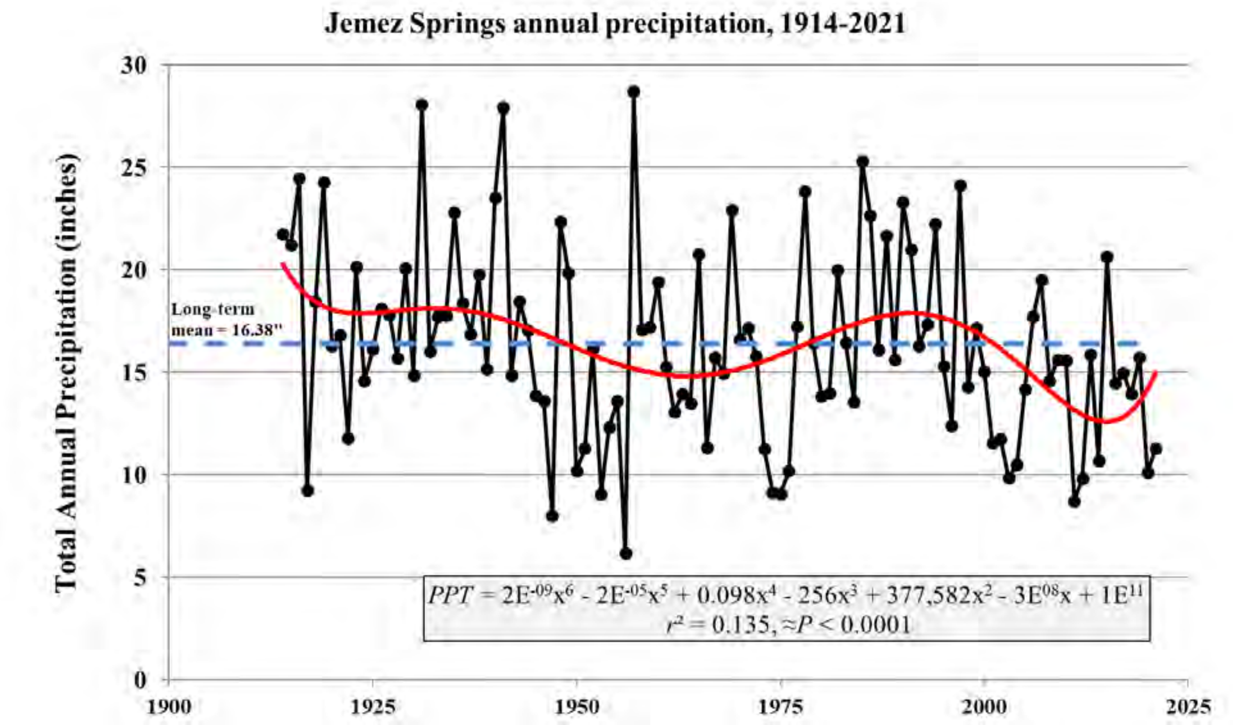


Fig. 2.5. Total annual precipitation data from Jemez Springs during 2014-2022.

Climate data from the CFLRP/LRMP RAWS network expand on the patterns observed from the Jemez Springs NWS station. The RAWS with the longest record is the **Valle Grande station**, and these data are reported below.

Temperature. Mean annual temperatures in the Valle Grande over the 18 years of record (2004-2021) show a rapid increase in annual temperatures of 0.125º C per year (Fig. 2.6); this is equivalent to 0.225º F per year, or 22.5º F per century, a rate that is an order of magnitude greater than the temperature increase observed in the Jemez Springs data. As with the Jemez Springs data, the warming trend is most apparent during the summer, with non-significant trends during winter (Fig. 2.7). Maximum temperatures also are increasing, but minimum temperatures do not appear to be changing significantly (Fig. 2.8). Climate data sets of short duration (less than 30 years) need to be interpreted cautiously, so the exceptionally rapid temperature increase may not represent the trend magnitude for the rest of this century; however, it is clear that atmospheric temperatures have been rising rapidly in the Valle Grande over the last 18 years.

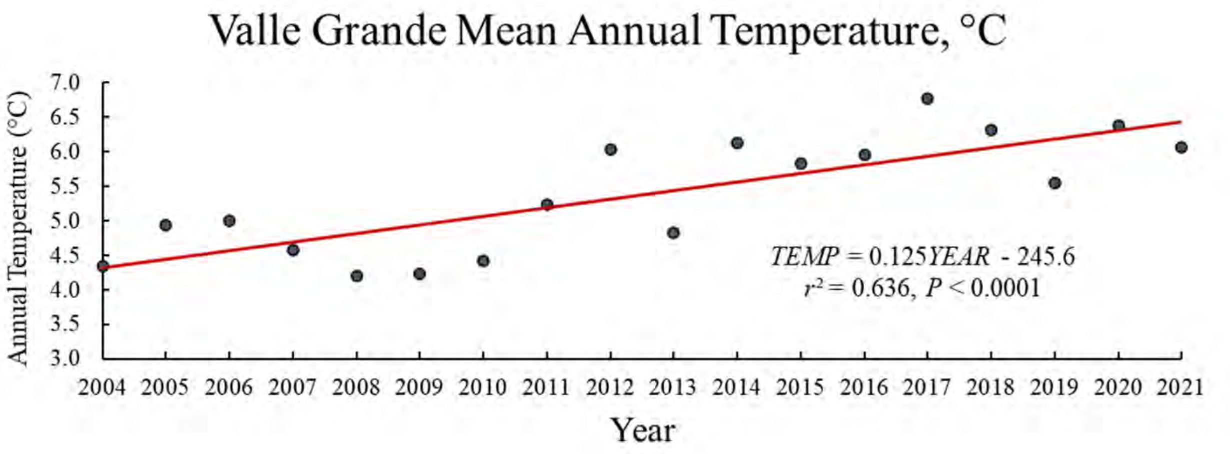
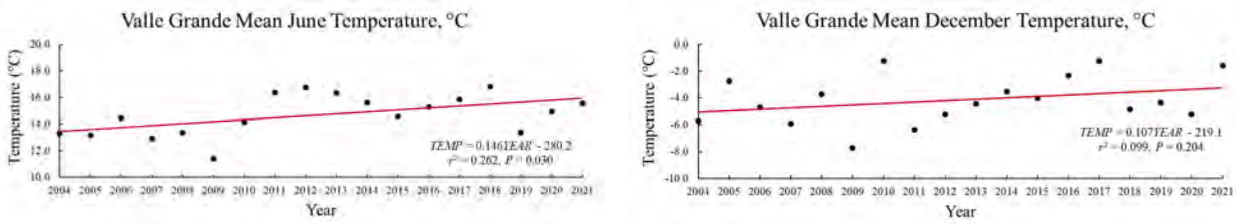
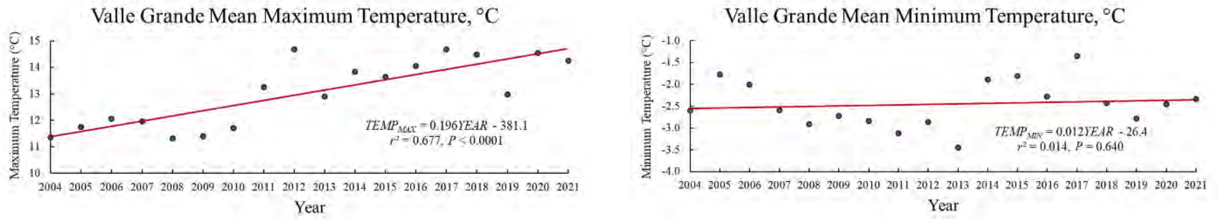

Valle Grande Mean Annual Temperature, °C

Fig. 2.6. Annual atmospheric temperature data from the Valle Grande RAWS, 2004-2022.


Valle Grande Mean June Temperature, °C

Valle Grande Mean December Temperature, °C

Fig. 2.7. Left: Monthly mean temperatures for June. Right: Monthly mean temperatures for December.


Valle Grande Mean Maximum Temperature, °C

Valle Grande Mean Minimum Temperature, °C

Fig. 2.8. Left: Mean annual maximum temperatures. Right: Mean annual minimum temperatures.

Precipitation. The total annual precipitation recorded in the Valle Grande averaged 598 mm/yr, with a low of 361 mm in 2020 and a high of 889 mm in 2015 (Fig. 2.9). Overall, the site exhibited no significant trend in annual precipitation during the period of record.

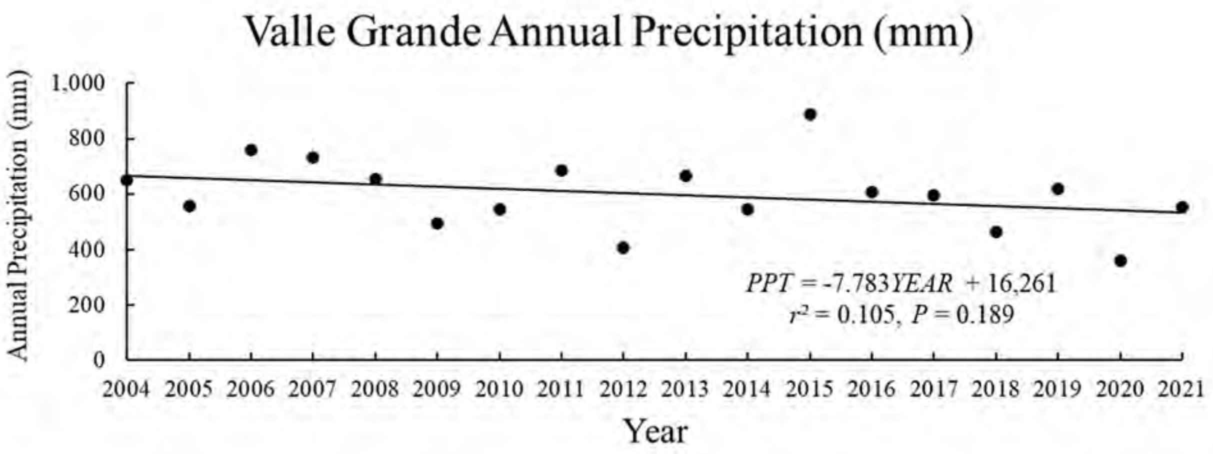


Fig. 2.9. Total annual precipitation (mm) in Valle Grande, 2004-2022.

Relative humidity. The mean annual relative humidity in the Valle Grande displayed a statistically significant downward trend, becoming generally drier (Fig. 2.10). This would be a result of warming atmospheric temperatures (which have been shown to be increasing), rather than a decrease in precipitation (which shows no significant trend). Mean annual relative humidity has dropped from ~61% to ~52% over the last two decades.

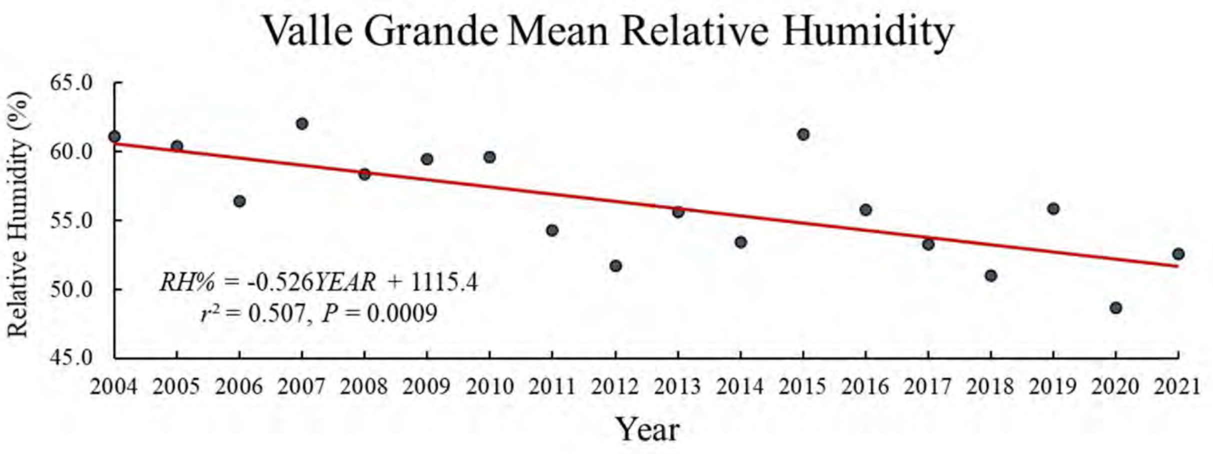


Fig. 2.10. Mean annual relative humidity (%) in Valle Grande, 2004-2022.

Wind speed. The mean annual wind speeds during 2004-2021 averaged 2.3 meters/sec, and ranged from 2.9 to 2.5 meters/second. Overall, there was no statistically significant trend in mean wind speeds over the period of record (Fig. 2.11). However, the mean maximum wind gust speeds did show a significant increase in speeds; the average gust speed recorded was 17.4 meters/sec, and over the 18 years of monitoring, wind gusts increased from ~16.5 meters/sec to ~18.5 meter/sec, or an increase of ~2 meters/sec (Fig. 2.12). Wind gust speeds are important in forest restoration, as these gusts can topple trees in exposed locations – e.g., newly thinned stands with fewer neighboring trees to shield isolated trees from high wind speeds. As with humidity, these higher wind gust speeds may be related to higher temperatures, as warmer atmospheric temperatures harbor higher energy (heat) levels that drive wind dynamics.

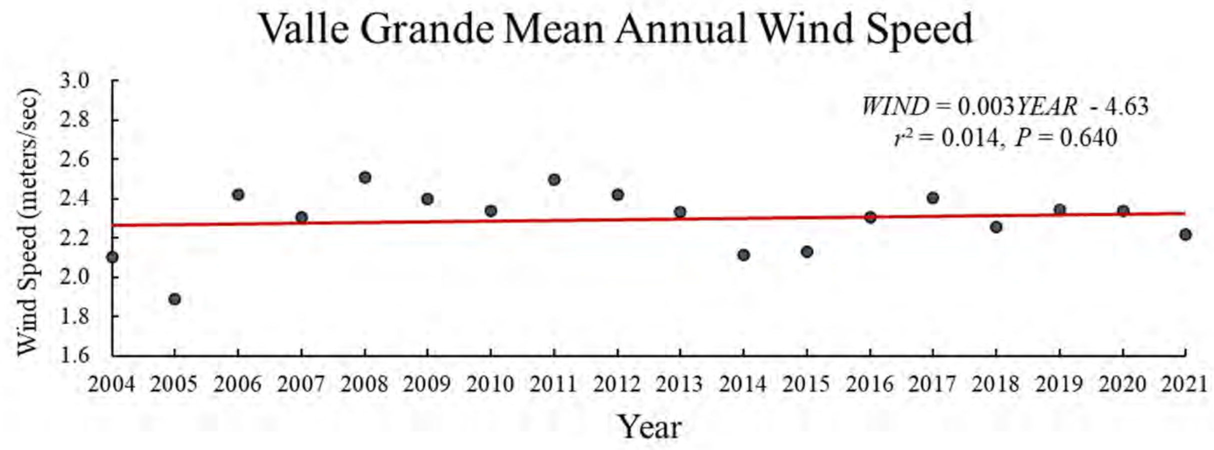


Fig. 2.11. Mean annual wind speed in the Valle Grande, 2004-2021

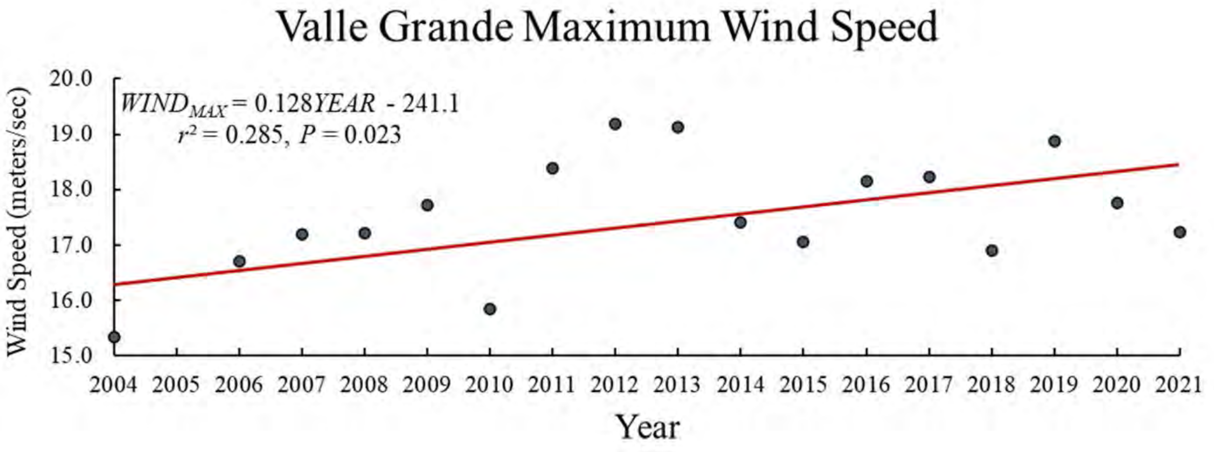


Fig. 2.12. Mean annual maximum wind gust speed in the Valle Grande, 2004-2022.

Collaborators: NPS Valles Caldera National Preserve staff (Scott Compton, David Pittenger, Bob Parmenter); University of New Mexico (Doug Moore); University of Nevada's Desert Research Institute RAWS Network; National Weather Service; NRCS Climate Reference Network; NRCS SNOTEL Network.

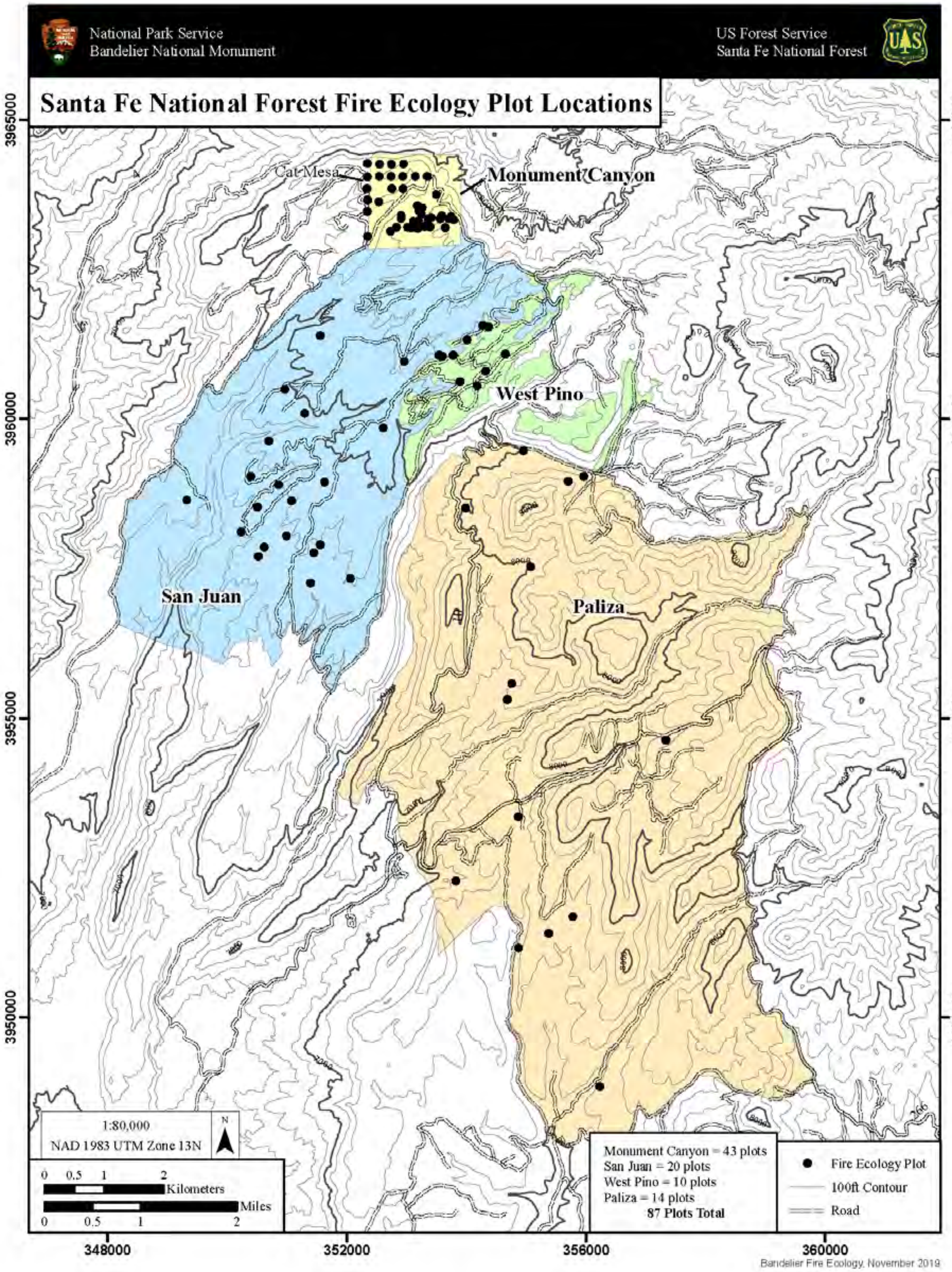
Chapter 3. Vegetation Monitoring

Monitoring of the CFLRP/LRMP projects is conducted by the NPS Valles Caldera's botany team and the NPS Pueblo Parks Fire Ecology Group. Sites are generally sampled prior to the treatments being implemented, with permanent plots being set up ahead of time and then sampled again at various time intervals after the treatment(s). In many cases, the sites were thinned and then burned, so monitoring takes place before and after each treatment type. Monitoring studies of the vegetation and fuel loads include assessing forest stand structure (species composition, density and basal areas of trees), downed woody debris (branches and logs), shrubs and herbaceous vegetation (usually identified to plant species level); data also include percentage cover of litter and bareground/rock. Photographs of each site are taken, and these photo points allow the monitoring teams to return to the same point to re-photograph the sites repeatedly over the years; there are also a large number of photo point sites that are not associated with detailed data collection, but nonetheless contribute additional understanding of the post-treatment responses of the forests with respect to stand characteristics.
A summary of the projects with vegetation and fuels monitoring is presented in Table 3.1. Fire Ecology monitoring locations are shown in Map 3.1 (SFNF) and Map 3.2 (VCNP).

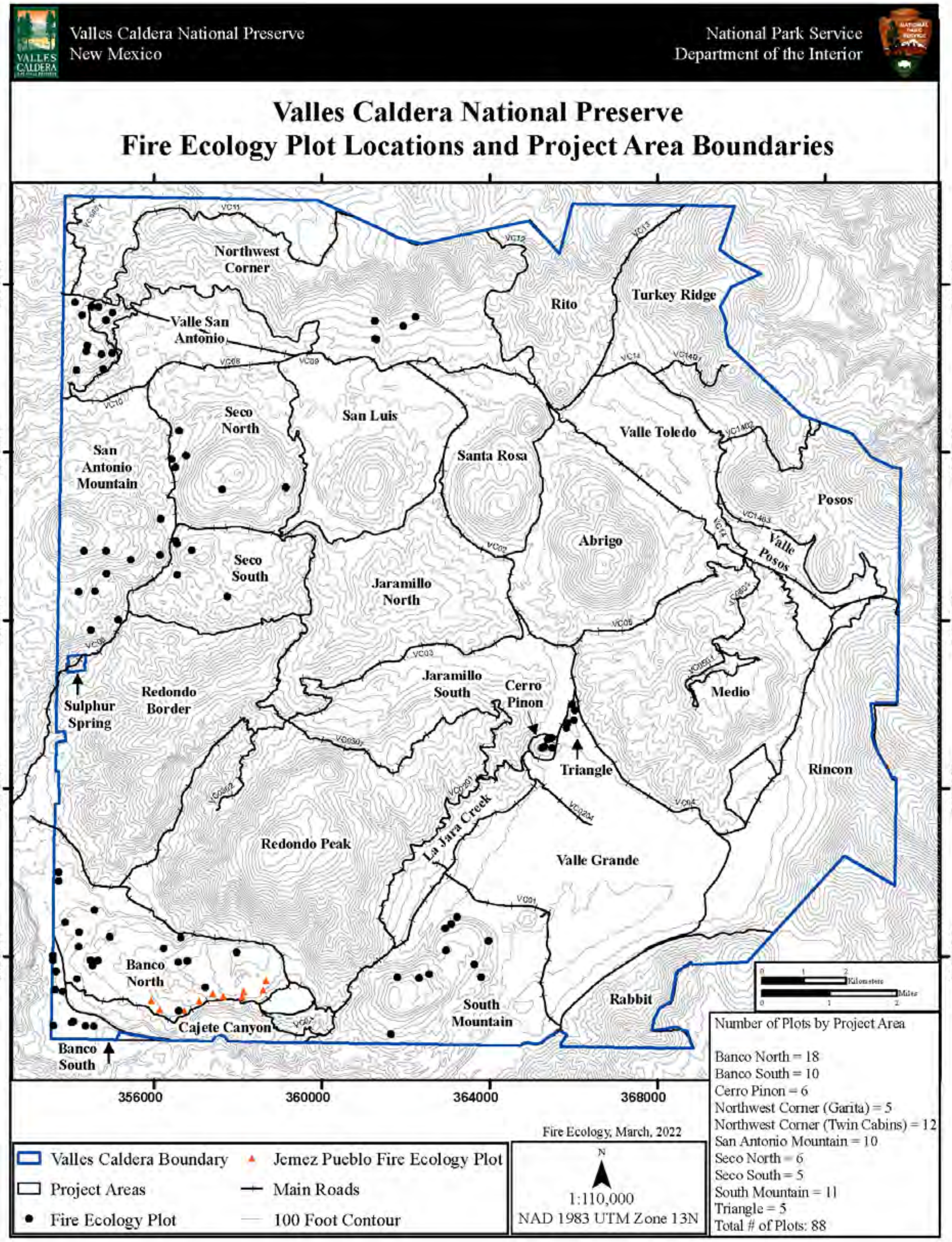
Table 3.1. Summary listing of CFLRP/LRMP projects and vegetation/fuels monitoring details.

Land Mgmt. Agency	Project Area	Monitoring Group	Vegetation Community	Treatment Year	# of Plots	Data Collection Years	Protocols
USFS	Monument Canyon	Pueblo Parks Fire Ecology Group	Ponderosa pine	2012	25	2009, 2012, 2013, 2014, 2017	Trees, shrubs, veg, fuels, photos
USFS	San Juan Mesa	Valles Caldera botany team	Ponderosa pine	2012	27	2012, 2013, 2014, 2017, 2019	Veg, Photos
USFS	San Juan Mesa	Pueblo Parks Fire Ecology Group	Ponderosa pine	2012	20	2010/2011, 2012, 2016, 2021	Trees, shrubs, veg, fuels, photos
USFS	San Juan Mesa/Pino	Valles Caldera botany team	Ponderosa pine	2017?	10	2015, 2019	Veg, Photos
VALL	Banco North	Valles Caldera botany team	Ponderosa pine	2015, 2016, 2017, 2019	24	2012, 2015, 2016, 2017, 2018, 2019	Veg, Photos
VALL	Banco North	Pueblo Parks Fire Ecology Group	Ponderosa pine/Douglas fir	2015, 2016, 2017, 2019	17	2015, 2016, 2017, 2019	Trees, canopy closure, shrubs, veg, fuels, photos
VALL	Banco North Weeds	Valles Caldera botany team	Ponderosa pine	2015, 2016, 2017, 2019	11	2015, 2016, 2017, 2018, 2019, 2021	Veg, Photos

VALL	Seco North unit 5	Pueblo Parks Fire Ecology Group	Douglas fir	2017	4	2016, 2017, 2019, 2020, 2021	Trees, shrubs, veg, fuels, photos
VALL	Seco North unit 5	Valles Caldera botany team	Mixed Con	2017, 2019	10	2016, 2018, 2019, 2020, 2021	Trees, shrubs, veg, fuels, photos
USFS	North Paliza	Valles Caldera botany team	Ponderosa pine	2014	10	2014, 2015, 2016, 2017, 2018	Trees, shrubs, veg, fuels, photos
USFS	North Paliza	Pueblo Parks Fire Ecology Group	Ponderosa pine/Douglas fir	2014	7	2012/2013, 2014, 2016, 2019	Trees, shrubs, veg, fuels, photos
VALL	Banco South	Valles Caldera botany team	Ponderosa pine	2012	9	2004, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2018, 2020, 2021	Veg, Photos
VALL	Banco South	Pueblo Parks Fire Ecology Group	Ponderosa pine	Postponed to 2023	10	2020	Canopy Closure, fuels
VALL	South Mountain	Pueblo Parks Fire Ecology Group	Douglas fir	2017, 2018	9	2016/2017, 2019	Trees, canopy closure, shrubs, veg, fuels, photos
USFS	Conejos Rx	Valles Caldera botany team	Ponderosa pine		3	2013, 2020	Trees, shrubs, veg, fuels, photos
USFS	East Fork	Valles Caldera botany team	Ponderosa pine		5	2018, 2019	Trees, shrubs, veg, fuels, photos
USFS	South Holiday	Valles Caldera botany team	Ponderosa pine		10	2018	Trees, shrubs, veg, fuels, photos
USFS	South Paliza	Valles Caldera botany team	Ponderosa pine		20	2013, 2021	Trees, shrubs, veg, fuels, photos
USFS	South Paliza	Pueblo Parks Fire Ecology Group	Ponderosa pine/Douglas fir		7	2012/2013	Trees, shrubs, veg, fuels, photos



Map 3.1. Locations of Pueblo Parks Fire Ecology monitoring plots on the SFNF.



Map 3.2. Locations of Pueblo Parks Fire Ecology monitoring plots on VCNP.

Recent monitoring efforts have focused on three main areas: San Juan Mesa and Monument Canyon on the Santa Fe National Forest and Cerro Seco on the Valles Caldera National Preserve. Summary reports of these long-term monitoring following thinning and burning are presented below.

San Juan Mesa: Vegetation Monitoring

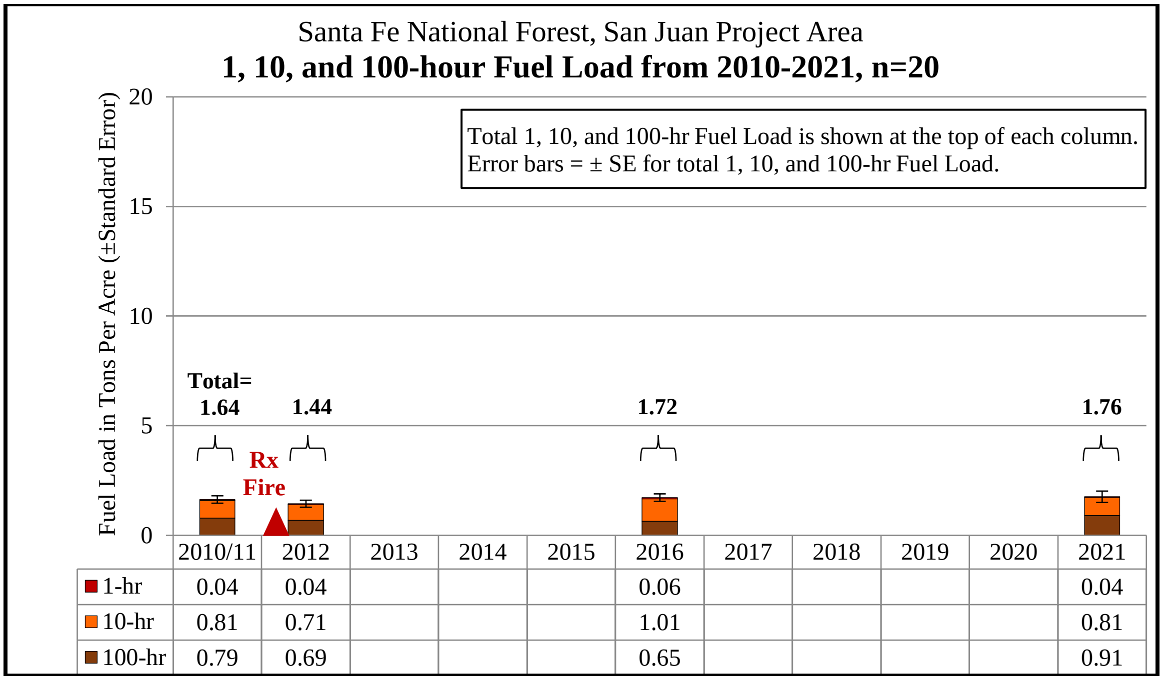
The San Juan Project Area is a mid-elevation ponderosa pine forest and savanna with a combined overstory and midstory tree density of approximately 209 trees per acre. The overstory, approximately 157 trees per acre, is comprised mostly of Ponderosa pine (*Pinus ponderosa*). Douglas fir (*Psuedotsuga menziesii*) and white fir (*Abies concolor*) are a small component and limber pine (*Pinus flexilis*) is occasionally present. The midstory contains approximately 133 trees per acre. Two-needle pinyon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*) are common midstory trees. Alligator juniper (*Juniperus deppeana*) is present but less common. Oak (*Quercus spp*.) is often present, occasionally as dense thickets, due to a history of fire exclusion. (Note: The biological description is based on Fire Ecology data collected on 20 plots between 2010 and 2016.)

Reproduction is present at approximately 20 trees per acre, consisting primarily of ponderosa pine (16 trees per acre) with a smaller component of two-needle pinyon, one-seed juniper, and alligator juniper. Douglas fir is occasionally present. Surface fuels are low, at approximately 8 tons per acre, with litter and duff load as the greatest contributor at 4 tons per acre. 1000-hour fuels are approximately 2 tons per acre. 1, 10, and 100-hour fuels are approximately 2 tons per acre. Litter and duff depths are approximately 0.6 inches. Shrub density is approximately 106 stems per acre. Common shrubs include oak, New Mexico locust (*Robinia neomexicana*), Fendeler's ceanothus (*Ceanothus fendleri*), and Apache plume (*Fallugia paradoxa*). The surface layer is commonly long needle litter (73% cover), bare ground (3.5% cover), and wood (3.6% cover) but also includes a sparse herbaceous component at approximately 20% cover. The lifeform with the highest percent cover (7.5%) is graminoid (grass), followed by tree at 5%, shrub at 4%, forbs (wildflowers) at 2.9%, and grass-like at 1%. Graminoid percent cover is comprised of 7.48% native species and 0.02% non-native; tree, shrub, and grass-like species are entirely native; forbs consist of 2.8% native species and 0.1% non-native.

Common grass species include mountain muhly (*Muhlenbergia montana*), blue grama (*Bouteloua gracilis*), and prairie Junegrass (*Koeleria macrantha*), all native perennial grasses. Predominant forb species include Carruth's sagewort (*Artemisia carruthii*), Colorado rubberweed (*Hymenoxys richardsonii*), and Fendler's sandmat (Chamaesyce fendleri), all native and perennial. Species richness is recorded at 137 species, including 133 native species and 4 non-native species. Non-native species include two perennial grasses, Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*), a biennial forb, common mullein (*Verbascum Thapsus*), and a perennial forb, common dandelion (*Taraxacum officinale*).

The Santa Fe National Forest implemented a broadcast prescribed fire in the San Juan Project Area in 2012 (Fig. 3.2). Fire Ecology data were collected on 20 plots in 2010/2011, prior to the prescribed fire, and after the fire in 2012, 2016, and 2021.

Surface Fuels Monitoring



	2010/11	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
🟥 1-hr	0.04	0.04				0.06					0.04
🟧 10-hr	0.81	0.71				1.01					0.81
🟫 100-hr	0.79	0.69				0.65					0.91

Fig. 3.1. San Juan Mesa fuel load results.

Average 1, 10, and 100-hour fuel load was recorded at 1.64 tons per acre in 2010/2011. After the broadcast prescribed fire in 2012, it was recorded at 1.44 tons per acre, a 12.2 percent decrease from pre-fire levels. In 2016, 1, 10, and 100-hour fuels were recorded at 1.72 tons per acre and remained low at 1.76 tons per acre in 2021 (Fig. 3.1).

Fig. 3.2. Prescribed fire in San Juan Project Area, 2012. Photo: Fire Ecology Program

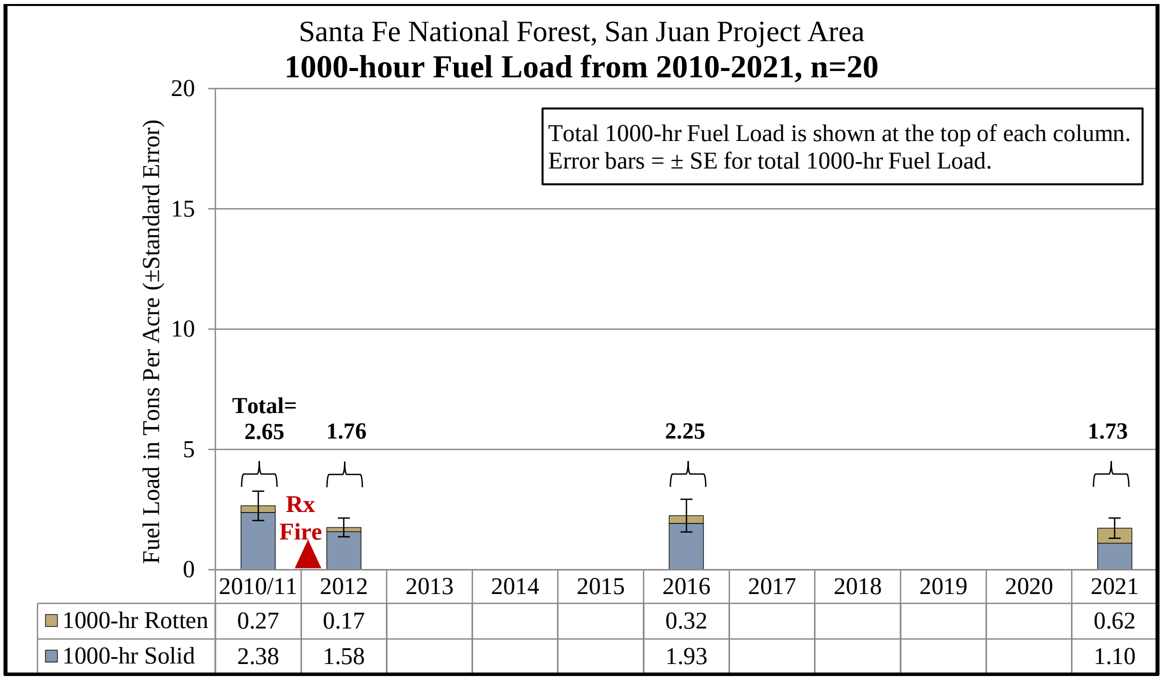
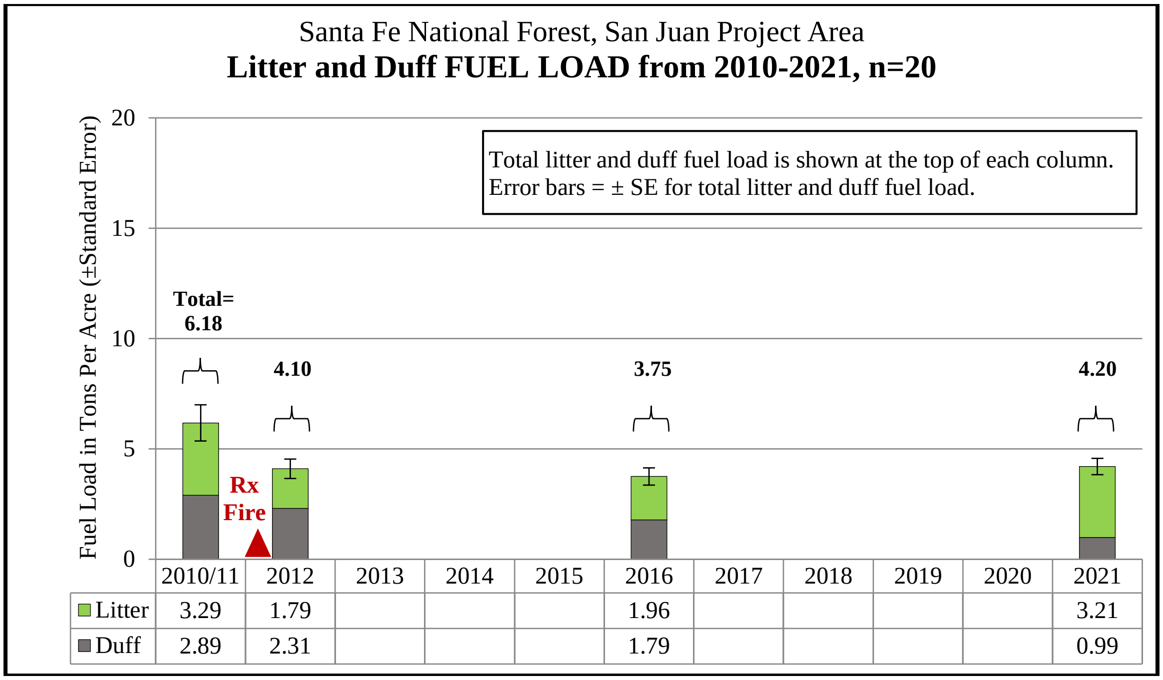


Fig. 3.3. San Juan Mesa 1000-hour fuel load results.

Average 1000-hour fuel load was recorded at 2.65 tons per acre in 2010/2011, with solid 1000-hour fuels as the largest contributor at 2.38 tons per acre and rotten 1000-hour fuels at 0.27 (Fig. 3.3). After the broadcast prescribed fire in 2012, 1000-hour fuels were recorded at 1.76 tons per acre, a 33.59 percent decrease from pre-fire levels. In 2016, 1000-hour fuels were recorded at 2.25 tons per acre. In 2021, 1000-hour fuel load was recorded at 1.73 tons per acre.



	2010/11	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
🟩 Litter	3.29	1.79				1.96					3.21
■ Duff	2.89	2.31				1.79					0.99

Fig. 3.4. San Juan Mesa litter and duff fuel load results.

Average litter and duff fuel load was recorded at 6.18 tons per acre in 2010/2011, with litter contributing 3.29 tons per acre and duff at 2.89 (Fig. 3.4). After the broadcast prescribed fire in 2012, litter and duff fuel load was recorded at 4.10 tons per acre, a 33.66 percent decrease from pre-fire levels. In 2016 and 2021, there was little recorded change in litter and duff fuel load, at 3.75 tons per acre and 4.20, respectively.

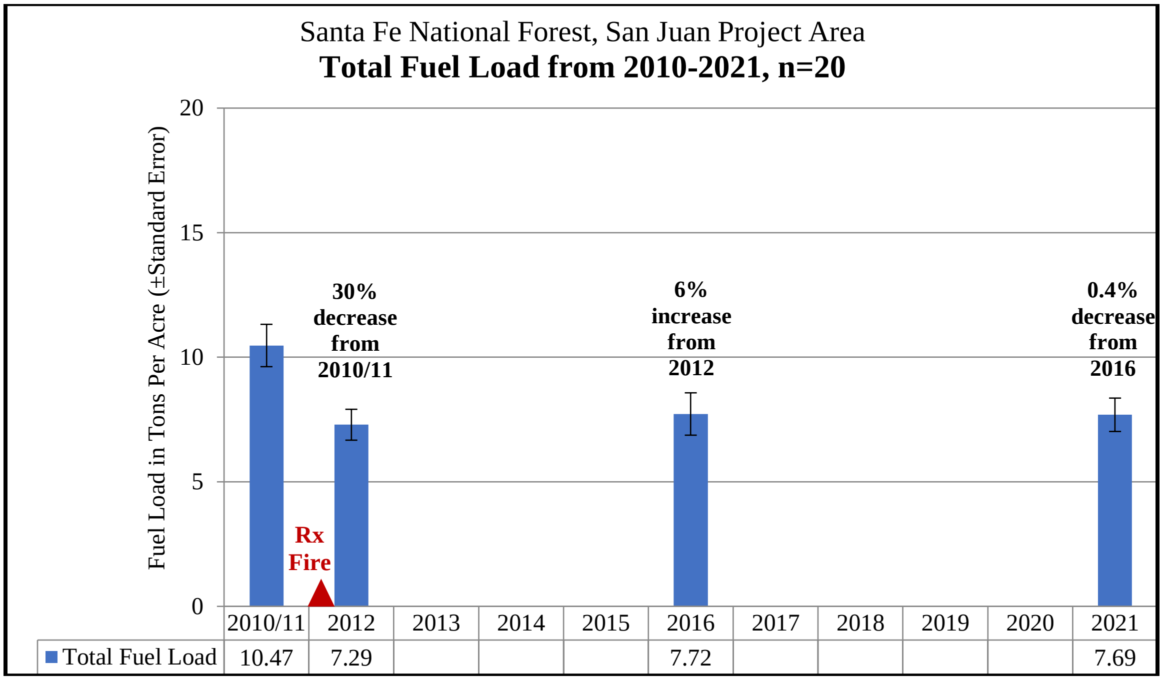
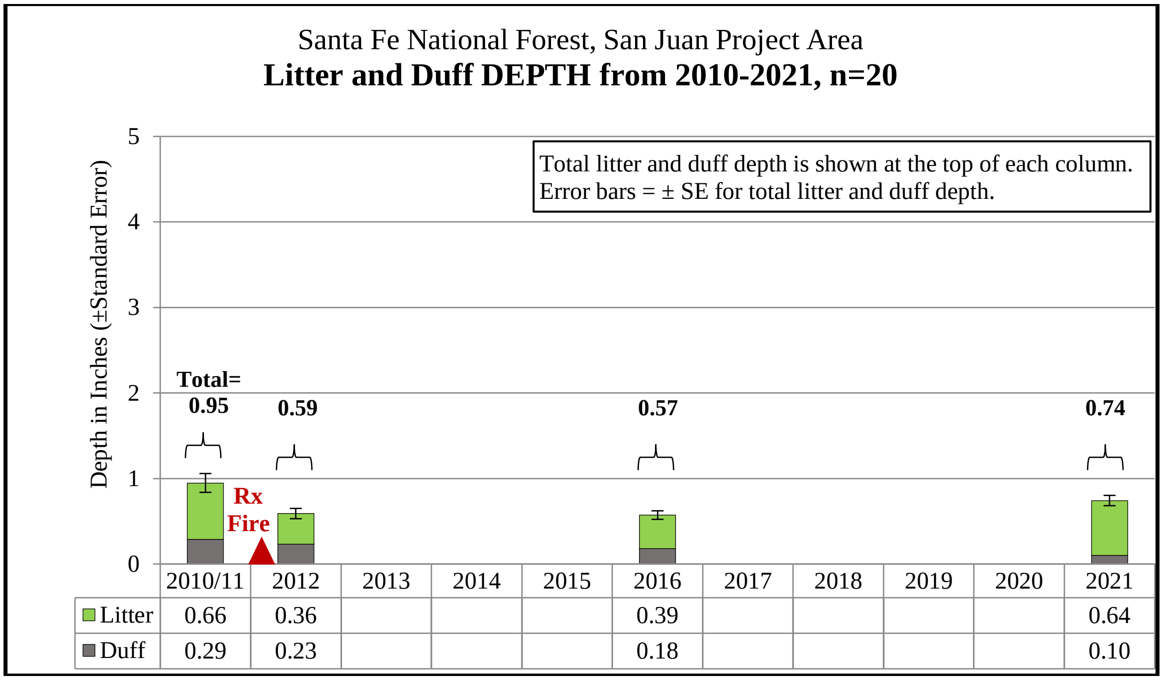


Fig. 3.5. San Juan Mesa total fuel load results.

Average total fuel load was recorded at 10.47 tons per acre in 2010/2011 (Fig. 3.5). After the broadcast prescribed fire in 2012, total fuel load was recorded at 7.29 tons per acre, a 30.37 percent decrease from pre-fire levels. In 2016 and 2021, no change was recorded in total fuel load, 7.72 and 7.69 tons per acre, respectively.

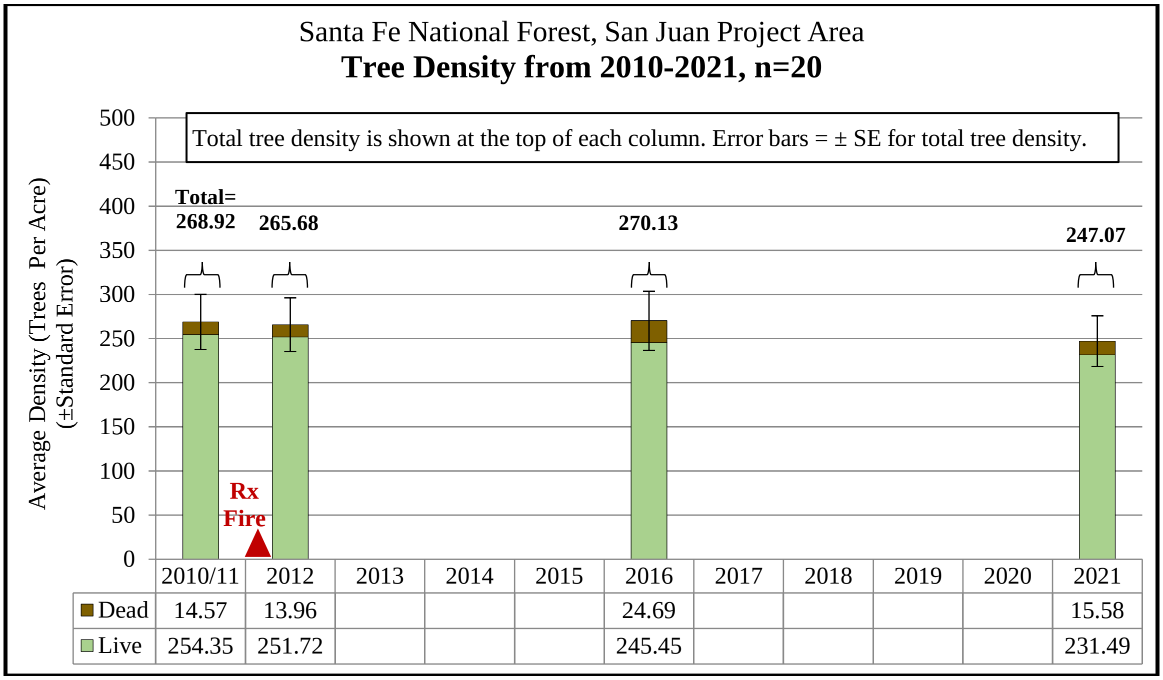


	2010/11	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
🟩 Litter	0.66	0.36				0.39					0.64
■ Duff	0.29	0.23				0.18					0.10

Fig. 3.6. San Juan Mesa litter and duff depth results.

Average litter and duff depth was recorded at 0.95 inches in 2010/2011, with litter as the largest contributor at 0.66 inches and duff at 0.29 (Fig. 3.6). After the broadcast prescribed fire in 2012, litter and duff depth was recorded at 0.59 inches, a 37.90 percent decrease from pre-fire levels. In 2016, litter and duff depths were recorded at 0.57 inches. A small increase in litter and duff depths was recorded in 2021, at 0.74 inches.

Tree Density



	2010/11	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
■ Dead	14.57	13.96				24.69					15.58
■ Live	254.35	251.72				245.45					231.49

Fig. 3.7. San Juan Mesa tree density results.

Average tree density was recorded at 268.92 trees per acre in 2010/2011, with live trees as the largest contributor at 254.35 trees per acre and dead trees at 14.57 (Fig. 3.7). After the broadcast prescribed fire in 2012, tree density was similar to pre-fire levels, at 265.68 trees per acre. In 2016, tree density was recorded at 270.13 trees per acre, with an increase in dead trees and a decrease in live trees (a shift in the ratio of live to dead trees). Tree density was recorded at 247.07 in 2021, an 8.54 percent reduction from 2016, with both live and dead tree categories showing a reduction in density.

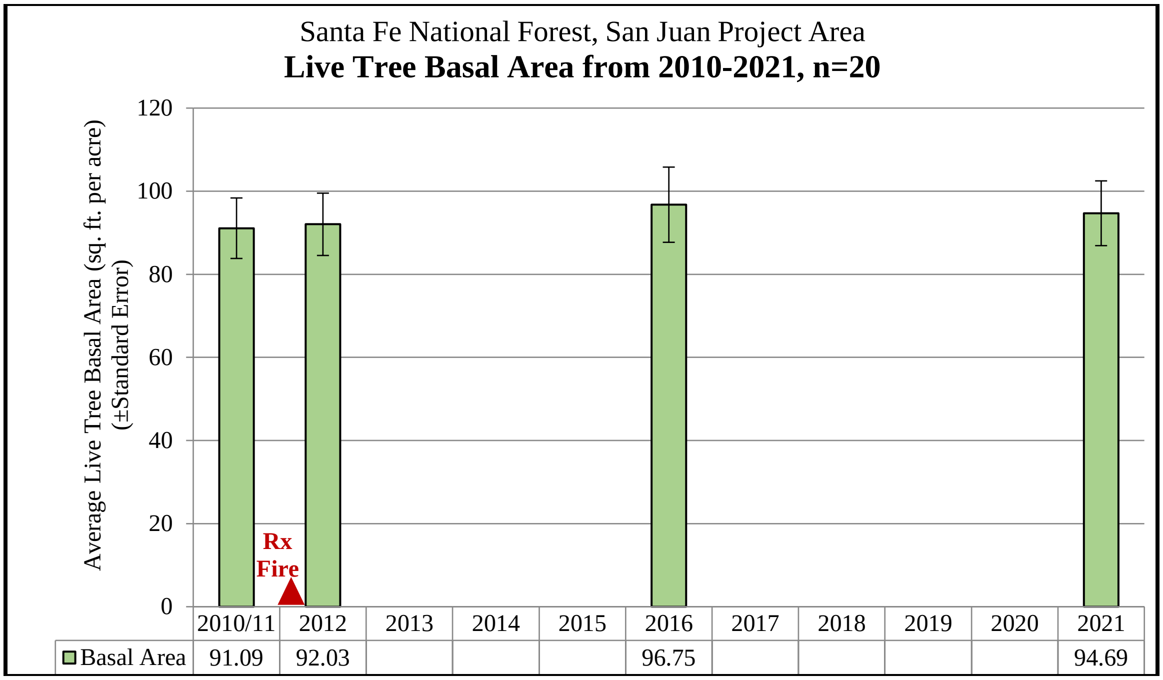


Fig. 3.8. San Juan Mesa live tree basal area results.

Average live tree basal area was recorded at 91.09 sq. ft. per acre in 2010/2011 (Fig. 3.8). After the broadcast prescribed fire in 2012, it was nearly the same at 92.03 sq. ft. per acre. Live tree basal area increased slightly to (96.75 sq. ft. per acre) in 2016 and remained similar in 2021 at 94.69 sq. ft. per acre.

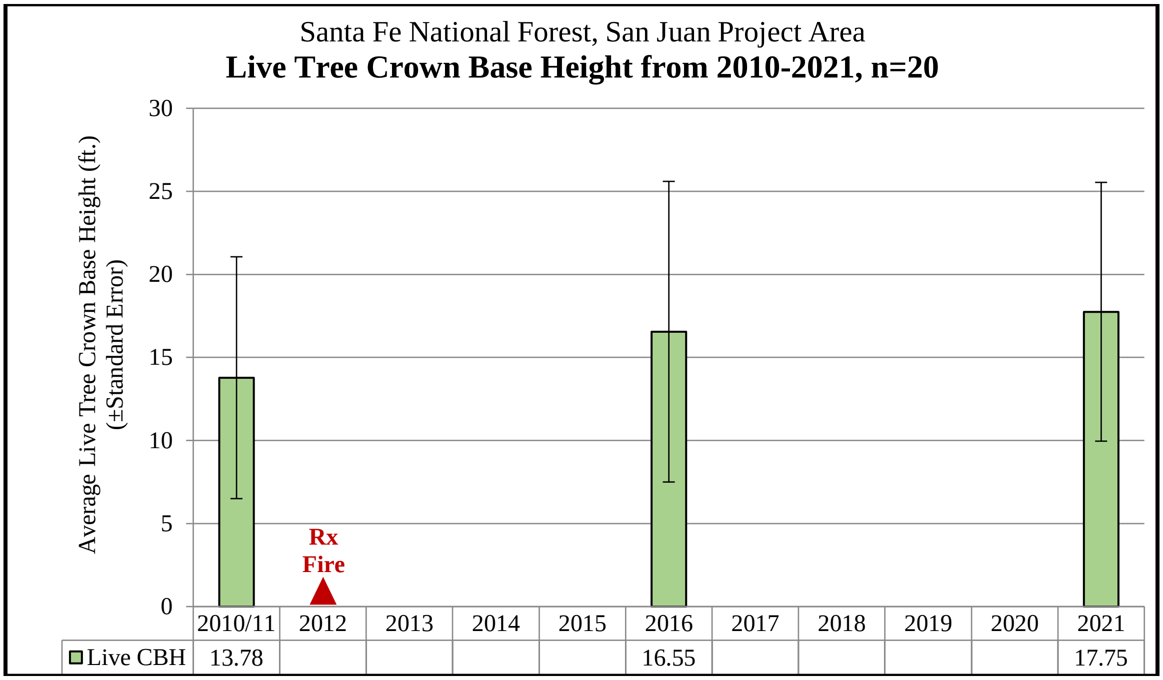
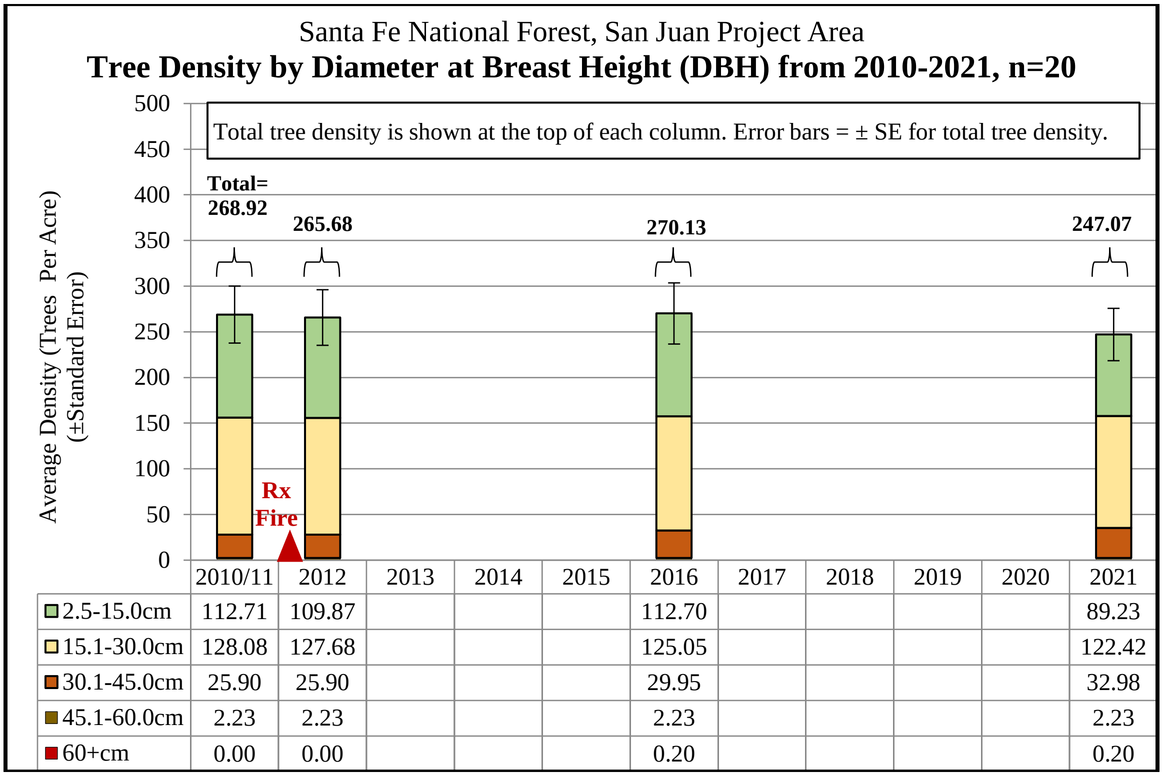


Fig. 3.9. San Juan Mesa live tree crown base height results.

Average live tree crown base height was recorded at 13.78 ft. in 2010/2011 (Fig. 3.9). In 2016, it was recorded at 16.55 ft., a 20.10 percent increase from 2010/2011, prior to the broadcast prescribed fire (2012). Live tree crown base height was recorded at 17.75 in 2021.



	2010/11	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
🟩 2.5-15.0cm	112.71	109.87				112.70					89.23
🟨 15.1-30.0cm	128.08	127.68				125.05					122.42
🟧 30.1-45.0cm	25.90	25.90				29.95					32.98
🟫 45.1-60.0cm	2.23	2.23				2.23					2.23
🟥 60+cm	0.00	0.00				0.20					0.20

Fig. 3.10. San Juan Mesa tree density and DBH results.

Average tree density in all size classes appears to remain fairly consistent from 2010 to 2016 (Fig. 3.10). In 2021, there is a noticeable reduction in the 2.5-15.0 cm size class, from 112.70 trees per acre in 2016 to 89.23 in 2021. A small reduction in the 15.1-30.0 cm size class in 2021 and increase in the 30.1-45.0 cm size class can be explained by tree growth into the 30.1-45.0 cm size class. Tree density in the 45.1-60.0 cm size class is low and remains consistent at 2.23 trees per acre throughout the monitoring period.

Photo points established prior to the treatments allowed further understanding of the planned fire's effects. An example photo set is shown in Fig. 3.11. Note the successful consumption by the fire of dead and down woody fuels, and a substantial reduction of the needle-cast litter and duff layer. However, as this was the first ground fire in decades, the heat of the fire killed the lower branch needles, which fell during the next 2 years; hence, the apparently heavy needle layer on the ground in the 2016 photo. A second planned fire will likely remove much of this needle layer, and should open up the mineral soil to increased grass and forb colonization. This issue has been observed at numerous treatment sites in the Santa Fe National Forest and the Valles Caldera National Preserve.

Fig. 3.11. Top left. Pre-treatment Fire Ecology plot photo 2010/2011. Top right: Post-treatment photo 2012. Bottom left: Post-treatment photo 2016; Bottom right: Post-treatment photo 2021.

Monument Canyon Research Natural Area: Vegetation Monitoring

The United States Forest Service (USFS) designated Monument Canyon Research Natural Area (MCRNA) in 1932 to protect the old growth ponderosa pine forests from logging, grazing, and other human influences. Over time, this designation has resulted in some of the least human-disturbed ponderosa pine forests in Northern New Mexico.

MCRNA covers approximately 640 acres of a relatively flat plateau and consists mainly of mid-elevation (7,800 – 8,400 ft.) old growth ponderosa pine forests with smaller areas of mixed-conifer forest. This Biological Description is specific to a 235-acre portion of MCRNA that was mechanically thinned and masticated in 2007. The area was thinned to reduce the density of smaller diameter trees that had increased due to long-term fire exclusion. The next phase of treatment included a broadcast prescribed fire in 2012, with the objective to further reduce smaller diameter trees and forest fuels, maintain larger diameter trees, and increase native herbaceous vegetation.

The combined overstory and midstory tree density is approximately 123 trees per acre. The overstory, approximately 81 trees per acre, is comprised mostly of Ponderosa pine (*Pinus ponderosa*), at 70 trees per acre. White fir (*Abies concolor*), limber pine (*Pinus flexilis*), and Douglas fir (*Psuedotsuga menziesii*) are a smaller component. The midstory contains approximately 42 trees per acre, with 37 trees per acre consisting of ponderosa pine. White fir and limber pine are common midstory trees. Rocky Mountain juniper (*Juniperus scopulorum*) and Douglas fir are present but less common. Oak (*Quercus spp.*) are often present, occasionally in dense thickets.

Reproduction is present but highly spatially variable at approximately 78 trees per acre, consisting primarily of ponderosa pine (62 trees per acre) with a smaller component of aspen (*Populus tremuloides*), white fir, and Douglas fir. A notable increase in aspen is observed five years (2017) after the prescribed fire, from 1 stem per acre at pre-treatment to 9 at post-treatment.

Surface fuels are approximately 18 tons per acre, with 1000-hour fuels as the greatest contributor at 9 tons per acre. Litter and duff fuel load is approximately 8 tons per acre. 1, 10, and 100-hour fuels combined are approximately 1.5 tons per acre. Litter and duff depths are approximately 1.1 inches.

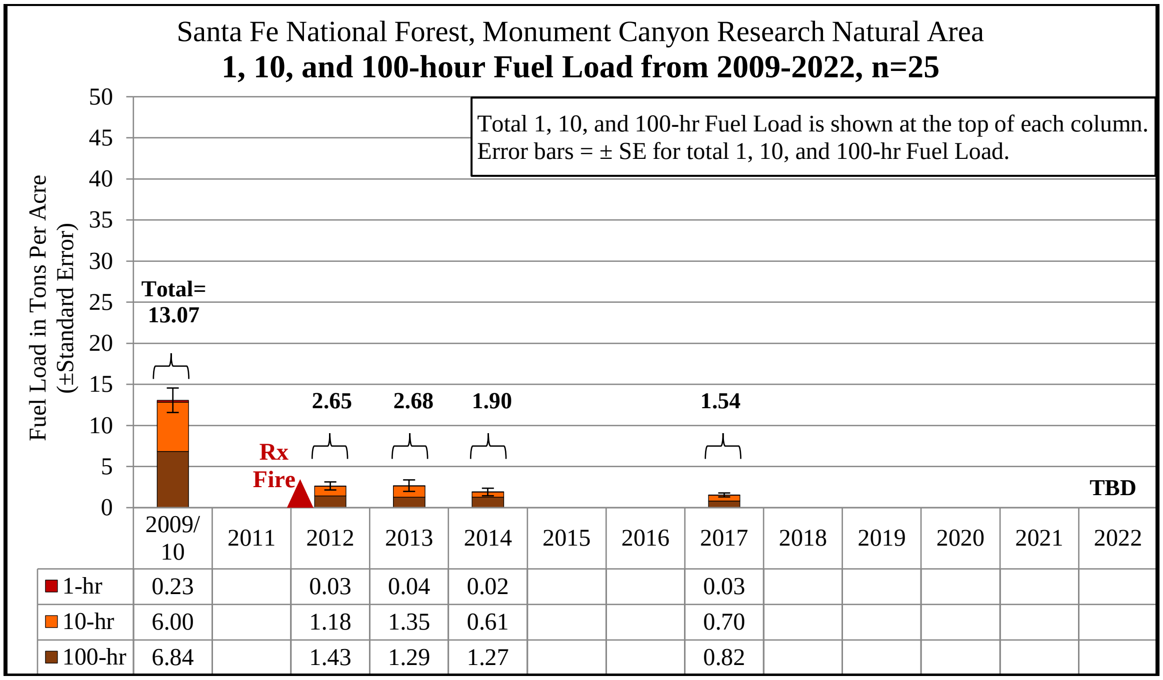
Shrub density is approximately 62 stems per acre. Common shrubs include oak, New Mexico locust (*Robinia neomexicana*), American red raspberry (*Rubus idaeus*), and wax current (*Ribes cereum*).

The surface layer cover is approximately 57% non-vegetated substrate, commonly long needle litter (44% cover), bare ground (7% cover), and wood (4% cover) and includes an herbaceous component at approximately 55% cover. The lifeform with the highest percent cover (23%) is forb, followed by graminoid at 18%, grass-like at 9%, tree at 2%, and shrub at 2%. Forb percent cover consists of 13% native species and 10% non-native; graminoid percent cover is comprised of 17.98% native species and 0.22% non-native; grass-like, tree, and shrub species are entirely native. Common forb species include common mullein (*Verbascum thapsus*), a non-native biennial, and two native perennial forbs, Wooton's ragwort (*Senecio wootonii*) and woodland strawberry (*Fragaria vesca*). Predominant grass species include Arizona fescue (*Festuca arizonica*), rough bentgrass (*Agrostis scabra*), and squirreltail (*Elymus elymoides*), all native perennial grasses. Grass-like species are all native perennial sedges (*Carex spp*.).

Species richness is recorded at 85 species; 73 species were detected on vegetation transects and an additional 12 were observed within 5 meters on either side of the vegetation transects. Of the 85 species, 79 are native and 6 are non-native. Non-native forbs include a biennial forb, common mullein, two perennial forbs, bull thistle (*Cirsium vulgare*) and common dandelion (*Taraxacum officinale*), and one annual, Canadian horseweed (*Conyza canadensis*). Non-native grasses include Kentucky bluegrass (*Poa pratensis*), a perennial, and cheatgrass (*Bromus tectorum*), an annual. (Note: This biological description is based on Fire Ecology data collected on 25 plots in 2017.)

The Santa Fe National Forest implemented a broadcast prescribed fire in Monument Canyon Research Natural Area in 2012. Fire Ecology data was collected on 25 plots in 2009/2010, prior to the prescribed fire, and after the fire in 2012, 2013, 2014, and 2017. Ten-year postburn data will be collected in 2022.

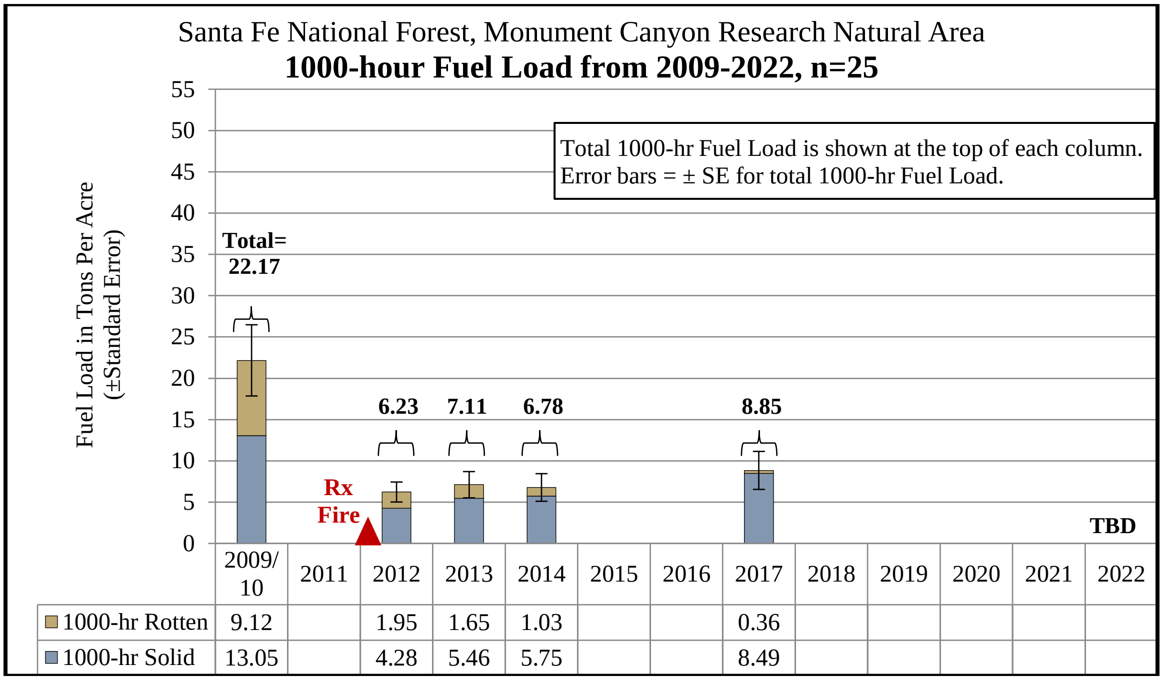
Surface Fuels



	2009/ 10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
🟥 1-hr	0.23		0.03	0.04	0.02			0.03					
🟧 10-hr	6.00		1.18	1.35	0.61			0.70					
🟫 100-hr	6.84		1.43	1.29	1.27			0.82					

Fig. 3.12. Monument Canyon fuel load results.

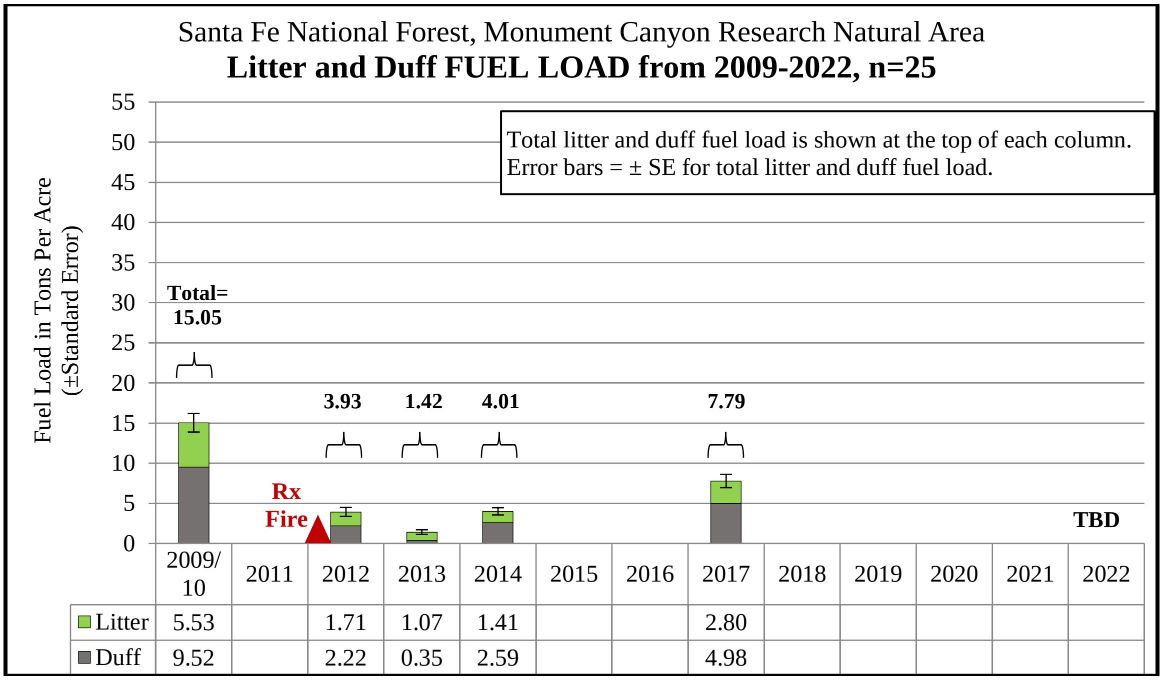
Due to thinning and mastication in 2007, average 1, 10, and 100-hour fuel load was recorded at extremely high levels (13.07 tons per acre) in 2009/2010 (Fig. 3.12). After the broadcast prescribed fire in 2012, it was recorded at 2.65 tons per acre, a 79.73 percent decrease from pre-fire levels. 1, 10, and 100-hour fuels remained low in 2013, 2014, and 2017.



	2009/ 10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
🟫 1000-hr Rotten	9.12		1.95	1.65	1.03			0.36					
🟦 1000-hr Solid	13.05		4.28	5.46	5.75			8.49					

Fig. 3.14. Monument Canyon 1000-hour fuel load results.

Average 1000-hour fuel load was recorded at 22.17 tons per acre in 2009/2010, with solid 1000-hour fuels as the largest contributor at 13.05 tons per acre and rotten 1000-hour fuels at 9.12 (Fig. 3.14). After the broadcast prescribed fire in 2012, 1000-hour fuels were recorded at 6.23 tons per acre, a 72.00 percent decrease from pre-fire levels. 1000-hour fuel load remained fairly consistent from 2012-2014, with a slight increase in 2017.



	2009/10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
🟩 Litter	5.53		1.71	1.07	1.41			2.80					
■ Duff	9.52		2.22	0.35	2.59			4.98					

Fig. 3.15. Monument Canyon litter and duff fuel load results.

Due to mastication in 2007, average litter and duff fuel load was recorded at 15.05 tons per acre in 2009/2010, with duff contributing 9.52 tons per acre and litter at 5.53 (Fig. 3.15). After the broadcast prescribed fire in 2012, litter and duff fuel load was recorded at 3.93 tons per acre, a 73.89 percent decrease from pre-fire levels. Litter and duff fuel load remained low in 2013 and 2014. In 2017, litter and duff was recorded at 7.79 tons per acre.

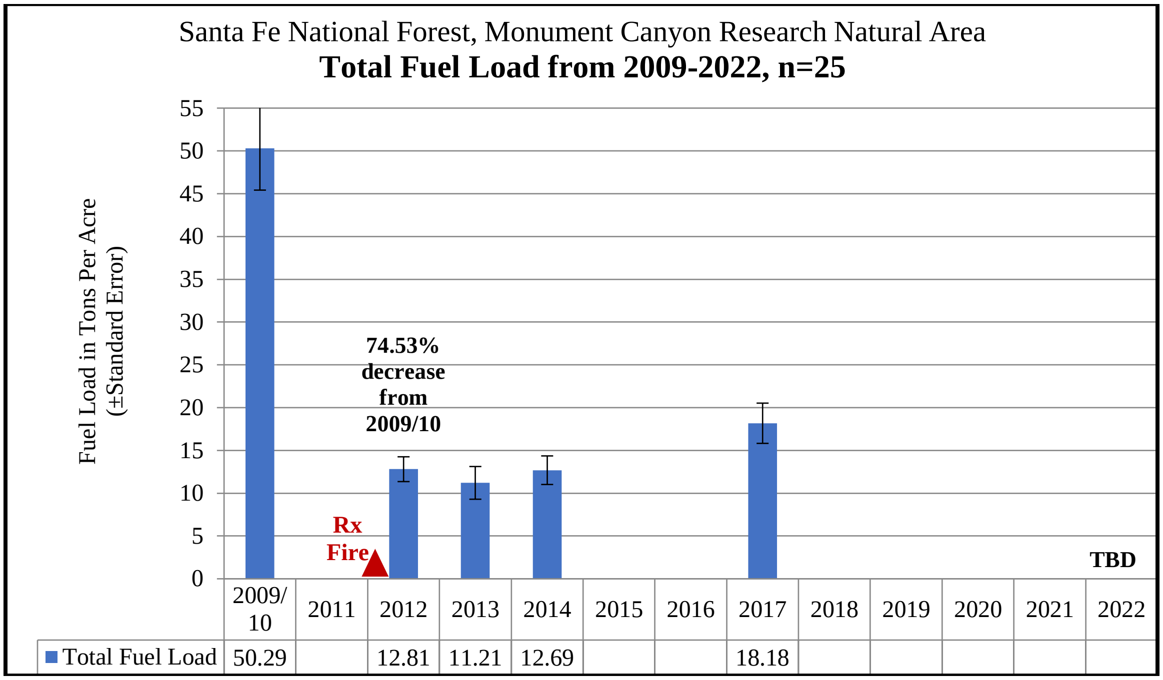
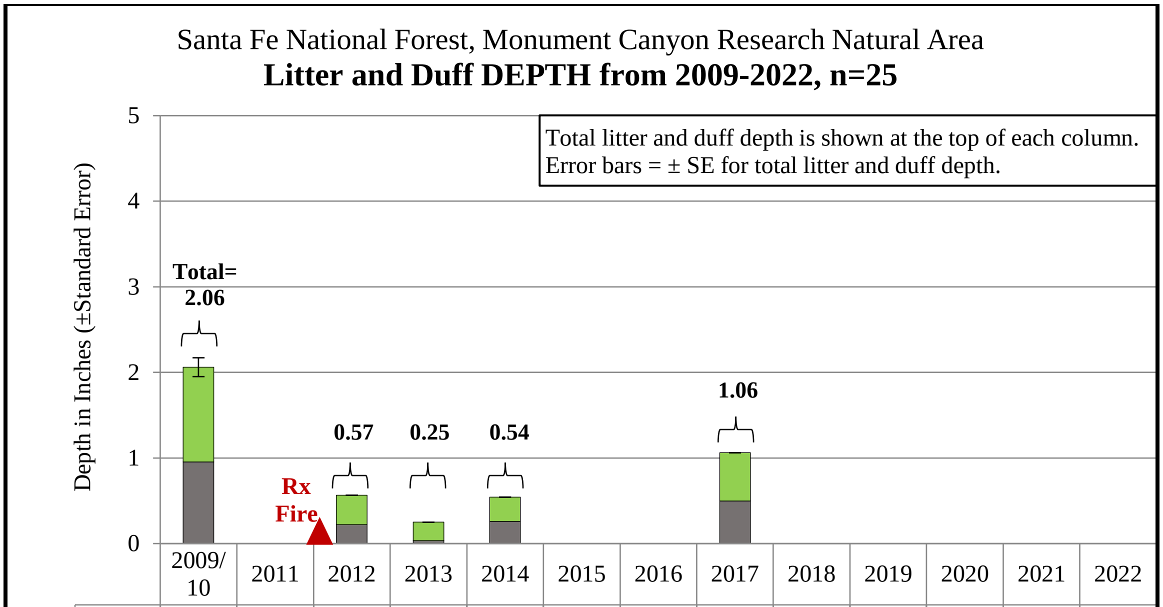


Fig. 3.16. Monument Canyon total fuel load results.

Average total fuel load was recorded at 50.29 tons per acre in 2009/2010 (Fig. 3.16). After the broadcast prescribed fire in 2012, total fuel load was recorded at 12.81 tons per acre, a 74.53 percent decrease from pre-fire levels. Between 2012, 2013, and 2014, little to no change was recorded in total fuel load. In 2017, total fuel load was recorded at 18.18 tons per acre.



	2009/ 10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
🟩 Litter	1.11		0.34	0.21	0.28			0.56					
■ Duff	0.95		0.22	0.04	0.26			0.50					

Fig. 3.17. Monument Canyon litter and duff depth results.

Average litter and duff depth was recorded at 2.06 inches in 2009/2010, with litter as the largest contributor at 1.11 inches and duff at 0.95 (Fig. 3.17). After the broadcast prescribed fire in 2012 (Figs. 3.18 and 3.19), litter and duff depth was recorded at 0.57 inches, a 72.33 percent decrease from pre-fire levels. In 2013 and 2014, litter and duff depths remained low. In 2017, litter and duff depth was recorded at 1.06 inches.

Fig. 3.18. Pre-treatment (2009) and post-treatment (2014) surface fuel loading in Monument Canyon Research Natural Area. Photos: Fire Ecology Program, 2009 and 2014

Fig. 3.19. Prescribed fire conducted in Monument Canyon Research Natural Area, 2012.
Photos: Fire Ecology Program, 2012.

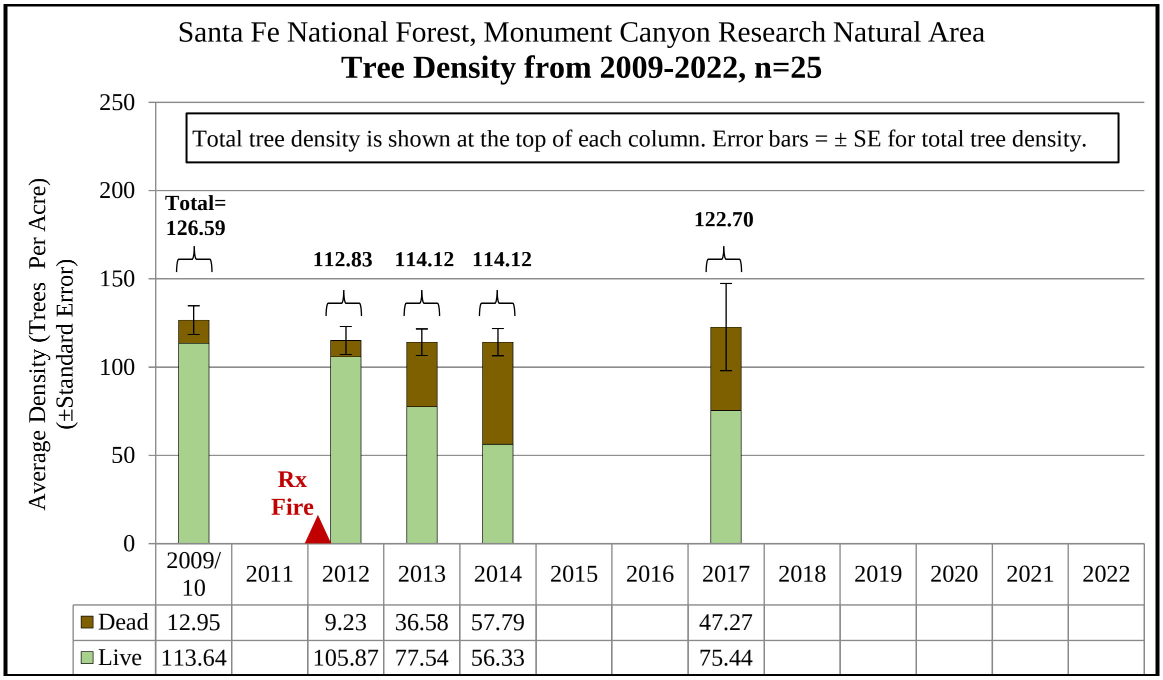
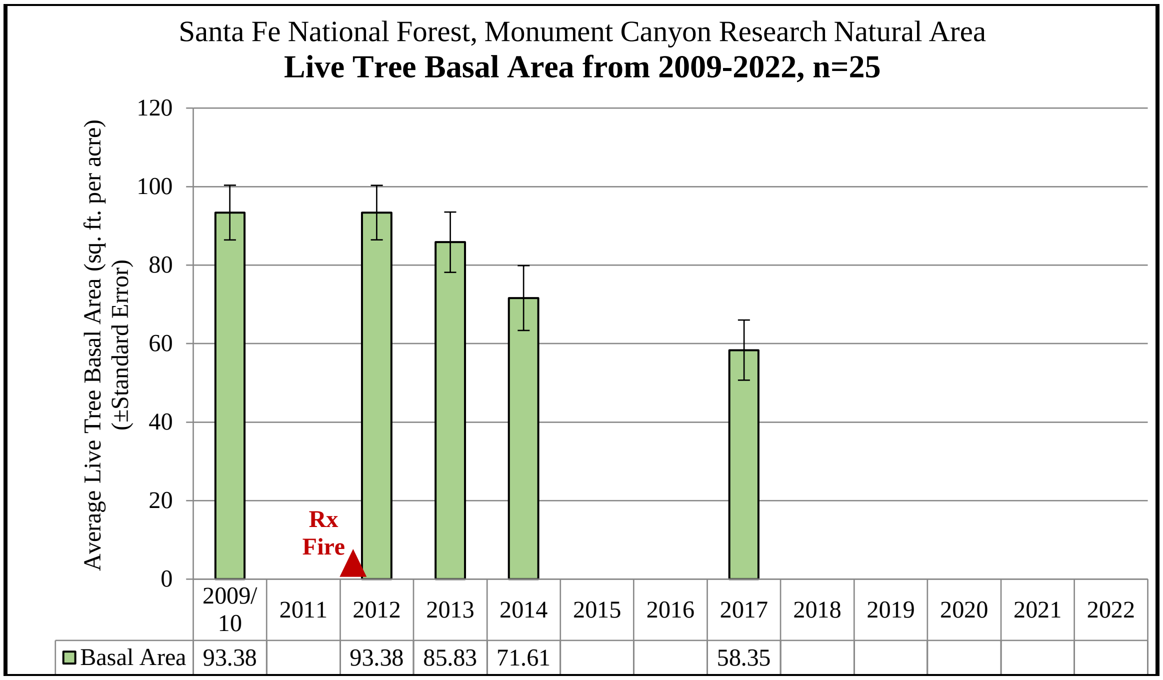


Fig. 3.30. Monument Canyon tree density results.

Average tree density was recorded at 126.59 trees per acre in 2009/2010, with live trees as the largest contributor at 113.64 trees per acre and dead trees at 12.95 (Fig. 3.20). After the broadcast prescribed fire in 2012, tree density was recorded at 112.83 trees per acre. Total tree density remained at 114.12 trees per acre in 2013 and 2014, although the ratio between live and dead trees fluctuated, with live tree density reducing and dead tree density increasing. In 2017, total tree density increased to 122.70 trees per acre, with live tree density recorded at 75.44 trees per acre due to tree growth from the seedling category (less than 2.5 inches in diameter).



	2009/10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
🟩 Basal Area	93.38		93.38	85.83	71.61			58.35					

Fig. 3.21. Monument Canyon live tree basal area results.

Average live tree basal area was recorded at 93.38 sq. ft. per acre in 2009/2010 (Fig. 3.21). After the broadcast prescribed fire in 2012, it was recorded at the same level, but decreased slightly in 2013 and 2014. In 2017, although live tree density increased, live tree basal area decreased to 58.35 sq. ft. per acre because the live tree density increase was due to small diameter trees.

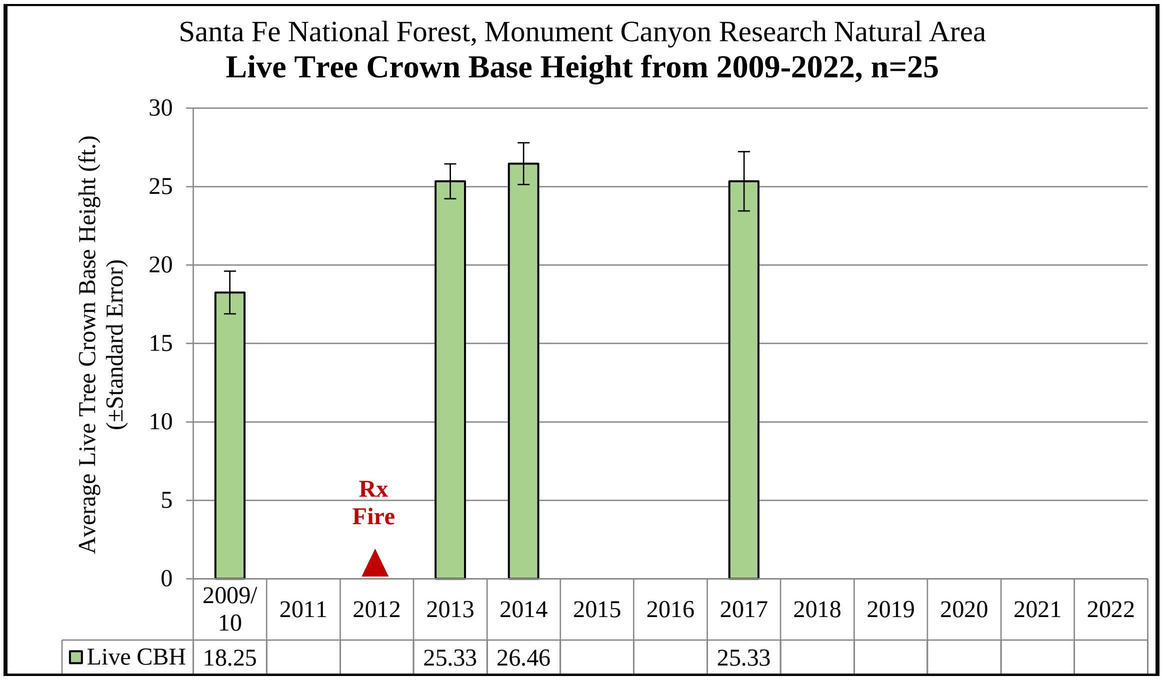


Fig. 3.22. Monument Canyon live tree crown height results.

Average live tree crown base height was recorded at 18.25 ft. in 2009/2010 (Fig. 3.22). In 2013, it was recorded at 25.33 ft., a 38.80 percent increase from 2009/2011, prior to the broadcast prescribed fire (2012). Live tree crown base height remained at similar levels in 2014 and 2017.

Cerro Seco: Unit 5 Vegetation Monitoring.

As part of the LRMP on the Preserve, the south and west sides of Cerro Seco were thinned using mechanical and hand-crew techniques. One of the thinning units, Unit 5, was selected for intensive monitoring with respect to changes in micro-habitat for the Jemez Mountains Salamander, a Federally-listed endangered species. Cerro Seco Unit 5 was outside of the salamander's designated critical habitat, but was adjacent to critical habitat and was deemed to be comparable in stand structure – hence, the site was selected for the treatments (thinning and burning) and extensive monitoring.

The prescription for this unit was to create patches of open meadow and "island" stands of spruce and fir, with any Ponderosa pine, aspen and Douglas fir trees left standing in the meadow areas (i.e., the thinning would only remove spruce and white fir). The unit was treated mechanically in winter 2017-2018 (Fig. 3.23), with logs hauled away to Walatowa Timber Industries mill. Slash was mechanically scattered on the site. A planned broadcast burn was conducted on the site in autumn 2019 (Fig. 3.24).

Fig. 3.23. Cerro Seco Unit 5 post-thinning, with islands of spruce-fir and individual Ponderosa pines in clearings.

Fig. 3.24. Planned (prescribed) broadcast burn on Cerro Seco Unit 5, Oct. 2019.

Forest stand and herbaceous vegetation monitoring plots were installed in the summer of 2016 and 2017 using a modified NPS Fire Effects Monitoring protocol. This project consisted of 10 monitoring sites – 5 control and 5 treatment plots. The treatment and control types refer to forest restoration treatments which include forest thinning treatments and prescribed burns. Forest thinning (clear cut) operations were completed in the winter of 2017/2018. All 10 forest plots and herbaceous vegetation sites were resampled in the summer of 2018. Vegetation was again resampled in the summer of 2019. The 5 plots located in the treatment area were burned in fall of 2019 during the unit's broadcast burn. All vegetation transects and forest plots were resampled again in the summers of 2020 and 2021.

Vegetation Monitoring Results

Percent canopy cover for live trees was calculated for each year (Fig. 3.25). As expected, live tree cover decreased substantially in the experimental treatment plots after thinning operations occurred in the winter of 2017-2018 and has remained relatively constant since then. Overall canopy cover across the entire treated unit remained at ~40%, due to the overall mosaic of un-thinned spruce-fir "islands" (with >70% canopy cover) and open meadows with near zero canopy cover. The prescribed fire in 2019 resulted in almost no change in tree canopy cover, as the fire remained on the ground's surface (Fig. 3.24).

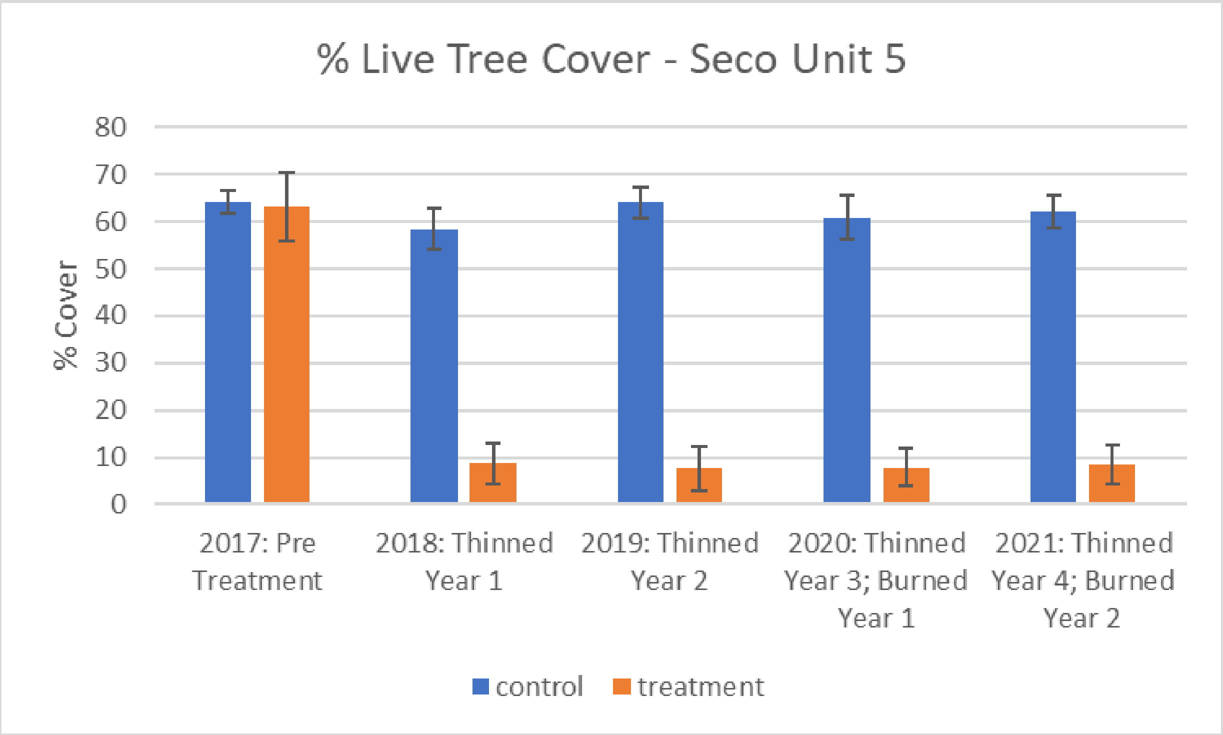


Fig. 3.25. Results of tree canopy percentage cover on Cerro Seco Unit 5, 2017-2021.

Percentage cover for live forbs was calculated for each year pre- and post-treatment (Fig. 3.26). Live forb cover appears to have peaked in 2019 - during the second year, post thinning. Live forb cover was also highest in 2019 for control plots, so this may be due in part to a fairly wet year relative to the other years in which herbaceous vegetation was monitored.

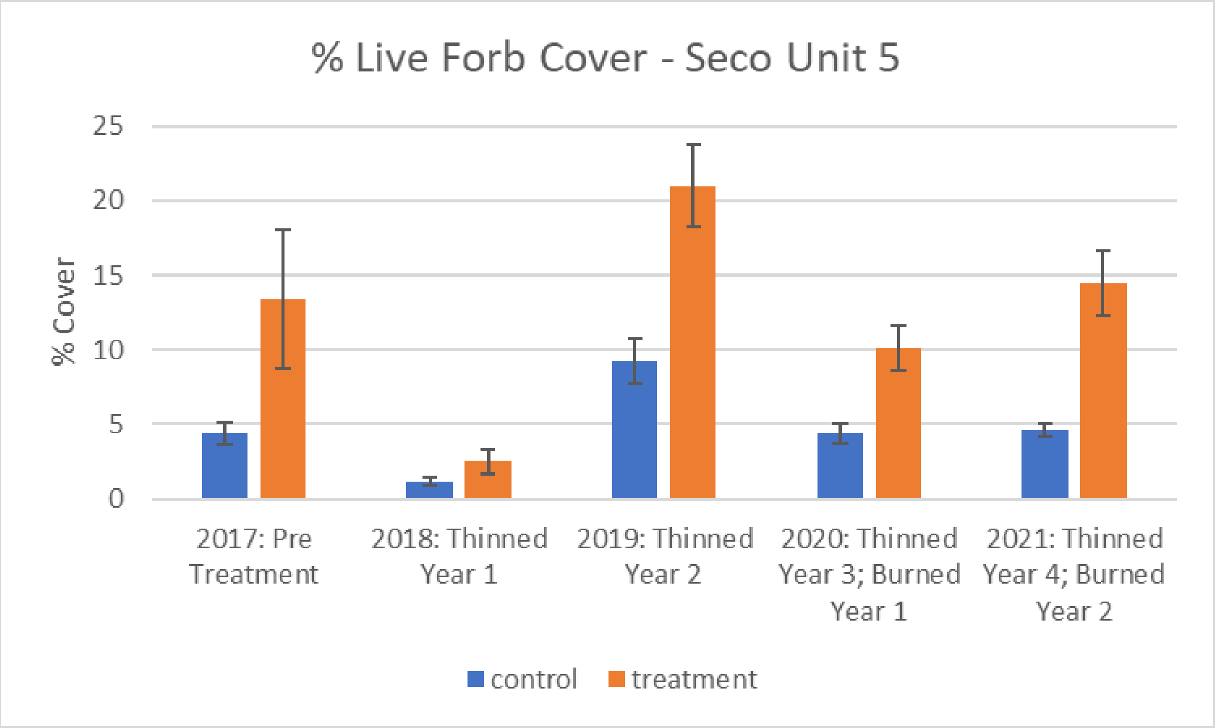


Fig. 3.26. Results of forb percentage cover on Cerro Seco Unit 5, 2017-2021.

Percentage cover for live grass was calculated for each year (Fig. 3.27). As with live forb cover, live grass cover was lowest for both treatment and control plots in 2018, during the first year after thinning treatments. 2018 was also a drought year, which may have contributed to less understory growth overall. Percentage live grass cover has remained relatively consistent for the last three years, with its peak (thus far) occurring in 2021(the fourth year since thinning and the second year since being burned) by a small margin.

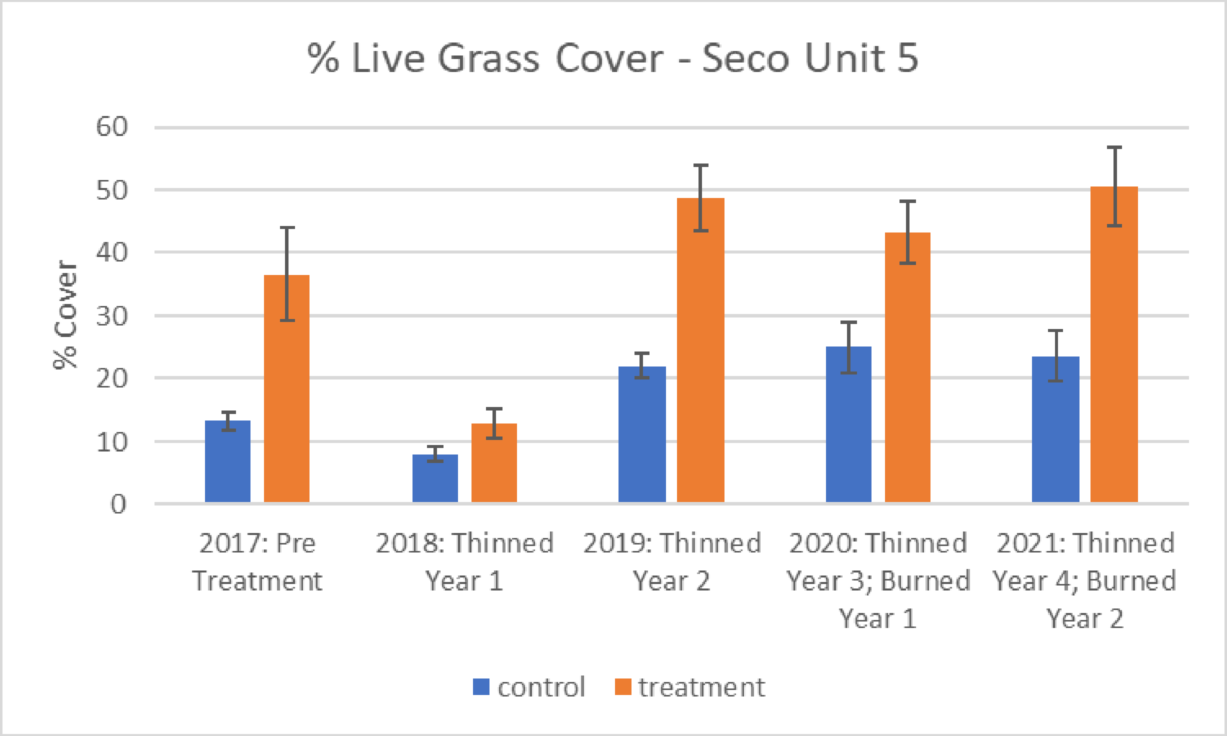


Fig. 3.27. Results of grass percentage cover on Cerro Seco Unit 5, 2017-2021.

Repeat photographs of the experimental treatment plots in thinned areas show the increase in grass and forb cover between 2018 and 2021 (Fig. 3.28). One of the LRMP goals is to diversify the habitat types and improve wildlife habitat in the project area, and creating a mosaic of meadows and forest stands with reduced fuel loads accomplishes that goal. Forage for elk, deer and other herbivorous species has been increased, and greater amounts of herbaceous fuels to support ground-level low-intensity fires have been established.

Fig. 3.23. Repeat photos of 3 monitoring sites in the Cerro Seco treatment areas in 2018 (left) and 2021 (right).

Conclusions

Based on the increase in percent cover for live forbs and live grasses on treatment versus control plots, the combination of forest thinning operations and prescribed fire has largely been successful at converting what was once a second-growth spruce thicket into open grassland where a few Ponderosa pines, aspens and Douglas firs remain; this appears in 1935 aerial photographs to have historically been the original and predominate ecotype for this area of the Preserve prior to 20th century logging and fire suppression. Understory vegetation cover typically peaks several years after low-intensity fire, so future sampling of these plots will be of great interest. Island patches of spruce that remain unthinned may or may not survive when more frequent ground fires move through the area; future monitoring will provide updated information on that outcome.

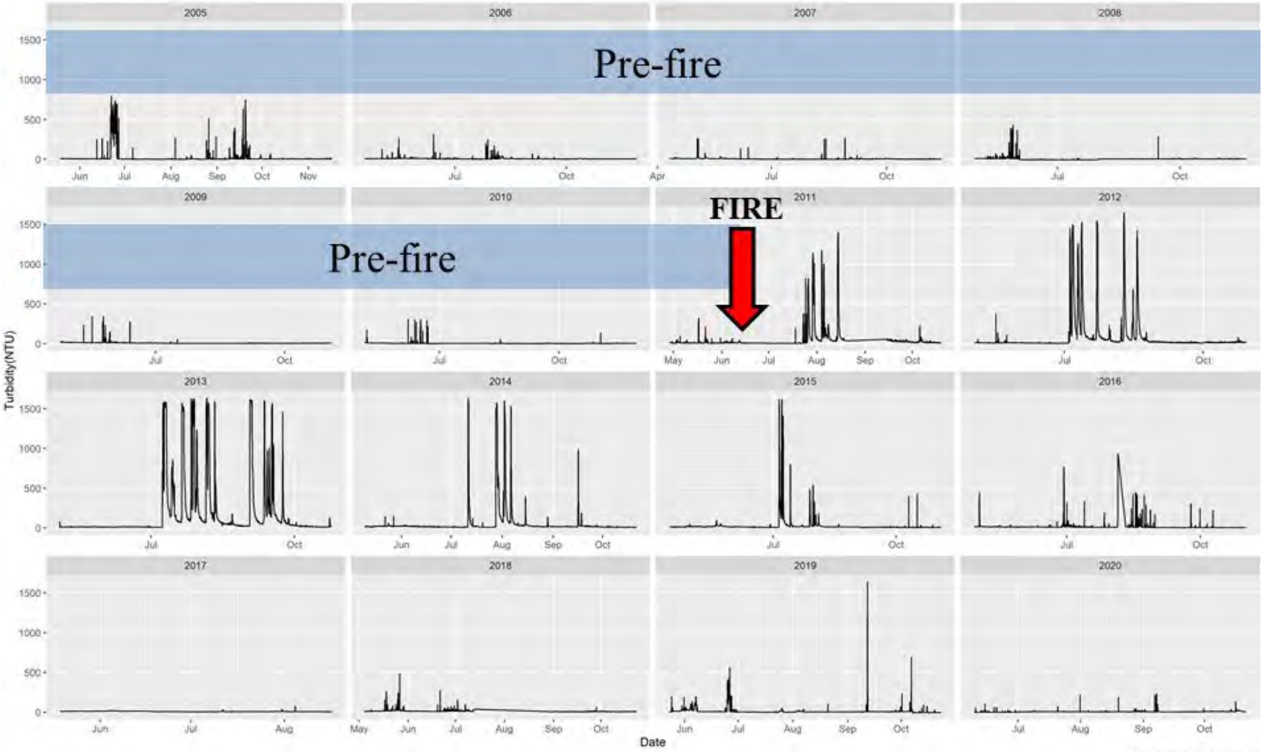
Collaborators: National Park Service, Valles Caldera National Preserve and Pueblo Parks Fire Ecology Group; University of New Mexico; New Mexico State University; Keystone Restoration Ecology (wetland vegetation); Rio Grande Return (stream riparian vegetation).

Chapter 4. Stream Water Quality

Stream water quality has been monitored on the Valles Caldera National Preserve (Preserve) since 2005, and on the Santa Fe National Forest (SFNF) since 2011. A total of 8 sites are monitored using automated Sonde instruments at permanent locations (Fig. 4.1). Sondes are operated during the ice-free times of the year (typically May through October). Sondes are re-calibrated approximately every 3 weeks during the field season. Data are uploaded into the NPS software, AQUARIUS, for archival and analysis.

Fig. 4.1. Map of CFLRP/LRMP project area with stream water quality monitoring stations (blue stars with Sondes (inset)).

The data from these Sondes have indicated that the post-fire flooding from the 2011 Las Conchas fire and the 2013 Thompson Ridge fire have dominated water quality from the time of the fires to 6-7 years post-fire. For example, the data on turbidity provide the most direct evidence for post-fire water quality dynamics (Fig. 4.2). Prior to the 2011 fire, pulses of turbidity in San Antonio Creek were relatively mild, but after the fire, summer flash floods continued from 2011 through 2016, until 2017 when the watershed had developed sufficient herbaceous plant cover to prevent large-scale runoff events.



Data compiled by D. Pittenger

Fig. 4.2. Turbidity data from San Antonio Creek prior to and after the 2011 Las Conchas Fire.

Most of the streams in the CFLRP/LRMP project area are listed as “impaired” by the New Mexico Environment Department (NMED) for temperature and turbidity. The restoration efforts under the CFLRP and LRMP programs, coupled with grants from NMED and the Rio Grande Water Fund, obtained by collaborating groups such as Los Amigos de Valles Caldera, the Rio Puerco Alliance, WildEarth Guardians and the Rio Grande Return, have included wetland restoration, streambank stabilization, willow-planting along with other woody riparian shrubs and trees, and construction of “beaver dam analogs” (BDAs; Fig. 4.3).

Fig. 4.3. Beaver Dam Analog structure and willow planting on the SFNF, San Antonio Creek; project completed by Rio Grande Return with funding from NMED.

Thus far, the upper reaches of Jaramillo Creek on the Preserve have been restored with wetland rehabilitation and streambank willow planting (Fig. 4.4). As a result, NMED has removed the impairment designation for temperature on this reach, due to the shading effect of the willows on the creek. Other reaches in the San Antonio Creek, Indios Creek, Redondo Creek and Sulphur Creek have been planted with willows, and we will monitor these streams in future years to assess the degree to which impairments are reversed.

Fig. 4.4. Jaramillo Creek willow plantings; note elk exclosure fences to prevent herbivory. Fences will be removed in future years, once the willows have becomes well-established.

Collaborators: NPS Valles Caldera staff (Scott Compton, David Pittenger); New Mexico Environmental Department; Rio Grande Return; WildEarth Guardians; Los Amigos de Valles Caldera; Keystone Restoration Ecology.

Chapter 5. Fisheries Monitoring

Fisheries monitoring takes place at 24 permanently-marked locations on the Santa Fe National Forest (SFNF) and Valles Caldera National Preserve (Preserve) (Fig. 5.1). Monitoring on the Preserve began in spring, 2003, and on the SFNF in spring, 2013. Sampling occurs each spring and autumn. Sampling from spring 2020 through spring 2021 was suspended due to the Covid-19 pandemic; sampling resumed in fall 2021.

Fish are collected alive using backpack electroshockers (Fig. 5.2) along a 100-meter or 50-meter reach of stream. The sample reach is blocked off with nets at both ends to prevent fish from leaving or entering the reach during sampling. Field crews make 3 passes with the electroshockers, netting out the stunned fish and placing them in buckets. The fish are then taken to a data processing table, where workers identify, measure and weigh each fish. Fish are kept alive in aerated buckets during this process, and when finished, they are placed into a fish “car” (large net box) in the stream. Once the 3 sample passes are complete and all the fish have been processed, the fish are released back into the stream all along the reach. The blocking nets are removed, and the crew moves to the next sampling site.

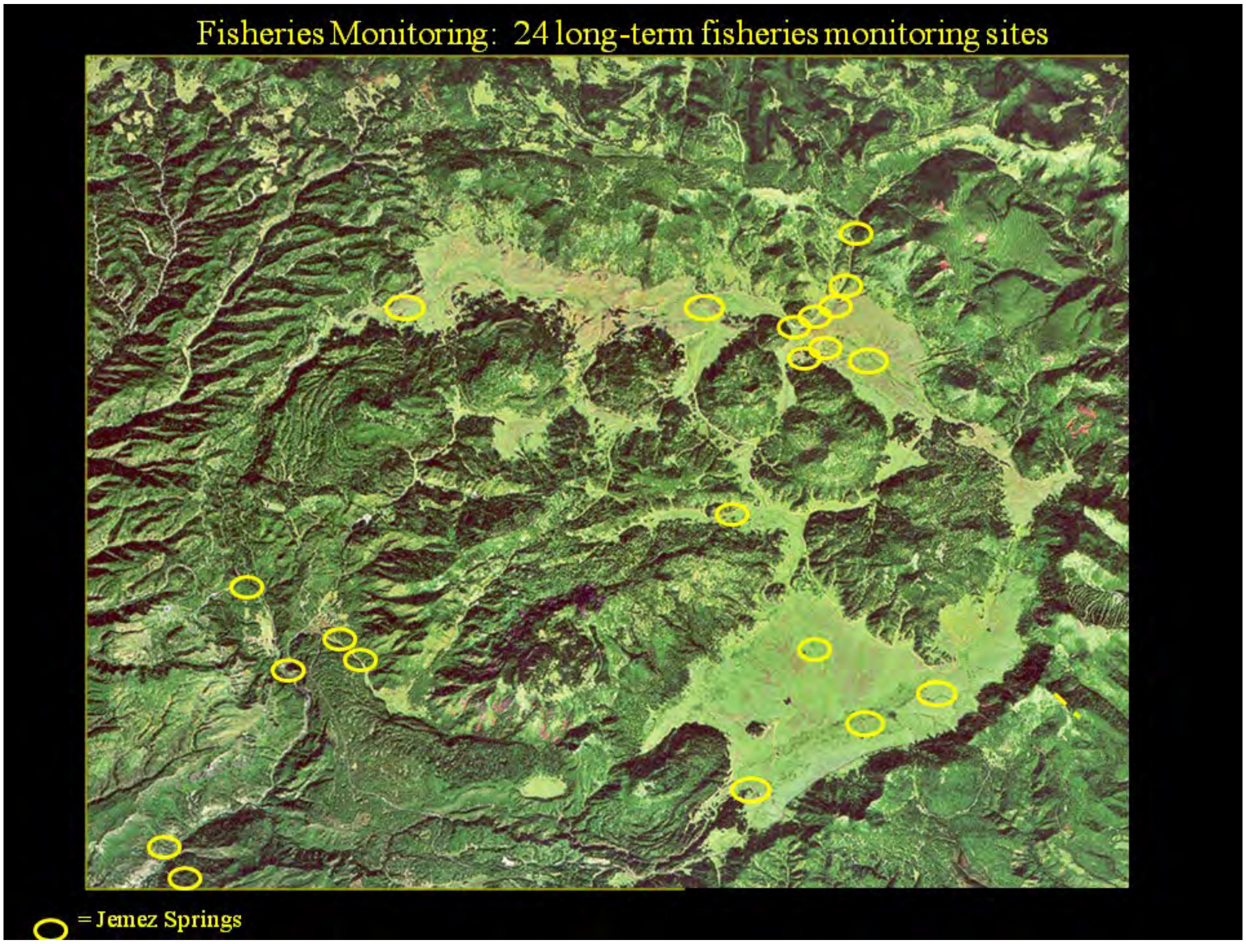


Fig. 5.1. Fish monitoring sites in the CFLRP Project Area (Jemez Springs and two sites in Vallecitos Creek not shown)

Fig. 5.2. Field crew using backpack electroshockers to sample fish in the East Fork Jemez River near Battleship Rock, SFNF.

Results to date have shown that:

(1) large wildfires in the CFLRP watershed (e.g., Las Conchas Fire in 2011, Thompson Ridge in 2013) caused high mortality rates in non-native introduce brown trout and rainbow trout populations (Fig. 5.3);

(2) native non-game fish (Rio Grande chub, Rio Grande sucker, long-nose dace, and fathead minnow) survived the fires and post-fire floods with no negative effect; native non-game fish species increased in abundance in the absence of the predatory trout (the “predator release” effect) but declined once the trout populations began to recover (Fig. 5.4).

(3) trout populations were affected only in the upper watersheds near the fire; trout populations further downstream did not exhibit population declines (Fig. 5.5, of the far western reach on the Rio San Antonio, away from the burned area around Valle Toledo);

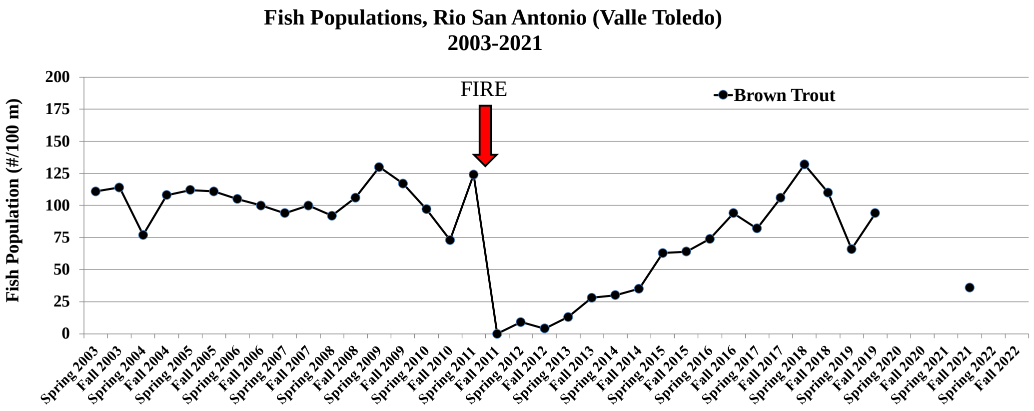


Fig. 5.3. Abundance of brown trout in the Rio San Antonio, Valle Toledo, before and after the 2011 Las Conchas Fire.

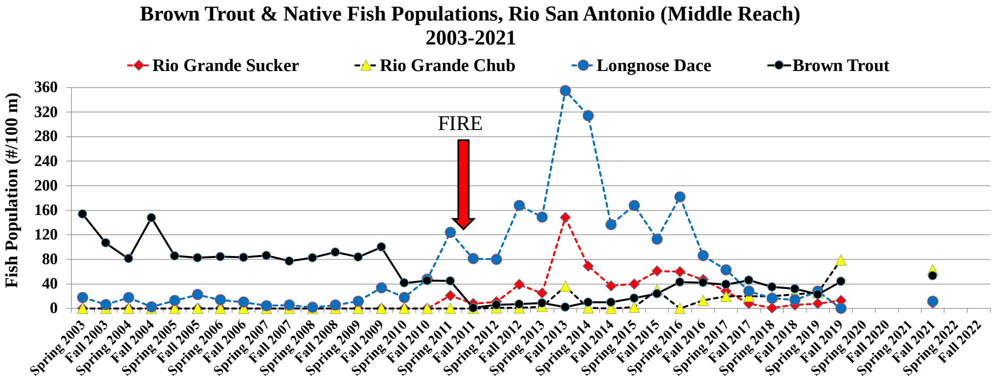


Fig. 5.4. Abundance of brown trout (black line) and native non-game fish (colored lines) in the Rio San Antonio, Middle Reach, before and after the 2011 Las Conchas Fire.

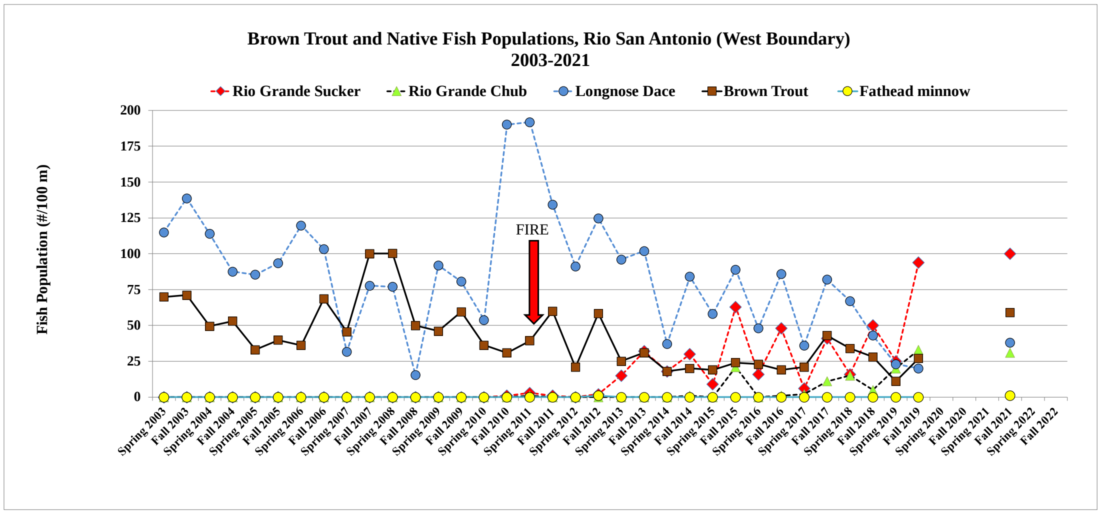


Fig. 5.5. Abundance of brown trout (black line) and native non-game fish (colored lines) in the Rio San Antonio, West Reach, before and after the 2011 Las Conchas Fire.

(4) Fish populations on the SFNF at Battleship Rock have shown little response to post-fire floods (e.g., the 2013 Thompson Ridge Fire that burned portions of the Rio San Antonio watershed); see Figs. 5.6 and 5.7 comparing the Rio San Antonio and East Fork Jemez River just upstream of their confluence.

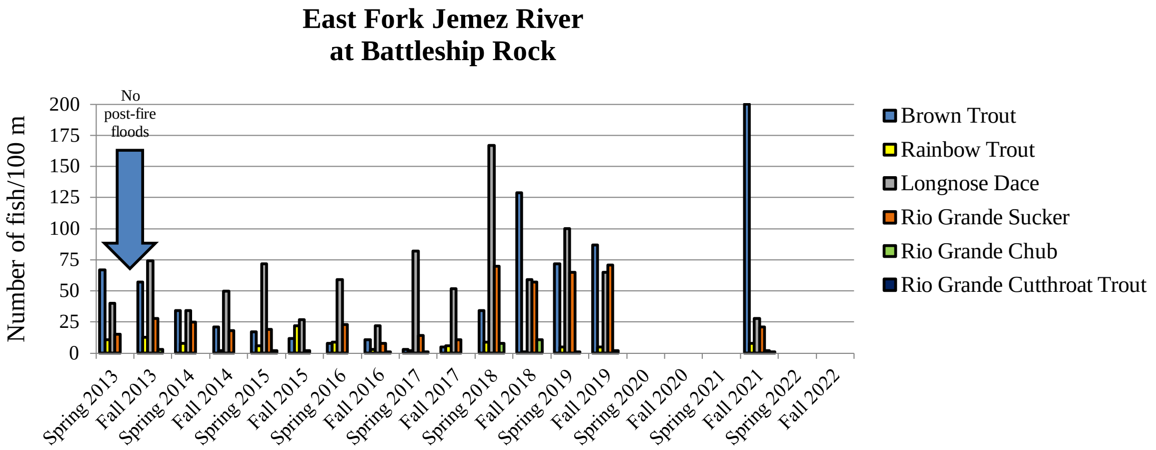


Fig. 5.6. Abundance of trout and native non-game fish in the East Fork Jemez River at Battleship Rock, before and after the 2013 Thompson Ridge Fire; the East Fork did not experience any significant post-fire flooding.

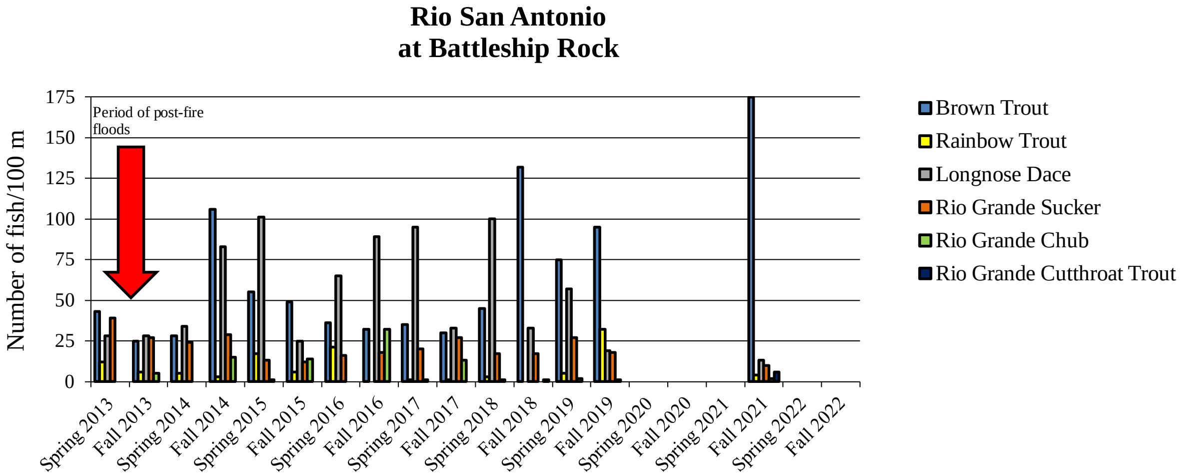


Fig. 5.7. Abundance of trout and native non-game fish in the Rio San Antonio at Battleship Rock, before and after the 2013 Thompson Ridge Fire; the Rio San Antonio experienced some post-fire flooding from Redondo Creek and Sulphur Creek, several miles upstream of Battleship Rock.

Conclusions:

1. 10 years post-Las Conchas and 8 years post-Thompson Ridge – monitoring results meeting expectations of post-fire recovery, in that non-native trout populations have recovered, and native non-game fishes have responded to predator decline and eventual predator recovery.

2. Watershed restoration implementation efforts have had no detectable negative impacts on trout fisheries and native fish populations.

3. Forest restoration activities are predicted to reduce high-severity fires, and this will be the major factor in maintaining healthy fish communities in the streams of the Jemez Mountains.

Collaborators: National Park Service, US Forest Service, NM State University's USGS Cooperative Fish & Wildlife Research Unit, Trout Unlimited, New Mexico Trout, Sierra Club Service Trip volunteers, New Mexico Gas Company (volunteer employees), WildEarth Guardians and Rio Grande Return Youth Conservation Corps members, and many citizen volunteers.

Chapter 6. Aquatic Invertebrates

In conjunction with fish and aquatic health monitoring, a macroinvertebrate biomonitoring program began in 2004 in the Preserve to monitor the long-term trends of grazing practices on water quality and the benthic macroinvertebrate community throughout the Preserve's streams. On 26 June 2011, a wildfire (Las Conchas Fire) started outside of the Preserve's boundary, ultimately burning 63,371 ha of Santa Fe National Forest, Bandelier National Monument, Los Alamos Laboratory, and the Preserve until fully contained on 1 August 2011. The Las Conchas wildfire became the largest wildfire in New Mexico's recorded history at the time. The fire burned 12,156 ha or one-third of the Preserve. Immediately after the wildfire in 2011, the Preserve added additional macroinvertebrate biomonitoring sites to supplement the long-term monitoring of the benthic macroinvertebrate communities throughout the Preserve to describe ecological changes occurring post-fire and recovery trajectory of the aquatic macroinvertebrate communities.

To describe ecological changes related to recovery of the aquatic macroinvertebrate community post-fire, the first objective was to continue biomonitoring of the aquatic macroinvertebrate community. Analysis of the biomonitoring data, however, was not straightforward. From 2004 to 2018, different investigators employed a total of three gear types for biomonitoring of the benthic macroinvertebrate community. Thus, our second objective was to resolve how the differing gear types affected the data and thus interpretation of our ecological metrics. When we compared the use of a commercial Surber sampler with 500 µm mesh (2004-2006), a Hess-like sampler with 500 µm mesh (2005-2014) and a commercial Hess with 250 µm mesh (2015-2018), we determined that the Surber sampler did not capture similar number of taxa relative to the Hess sampler, which resulted in different density and diversity estimates of macroinvertebrates. Moreover, we learned the two mesh sizes (250 µm versus 500 µm) resulted in size selectivity of taxa whereby larger and more common taxa were captured by the 500 µm mesh and the smaller and rarer taxa were captured by the 250 µm mesh. We learned that there were no comparable diversity metrics among the gear types or mesh sizes. Given this, we characterized environmental variables that were critical to the recovery and health of the aquatic macroinvertebrate community while treating each gear type or mesh size as a unique dataset. As such, our third objective was to identify which environmental variables co-occurred with aquatic macroinvertebrate assemblages as primary drivers of ecological change before and after the wildfire.

We found 158 taxa of aquatic invertebrates. We used random-forest algorithms to characterize ecological metrics best explained by the environmental variables. We learned that water temperature, dissolved oxygen, and water turbidity were the important predictors of Shannon diversity and feeding group richness. Our fourth objective compared these ecological metrics before and after the Las Conchas wildfire to determine the impact and time to recovery of the aquatic macroinvertebrate assemblages. We learned the aquatic macroinvertebrate communities before and after the fire between un-burned and burned streams of the Preserve exhibited large inter-annual variation, which precluded our ability to detect changes to wildfire effects and recovery. These temporal responses appear unrelated to fire effects and may simply reflect the overarching influence of the larger diel or daily range in stream temperature and seasonal pulses of materials that occur in open meadow grassland streams.

In summary, differences in gear types and mesh sizes prevented the standardization of 11 years of biomonitoring data which precluded long-term and seamless comparisons of ecological metrics of the aquatic macroinvertebrate community before and after the wildfire. However, for the gear-types with similar mesh sizes immediate post-fire, we found significant relationships among ecological metrics with environmental variables of water temperature, dissolved oxygen and turbidity. The ecological metrics suggest that time to recovery of the benthic invertebrate community was relatively short-term (<12 months; Fig. 6.1) and that this recovery was supported by improvement of water quality as the surrounding watershed began its recovery.

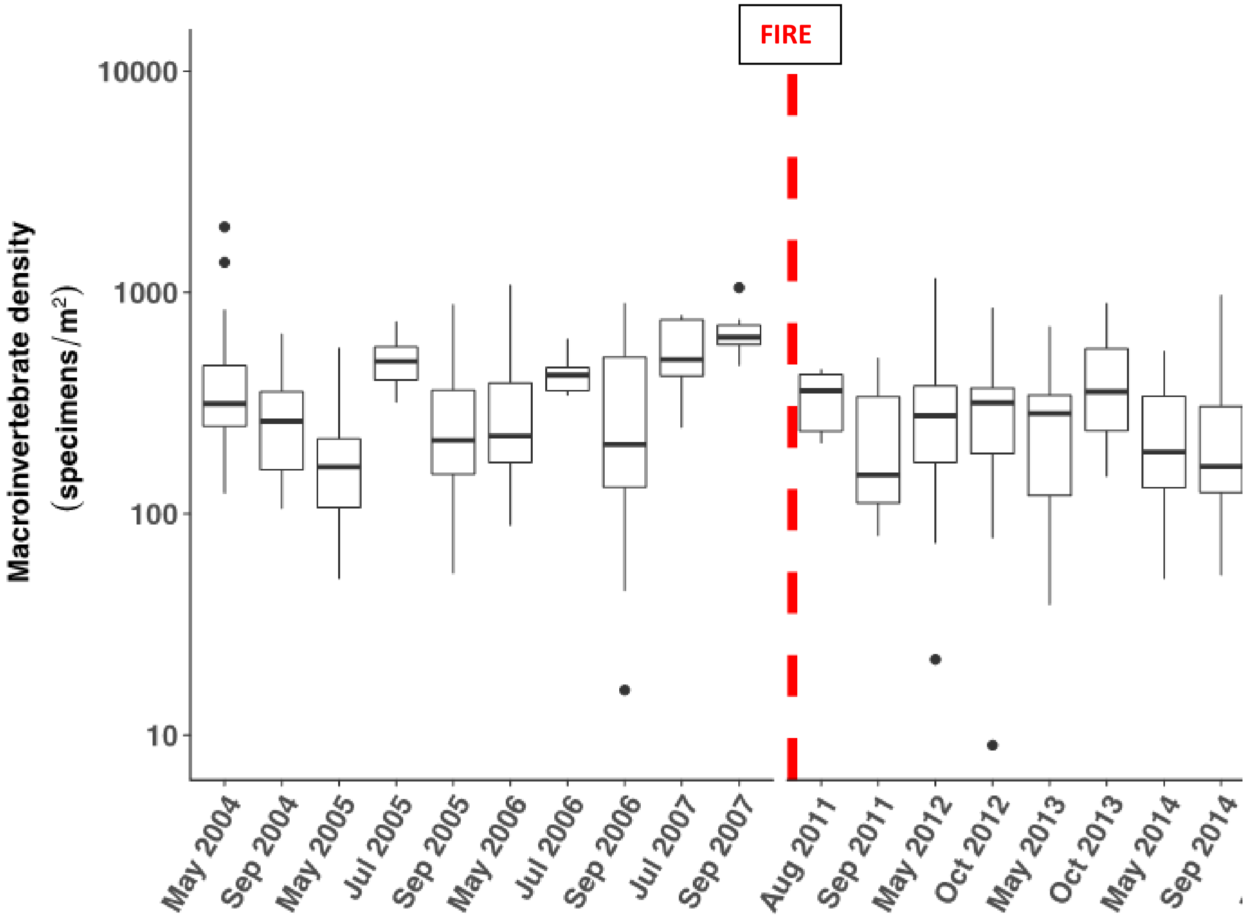


Fig. 6.1. Aquatic macroinvertebrate densities in Indios Creek prior to and after the Las Conchas Fire in 2011. Box plots represent means (black bars), Standard Errors (boxes), 95% Confidence Intervals (whiskers), and outlier data points (black dots). Note that numbers were slightly depressed in September 2011, but had recovered by spring of 2012.

Collaborators: Dr. Colleen Caldwell, New Mexico State University's USGS Fish & Wildlife Research Cooperative Unit; Lauren Kremer, Colorado State University; Dr. Jerry Jacobi, Prof. Emeritus, Highlands University.

Chapter 7. Wildlife: Large Mammal Monitoring

Background

Our overall goal is to simultaneously monitor the responses of mule deer, elk, mountain lions and black bears to forest restoration treatments associated with the Southwest Jemez Mountains CFLRP and Valles Caldera's Landscape Restoration and Management Project (LRMP). Our goals were to monitor both the short- and long-term changes in vegetation, particularly forage conditions, and the attendant responses in movements and habitat selection of mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), mountain lions (*Puma concolor*) and black bears (*Ursus americanus*). Our specific research objectives were to: 1) assess changes in abundance of key forage species in response to forest restoration treatments and wildfires including herbaceous forage for elk, browse for mule deer, and mast producing species for black bear and mule deer; 2) estimate forage quality in treated and untreated areas; and 3) determine habitat selection and space use patterns of mule deer, elk, mountain lions and black bears in relation to forest restoration treatments and wildfire including the time between restoration activities and use by large mammals.

Study animal capture and handling

As of April 2020, all field-based data collection for the first phase of the Large Mammal Monitoring Project is complete. In total we captured 35 adult female mule deer, 114 adult female elk, 19 mountain lions (8 female, 11 male), and 54 black bears (19 females, 35 males) and fitted them with GPS telemetry collars to collect data on movements and to assess habitat selection patterns in relation to wildfires and treatments (Fig. 7.1).

Habitat Selection

Elk **–** We used model selection to partition diel shifts in behavior and used resource selection probability functions to model elk habitat selection hierarchically at diel scales within seasons. Across seasons, elk shifted from selecting grassland cover at dawn/dusk, to selecting for greater canopy and forest cover at midday, and then to areas with greater herbaceous biomass at night. In winter, elk selected for southern aspects during midday, for unburned areas at dawn/dusk, and for areas burned within the previous 1–3 years. In spring, elk selected for northern aspects and for areas burned within 1–3 years at midday, areas farther from roads, and for areas farther from water at midday. In summer, at dawn/dusk and midday, elk selected for areas farther from water and avoided forest cover, and at night, elk selected for areas burned within the previous 1–3 years. In fall, elk selected for areas burned the previous year at dawn/dusk and night, for higher elevations at midday, and for areas closer water at night. Thinning treatments did not feature prevalently in this analysis because most were relatively recent and or ongoing during this period of data collection; however, the highest use areas were within the Las Conchas fire burn area (see Table 7.1).

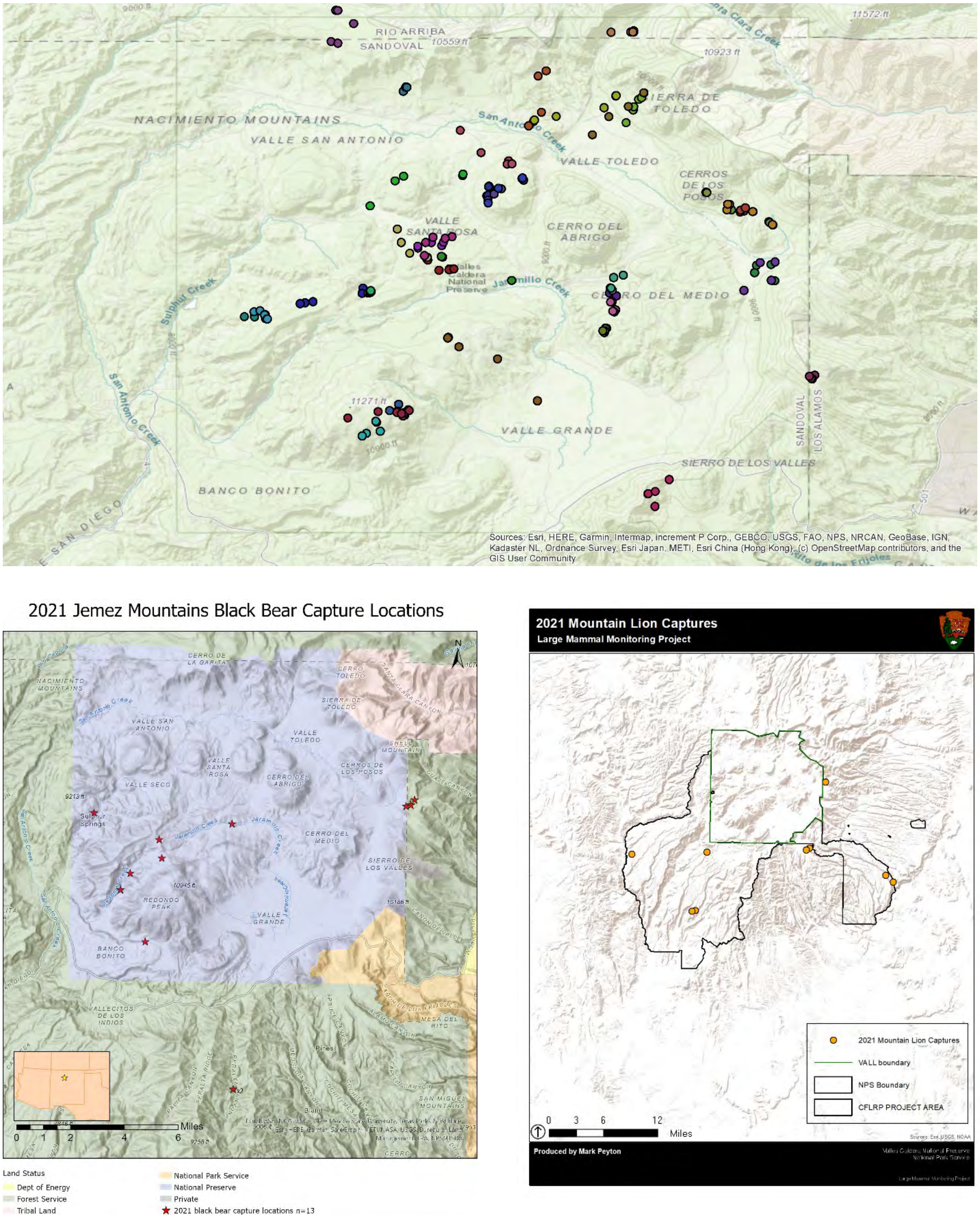


Fig. 7.1. Capture locations in 2021 for elk (top), black bears (bottom left) and mountain lions (bottom right).

Table 7.1. Percentage of elk location points collected in respective years located within untreated, thinned (by hand [NFH] or mechanically [NFM]), prescribed burned (RX), wildfire burned (MX), or sites both thinned and burned by any method from 2013-2018 in the Jemez Mountains of New Mexico. Treatments are divided by age in years since the treatment occurred.

Year	**Treatment Type and Age (Years)**														
	Untreated	**Thinned (NFH & NFM)**							**Burned RX**						
	NA	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**
2013	31.67	0.42	1.01	0.53	0.00	0.02	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
2014	29.84	0.01	0.51	0.28	0.03	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.09	0.00	0.00
2015	25.04	0.04	0.00	0.02	0.01	0.05	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.03	0.00
2016	18.64	0.03	0.00	0.01	0.01	0.00	0.00	0.01	1.71	0.00	0.00	0.00	0.01	0.00	0.02
2017	23.71	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00
2018	25.91	0.00	0.02	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.97	0.00	0.00	0.00	0.00
Average across years	25.80	0.10	0.26	0.14	0.01	0.01	0.00	0.00	0.54	0.19	0.20	0.00	0.02	0.01	0.00
Average across years and ages	25.80	0.07							0.14						

Year	**Treatment Type and Age (Years)**															
	Burned MX									**Both Thinned and Burned**						
	0.5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**
2013	20.82	0.00	44.19	0.10	0.01	0.00	0.00	0.00	0.00	0.88	0.05	0.00	0.00	0.00	0.00	0.00
2014	0.07	32.00	0.00	35.88	0.06	0.00	0.00	0.00	0.00	0.07	0.83	0.03	0.00	0.07	0.00	0.00
2015	0.00	0.07	22.06	0.00	51.63	0.37	0.00	0.00	0.00	0.21	0.15	0.25	0.00	0.02	0.01	0.00
2016	0.01	0.00	0.00	11.19	0.00	67.10	0.79	0.01	0.00	0.01	0.18	0.04	0.13	0.00	0.01	0.09
2017	0.00	0.00	0.00	0.00	17.83	0.00	56.81	0.21	0.00	0.42	0.00	0.00	0.00	0.07	0.00	0.00
2018	0.77	0.00	0.00	0.00	0.00	23.04	0.00	46.82	0.05	0.08	0.76	0.00	0.00	0.00	0.03	0.00
Average across years	3.61	5.35	11.04	7.86	11.59	15.09	9.60	7.84	0.01	0.28	0.33	0.05	0.02	0.03	0.01	0.02
Average across years and ages	8.00									0.10						

Mule deer **–** Landscape scale habitat selection results through 2015 are completed; mule deer habitat selection modeling with data through 2018 is in progress and will be completed in early 2021 in the final report.

Mule deer selected for areas burned by prescribed fire and generally avoided wildfire-burned and thinned areas when they were <5 years old. However, mule deer strongly selected for thinned areas ≥5years old. At both the landscape and home-range scale, grasslands were avoided during most seasons, pinyon-juniper woodlands were selected in winter, and oak vegetation and mixed-conifer forests were selected during summer. Our data suggests that mule deer may benefit from recent prescribed burns and older forest thinning, but the duration of post-treatment vegetation recovery influences the strength and direction of selection.

Black bears **–** Landscape scale habitat selection of black bears in response to wildfires and restoration treatments is in progress and will be available in the final report in 2021. However, micro-habitat selection at day bed sites and den sites are complete.

We investigated bed and den site selection of American black bears using GPS location data and a use/available study design to assess the influence of habitat characteristics, including wildfires, prescribed burns, and thinning treatments on bed and den site selection. The most supported models suggested that black bears were more likely to select bed sites with a combination of low horizontal visibility and high stand basal area. The highest-ranking model for den site selection indicated that black bears were more likely to select den sites with low horizontal visibility. Black bears used all disturbed sites to varying degrees, although 48% of bed sites were located in undisturbed habitat while only 11% and 2% of bed sites were located in thinned and prescribed burn sites, respectively. Thirty-nine percent of bed sites were located in previous wildfire locations but 67% of these were in areas with low burn severity. Thirty-eight percent of den sites were located in previously disturbed habitat, 8 of these sites were burned by wildfires. Accounting for the timing, size, and proximity of future restoration would aid in mitigating potential short-term negative effects on black bear bed and den site selection.

Mountain lions **–** Analyses of mountain lion habitat selection is in progress and will be presented in the final report.

Vegetation monitoring

Sampling and collection **–** Forage measurement and sampling was completed in September 2018. In total over 1,700 plots were measured between 2013 and 2018 across 6 stand types and 5 treatment types, including 34 exclosures and their controls. From these plots we collected over 8,400 forage samples for nutritional analyses. In addition, we collected over 1\,000 herbaceous and 2,300 shrub samples to be used in biomass-predicting regressions. In addition, over 470 seed bank samples were collected in 2017 and 2018, and seed bank trials on those samples were completed in 2019. We have germinated and tracked over 6,400 seedlings from those trials.

***Forage quality* –** Sample preparation of the 8,400 nutritional samples was completed in 2019. Over 3,400 samples were sent to SDK Labs for crude protein, lignin, ash, NDF, ADF, and other analyses. SDK Labs completed their analyses in 2019. A further 1,600 samples were sent to the WSU Wildlife Habitat and Nutrition Lab (WHNL) for tannin analyses. Lastly, 900 samples were analyzed for gross energy via bomb calorimetry at TTU, and a further 900 were sent to the WSU WHNL for gross energy analyses. These have been delayed by the covid19 pandemic and their completion date is unknown currently.

Preliminary results regarding the nutritional quality of herbaceous and woody forage across stand types and treatments suggest crude protein levels may vary by both stand type and treatment type, but not between herbaceous and woody species within-plot, lignin levels vary significantly ($P < 0.005$) as expected between herbaceous and woody species but not significantly across treatments or stand types, and mineral levels (via ash) vary significantly ($P < 0.005$) between herbaceous and woody species, and possibly by treatment in grassland plots.

***Forage biomass* –** Preliminary analyses of changes in herbaceous and woody forage biomass over time (2013-2018) in untreated plots in the 6 dominant stand types (aspen, grassland, oak woodland, pinon-juniper, ponderosa, and spruce-fir) show no significant changes in measured biomass within stands over time, except aspen stands, though individual stands varied greatly in their forage availability. Woody biomass in untreated aspen stands decreased significantly over time ($P < 0.05$). Untreated grassland and spruce-fir stands consistently produced the greatest available herbaceous forage consistently, while oak shrublands consistently produced the greatest available woody forage consistently. Broadly, there were few differences in herbaceous or woody biomass availability across the 5 treatments (not treated, thinned, prescribed fire, wildlife, and both thinned and burned) due to high variability across stand types. However, when our results were broken out by treated stand age (0.5 years to 18 years), some stand types differed between treated and untreated areas, though the majority of results affected by high variability across stand types. Stand-specific treatment effects on available biomass are patchy, depending on the available treatments and ages, but when fairly complete, more significant. For instance, available herbaceous biomass in older (4-8 yrs) wildfire-burned ponderosa stands is higher ($P < 0.05$) than to untreated ponderosa stands, while older thinned and wildfire-burned ponderosa sites have ($P < 0.05$) lower available woody biomass. Ponderosa-specific variability is still high enough to confound almost all other results, though visual trends suggest they may be ecologically meaningful.

All results presented above should be considered preliminary in nature and subject to change upon further analyses and addition of data on forage nutritional content from outstanding lab samples and the inclusion of additional covariates in the models.

Community distribution and spatial interaction of large mammals

We deployed grid of 145 remote cameras to investigate the impacts of restoration activities on the distribution, habitat use, and co-occurrence of large mammals (i.e., mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), black bears (*Ursus americanus*), mountain lions (*Puma concolor*), and coyotes (*Canis latrans*)) (Fig. 7.2). We placed cameras

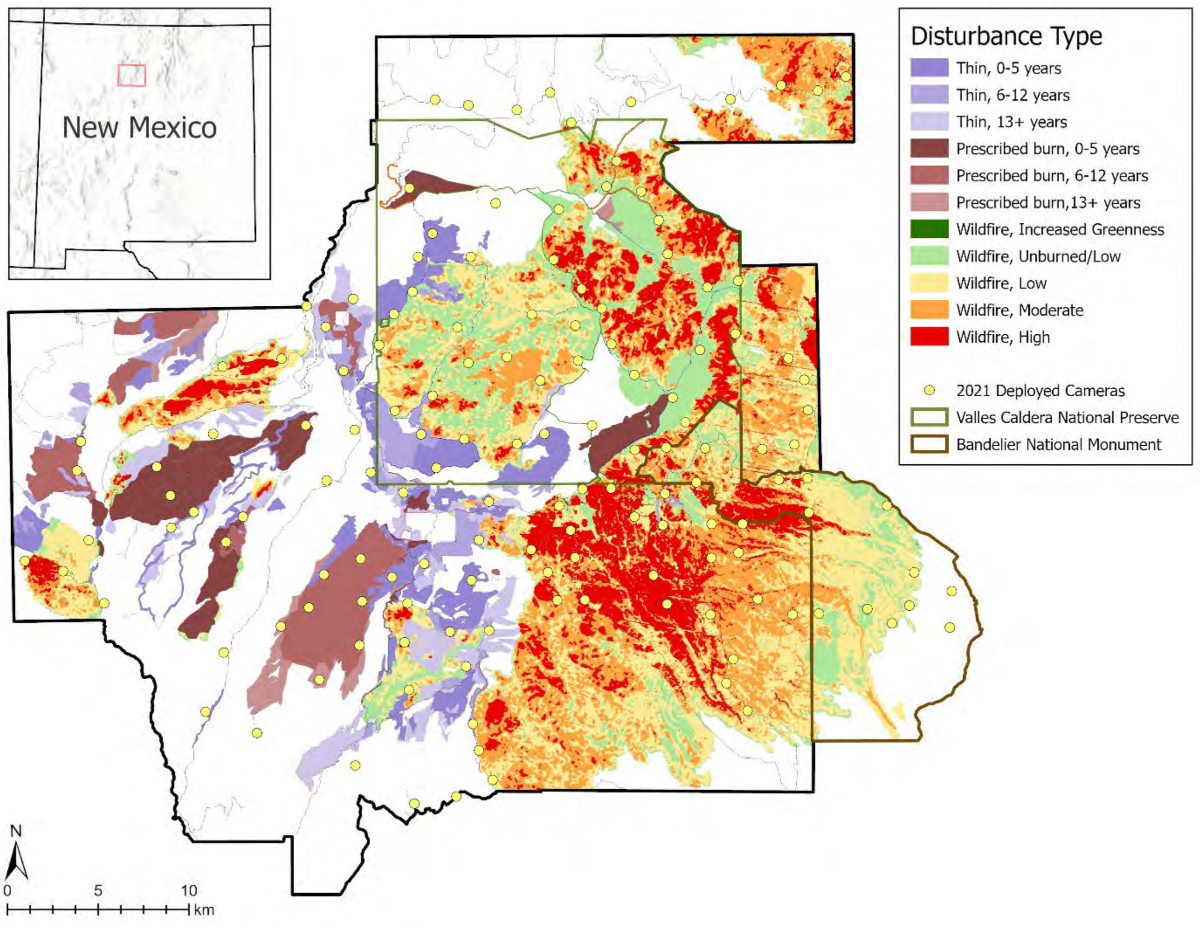


Fig. 7.2. Map of wildlife camera deployments across the Santa Fe National Forest, Valles Caldera National Preserve and Bandelier National Monument.

proportionally over the range of restoration treatments and wildfires in the region and processed images to identify animals. We will develop occupancy models to evaluate whether the disturbance history influences species' probability of use, specifically accounting for type of disturbance, time since treatment, and landscape metrics of disturbance type and severity. With multispecies occupancy models, we will investigate how these measures of disturbance affect co-occurrence in the mammal community.

In the 2021 field season, cameras were active for a total of 17,497 camera-days. We collected 2,037,518 images and have identified 27 species (see examples if Fig. 7.3). With sufficient data, we may develop models for additional species (e.g., bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and turkey (*Meleagris gallopavo*)). The second field season will span May 1 – October 31, 2022, and the analysis is expected by early summer 2023. This project composes Leah White's graduate research and will result in a master's thesis.

Fig. 7.3 Images collected from camera traps in the Southwest Jemez Mountains, including turkey vulture (A, *Cathartes aura*), turkey (*B, Meleagris gallopavo*), bobcat (C, *Lynx rufus*), elk (D, *Cervus canadensis*), coyote (E, *Canis latrans*), mountain lion and kittens (F, *Puma concolor*), and black bears (G, *Ursus americanus*).

PRODUCTS

Theses and Dissertations from former graduate students involved with the project include:

Kindschuh, S. R. 2015. Efficacy of GPS cluster analysis in predicting black bear carnivory sites. MS Thesis. M.S., New Mexico State University.

Roberts, C. 2015. Seasonal and diel elk habitat selection in the Jemez Mountains of New Mexico. MS Thesis. M.S., Texas Tech University.

Humagain, K. 2016. Ecological variation among vegetation cover types and forest stand dynamics in the South-West Jemez Mountains, New Mexico. PhD. Dissertation. Doctor of Philosophy, Texas Tech University.

Roerick, T. M. 2017. Habitat restoration effects and habitat selection of female mule deer in the Jemez Mountains, New Mexico. MS Thesis. M.S., New Mexico State University.

Bard. S. M. 2018. Microhabitat Selection and Pathogen Prevalence of American Black Bears (*Ursus americanus*) in the Jemez Mountains, New Mexico, USA. MS Thesis. M.S., New Mexico State University.

Anaya, A. J. 2019. Mountain Lion (*Puma concolor*) Kill rates and prey composition in north-central New Mexico. MS Thesis. M.S., New Mexico Highlands University.

Publications from former graduate students involved with the project include:

Roberts, C.P., J.W. Cain III, and R.D. Cox. 2016. Application of activity sensors for estimating behavioral patterns. Wildlife Society Bulletin 40:764–771.

Kindschuh, S.R., J.W. Cain III, D. Daniel and M.A. Peyton. 2016. Efficacy of GPS cluster analysis for predicting carnivory sites of a wide-ranging omnivore: the American black bear. Ecosphere 7: art e01513.

Humagain, K., C. Portillo-Quintero, R. D. Cox and J. W. Cain III. 2017. Mapping tree density in forests of the southwestern USA Using Landsat 8 Data. Forests 8(8):287.

Roberts, C. P., J. W. Cain III, and R. D. Cox. 2017. Identifying ecologically relevant scales of habitat selection: diel habitat selection in elk. Ecosphere 8: art e02013.

Roerick, T. M., J. W. Cain III, and J. V. Gedir. 2019. Forest restoration, wildfire, and habitat selection by female mule deer. Forest Ecology and Management 447:169-179.

Bard, S. M. and J.W. Cain III. 2019. Pathogen prevalence in American black bears (*Ursus americanus amblyceps*) of the Jemez Mountains, New Mexico, USA. Journal of Wildlife Diseases, 55:745-754.

Bard, S.M., and J.W. Cain III. 2020. Investigation of bed and den site selection by American black bears (*Ursus americanus*) in a landscape impacted by forest restoration treatments and wildfires. Forest Ecology and Management 460:art 117904.

Cooperators: James W. Cain, Leah White, Matt Keeling, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University; Sharon Valverde, Department of Natural Resources Management, Texas Tech University; Mark Peyton, National Park Service, Valles Caldera National Preserve; Warren Conway, Department of Natural Resources Management, Texas Tech University; Gary Roemer, Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University.

Chapter 8. Wildlife: Bird Monitoring

Summary

As part of the Southwest Jemez Collaborative Forest Landscape Restoration Project, Hawks Aloft, Inc. was subcontracted to conduct avian point count surveys from 2012-2021 to evaluate avian use within eight habitat types located in the Valles Caldera National Preserve and the Santa Fe National Forest. Cumulatively, over 10 years of surveys, avian density was highest in mixed conifer forest (2.30 birds/ha) and burned mixed conifer forest (2.12 birds/ha). Avian richness was highest in riparian habitat (104 species) and ponderosa pine (*Pinus ponderosa*) forest (84 species). We documented a total of 134 bird species. In a comparison of unthinned and thinned ponderosa pine forest plots, cumulative (2012-2021) avian density was significantly higher at treated points (2.14 birds/ha) than untreated (1.58 birds/ha); however, the difference was largely driven by data collected after the thinned points were subjected to prescribed fire. Density was highest at thinned and burned points (2.28 birds/ha), followed by thinned points (1.97 birds/ha) and untreated points (1.58 birds/ha). Avian richness was higher at unthinned points (53 species) than thinned points (52 species). No federally listed threatened or endangered species were observed, but we documented 57 avian species of conservation concern. The response of relatively common species of concern was variable among unburned and burned habitats of like type and between untreated and treated ponderosa pine forest. Grace's Warbler (*Setophaga graciae*), the highest priority regularly-occurring species of conservation concern in the survey area, was significantly more abundant in unburned forest than burned forest and significantly more abundant in treated ponderosa pine forest than untreated. Although the first ten years of data are revealing, longer-term data collection is necessary to reliably evaluate avian trends and response to wildfire and habitat treatment at both the community and species levels within the study area.

INTRODUCTION

Beginning in 2012, Hawks Aloft Inc. was subcontracted to conduct avian point count surveys for the Southwest Jemez Collaborative Forest Landscape Restoration Project (CFLRP). This project is a long-term monitoring effort focused on forest and watershed restoration activities in the southwest Jemez Mountains of north-central New Mexico. The overall goal of this project is to improve the resilience of ecosystems to recover from wildfires and other natural disturbance events in order to sustain healthy forests and watersheds (Santa Fe National Forest and Valles Caldera National Preserve 2010). Specific objectives include 1) reducing the risk of wildfire and restoring natural fire regimes; 2) increasing forest diversity and old growth characteristics; 3) improving fish and wildlife habitat; 4) improving water quality and watershed function; 5) mitigating climate change impacts; 6) protecting cultural resources; and 7) utilizing woody by-products to create local economic development opportunities.

Although mitigating climate change is listed as one of the key objectives of this project, it also is inherent in the overall goal of the project and many of the other project objectives. Climate change models project that the southwestern U.S. will become steadily hotter and drier over the remainder of the 21st century (e.g. Karl et al. 2009, Garfin et al. 2013, Kunkel et al. 2013), resulting in more frequent and severe drought, increases in insect outbreaks and associated tree mortality (Raffa et al. 2008, Bentz et al. 2010, McDowell et al. 2016), shifts in vegetation distributions (Allen and Breshears 1998, Gonzales et al. 2010) and increased risk of catastrophic fire (Westerling et al. 2006, Abatzoglou and Williams 2016, Harvey 2016, Harvey et al. 2016). The reality of increased fire risk was illustrated by the recent occurrence of three major fires within the project area. In 2011, the Las Conchas fire burned over 156,000 acres on the Valles Caldera National Preserve and adjacent Santa Fe National Forest land, making it the largest fire in New Mexico history (National Park Service 2012). In 2013, the Thompson Ridge fire burned nearly 24,000 acres within the Valles Caldera National Preserve. The Pino fire burned approximately 4,300 acres of the Santa Fe National Forest land in 2014. Additionally, several smaller fires have occurred in or near the study area since 2014.

The effects of climate change, such as those listed above, will have a substantial impact on birds (van Riper et al. 2014, Pearce-Higgins and Green 2014, Stephens et al. 2016). Thus, monitoring avian response to project activities designed to mitigate the negative impacts of climate change at both the community and individual species levels will be important factors in assessing project success. In addition, birds comprise the most diverse vertebrate taxa within the study area, and can serve as ecological indicators of overall environmental health (Temple and Wiens 1989, Canterbury et al. 2000, Gregory and van Strien 2010). In this interim report, we summarize avian data collected from 2012-2021, including an inventory of avian species observed, identification of species of conservation concern, and analyze avian use by habitat type, between burned and unburned points and between treated and untreated points.

STUDY AREA

The study area encompasses approximately 210,000 acres in the Southwest Jemez Mountains of north-central New Mexico, comprising the entire upper Jemez River watershed. The area includes 110,000 acres of the Santa Fe National Forest (USFS) and nearly 89,000 acres of the Valles Caldera National Preserve (VC), managed by the National Park Service. The Valles Caldera is a 13-mile circular depression that was formed about 1.25 million years ago after a supervolcano erupted in the Jemez Mountains (Goff et al. 2011). This eruption was preceded by an almost identical eruption some 400,000 years earlier that formed the equally large Toledo Caldera. The Toledo Caldera was mostly obliterated when the Valles Caldera formed in the same place. Resurgent doming of the central caldera floor occurred between 1.25 and 1.22 million years ago, and was followed by additional dome eruptions around the caldera margins up until about 40,000 years ago. These eruptions are interlayered with lake deposits, indicating the caldera has been at least partially filled by lakes since its formation. The depressions in Valles Caldera currently contain several grassland valleys that sustain a variety of wildlife unique to the area.

Avian point counts were established in five of the habitat types found within the overall study area: mixed conifer forest, ponderosa pine (*Pinus ponderosa*) forest, mountain valley grassland, riparian, and mountain meadow. Three additional habitat types were created at established points by the Las Conchas, Thompson Ridge, and Pino fires: mixed conifer burn, ponderosa pine burn, and mountain valley grassland burn. Mixed conifer forest plots were dominated by various mixtures of conifer, including Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), blue spruce (*Picea pungens*), southwestern white pine (*P. strobiformis*), limber pine (*Pinus flexilis*), and ponderosa pine. Mountain valley grassland plots were primarily devoid of woody vegetation and dominated by different mixtures of grasses, including Arizona fescue (*Festuca* *arizonica*), pine dropseed (*Blepharoneuron tricholepis*), Thurber fescue (*F. thurberi*), and Parry's oatgrass (*Danthonia parryi*). Vegetation in riparian habitat was highly variable among survey routes and elevation. Dominant woody species at lower elevations included cottonwood (*Populus fremontii*), willow (*Salix* spp.) and juniper (*Juniperus* spp.). Higher elevation riparian sites incorporated components of thinleaf alder (*Alnus incana*), willow, Douglas-fir and ponderosa pine. The mountain meadow plot was devoid of trees, with tufted hairgrass (*Deschampsia cespitosa*) and sedges (*Carex* spp.) comprising the primary vegetation.

Between 2012 and 2021, we initiated surveys at 17 different avian point count routes, including 10 on USFS land, six on the VC, and one with points in both management areas (Fig. 8.1). Among the 11 routes with point counts on USFS land (N = 122 survey points), five were classified as ponderosa pine forest, four were classified as riparian, and two were classified as mixed conifer forest. Among the seven routes with points located in the VC (N = 83 survey points), one route is classified as mixed conifer forest, one route is classified as ponderosa pine forest, one route is classified as riparian, and four are comprised of a mixture of habitats, including mixed conifer, mountain valley grassland, ponderosa pine, and mountain meadow. Many of the points in mixed conifer, ponderosa pine, and mountain valley grassland habitats burned during the Las Conchas and/or Thompson Ridge fires. Details of each route are provided below.

Banco Bonito- Located at the southern end of Banco Bonito in the southwestern portion of VC (Fig. 8.1 and 8.2). All 22 points on this route (BB01-BB22) were classified as ponderosa pine forest. Points BB02, BB04, and BB06 were thinned prior to the 2012 field season, BB08, BB10, and BB12 were thinned during 2014, and BB14 and BB16 were thinned prior to the 2015 field season. Points BB17-BB22 were established in 2017, with BB18, BB20, and BB22 having been treated prior to the initiation of point count surveys. All 11 points subjected to thinning were also subjected to prescribed fire prior to the 2018 field season. One untreated point, BB21, also was subjected to prescribed fire. With the addition of points BB17-BB22, it required two survey days (or two simultaneous observers) to complete all the points on this route. Banco Bonito was surveyed during all years from 2012-2021.

Cerro Pinon- Located in the southeastern portion of VC, the 12 points on this route follow Jaramillo Creek and the east fork of the Jemez River (Fig. 8.1 and 8.3). One point on this route (MC10) was classified as mixed conifer, but burned during the 2013 Thompson Ridge fire. Seven points (MV01a, MV01b, MV02a, MV02b, MV03, MV04, MV05) were classified as mountain valley grassland. All the mountain valley grassland points except for MV01a burned during the 2011 Las Conchas fire. Four points (PP04, PP05, PP09, PP10) were classified as ponderosa pine forest. PP04 and PP05 burned during the Las Conchas fire. PP09 burned during the Thompson Ridge fire. Portions of this route were surveyed during all years from 2012-2021.

Jaramillo Canyon- Located in the center of VC, the 11 points on this route are situated near Jaramillo Creek and bordered by the southeastern flanks of Cerros del Abrigo, the southern flanks of Puerta de Trasquilar and the northern flanks of Redondo Peak (Fig. 8.1 and 8.4). Eight points (MC03, MC03b, MC03c, MC05, MC07, MC08, MC09, MC11) were classified as mixed conifer forest, one point (MV14) was classified as mountain valley grassland, and four points (PP03, PP07, PP08, PP11a) were classified as ponderosa pine forest. MC03, MC03b, MC03c, MC05, and PP03 burned during the 2011 Las Conchas fire. MC07-MC09, MC11, MV14, PP07, PP08, and PP11a burned during the 2013 Thompson Ridge fire. Portions of this route were surveyed during all years from 2012-2021.

Obsidian Valley- Located in the northeast portion of VC, this route in the Valle Toledo, was bounded by the southwestern flanks of the Cerros de los Posos (Fig. 8.1 and 8.5). All 11 points on this route burned during the 2011 Las Conchas fire. Five points (MC01, MC02, MC04, MCNew4, MC06) were classified as mixed conifer forest, three points (MV06, MV07, MVNew3) were classified as mountain valley grassland, and three points (PP01, PP02, PP06) as ponderosa pine forest. Portions of the Obsidian Valley route were surveyed in 2012-2015 and 2021.

San Antonio Valley- Located in the northwestern portion of VC, the 17 points on this route were situated within the Valle San Antonio and on San Antonio Mountain (Fig. 8.1 and 8.6). Ten points (MCNew1, MCNew2, MC12, SAV01-SAV07) were classified as mixed conifer forest, one point (MM07) was classified as mountain meadow grassland, five points (MV08a, MV09, MV10a, MV11, MV12) were classified as mountain valley grassland, and one point (PP12) was classified as ponderosa pine forest. MV08a burned during the 2011 Las Conchas fire and MV12 burned during the 2013 Thompson Ridge fire. Portions of the San Antonio Valley route were surveyed during all years from 2012-2021.

South Mountain- Located in the southern portion of VC, the eight points on this route were on South Mountain to the west of Valle Grande (Fig. 8.1 and 8.7). All eight points on this route (SM01-SM08) were classified as mixed conifer forest, but four points were impacted by a prescribed burn following the 2018 survey season. This route was established in 2017 to increase the sample size of mixed conifer forest plots, and surveyed in 2017-2021.

USFS Area 3- Located on a large bank on the side of Virgin Mesa above residential Area 3 north of Jemez Springs and to the west of NM 4 (Fig. 8.1 and 8.8). The six points on this route (A01-A06) were classified as ponderosa pine forest. The points on this route were thinned following the 2019 field season. This route was surveyed in 2019-2021.

USFS Calaveras Canyon- Located on USFS land northwest of Calaveras Canyon and west of VC (Fig. 8.1 and 8.9). All 10 points on this route (FMCC01-FMCC10) were classified as mixed conifer forest. This route was surveyed in 2012 and 2013.

USFS Guadalupe River- Located on USFS land along the west side of the Guadalupe River in the southwestern portion of the study area (Fig. 8.1 and 8.10). All 18 points on this route (GR01-GR18) were classified as riparian habitat. This route was established in 2013 and points GR01-GR12 were surveyed in 2013 and 2014. Prior to the 2016 field season, points GR02-GR07 were replaced because they were centered on a road cut above the riparian area. In 2016, points GR01 and GR08-GR18 were surveyed.

USFS Jemez River- Located on USFS land along the Jemez River in the southern portion of the study area (Fig. 8.1 and 8.11). All 12 points on this route (JR01-JR12) were classified as riparian habitat. The points on this route were established in 2016 and surveyed in 2016-2021.

USFS Jemez River North- Located on USFS land along the Jemez River in the southern portion of the study area and north of the previously-established USFS Jemez River points (Fig. 8.1 and 8.12). All 12 points on this route (JRN01-JRN12) were classified as riparian habitat. The points on this route were established in 2017 and surveyed in 2017-2021.

USFS Paliza North- Located on USFS land east of Paliza Canyon in the southern portion of the study area (Fig. 8.1 and 8.13). All 10 points on this route (PZN01-PZN10) were classified as ponderosa pine forest. Three points on this route (PZN03, PZN04, and PZN09) burned in the 2019 Conejos fire. The points on this route were established in 2014 and surveyed in 2014-2016 and 2020-2021.

USFS Paliza South- Located on USFS land south of Jemez Pueblo land near Hondo Canyon in the southern portion of the study area (Fig. 8.1 and 8.14). All 10 points on this route (PZS01-PZS10) were classified as ponderosa pine forest. Two points on this route (PZS09 and PZS10) were thinned prior to the 2020 field season. The points on this route were established in 2014 and surveyed in 2014-2016 and 2020-2021.

USFS Ponderosa Spring- Located on USFS land on the northern flanks of Cerro del Pino to the south of VC (Fig. 8.1 and 8.15). All 12 points on this route (PS01-PS12) were classified as ponderosa pine forest. This route was surveyed during all years from 2012-2019.

USFS Ponderosa Spring Experimental- Located on USFS land on the northern and western flanks of Cerro del Pino and northeast of San Juan Canyon (Fig. 8.1 and 8.16). All 10 points on this route (PSE01-PSE10) were classified as ponderosa pine forest. But, all 10 points burned after the 2014 survey season in the Pino Fire. These points are slated for thinning at some point in the future. This route was surveyed during all years from 2012-2019.

USFS Riparian- Located on the edge of Redondo Meadow on both USFS land and southwestern portions of VC land (Fig. 8.1 and 8.17). Two points on this route were on USFS land (RIP01, RIP02) and 10 points (RIP03-RIP12) were on VC. All 12 points were classified as riparian habitat. This route was surveyed from 2012-2014.

USFS Thompson Ridge- Located on USFS land adjacent to the Thompson Ridge residential area immediately west of VC (Fig. 8.1 and 8.18). All 12 points on this route (TR01-TR12) were classified as mixed conifer. This route was surveyed during 2012, 2013, and 2015-2021.

In June 2016, three North American Breeding Bird Survey (BBS) routes were established (Fig. 8.19). The Route 10 BBS route follows FS 10 and NM Highway 4 through USFS land and the southeastern corner of the VC. The Redondo Border route follows roads in the VC running west of Redondo Peak and north into the Valle San Antonio. The Valle Grande route follows roads from the southern border of the VC north through the Valle Grande to the Valle San Antonio and east through the Valle Toledo.

METHODS

From 2012-2021, Hawks Aloft personnel established 213 point count locations based on input and assistance from VC and USFS personnel. Points were centered at least 250 m from the nearest neighboring point to assure survey independence. Universal Transverse Mercator Coordinates (UTM, NAD27) were recorded for each point to assist with relocation.

We conducted standard, 10-minute point count surveys (see Bibby et al. 2000) three times per year during the breeding season (i.e., 15 May to 30 July) at each of the points selected for survey in a given year. In some cases, fewer than three visits were completed in a given year at certain points due to inaccessibility and/or logistical issues (e.g., fire closures, washed out roads, etc.). Survey route selection for each year occurred prior to the beginning of the field season and was based on input from VC and USFS personnel. Sixteen observers (Gail Garber in 2012 and 2017-2021, Erin Greenlee in 2012, Michael Hilchey in 2012, Kieran Sullivan in 2012-2013, Raymond VanBuskirk in 2012-2013 and 2018, Mike Fugagli in 2013-2016, Trevor Fetz in 2014 and 2017-2021, Jennifer Goyette in 2014, Carol Fugagli in 2015-2016, Amanda Schluter in 2016-2018, Lisa Morgan in 2017, Katrina Hucks in 2018, Adam Johnson in 2018, Greg Finkelberg in 2019, John Stanek in 2019, and Brian Dykstra in 2020-2021), each experienced with avian identification by sight and sound, conducted the surveys. At each survey point, the observer recorded all birds seen or heard during a ten-minute period. We recorded the distance of birds from the survey point using Leupold RX-600i laser rangefinders whenever possible; in many instances, distance to the bird's location was estimated. We noted flyovers separately without measuring distance. We began surveys in the morning within 30 minutes after sunrise and attempted to finish within four hours after sunrise.

BBS routes were established by National Park Service personnel (Stephen Fettig) prior to the onset of this study, in accordance with U.S. Geological Survey (1998) protocol. Roadside survey stops for each of the three routes were located approximately 800 meters apart. UTM coordinates were recorded for each stop to assist with relocation. The Redondo Border and Route 10 survey routes were comprised of 50 points each. The Valle Grande route originally was comprised of 49 points because the road ended before a 50th point could be established; however, only 41 points were accessible in 2017, 2019, and 2020. All 49 points were surveyed in 2021. Each route was surveyed once during the month of June. Surveys started within 30 minutes of sunrise and were completed within four hours after sunrise. Surveyors drove each route, stopping at all survey points. At each stop, observers exited the vehicle and conducted a 3-minute count, recording all birds seen and heard within a 400 m radius. Traffic and excessive noise were noted at each point.

All standard, 10-minute point count data presented are based on observations within 125 m of a point in order to minimize the likelihood of double-counting individuals at adjacent points. Although we include species detected only as flyovers in a cumulative species list, we define species richness for all analyses as the total number of species detected within 125 m from a point, excluding species observed only as flyovers. We used post-hoc Tukey-Kramer HSD tests to determine statistical significance. We set statistical significance for all comparisons at $\alpha < 0.05$. All statistical analyses were conducted using JMP 5.0 statistical software (SAS institute 2002). Because BBS data were collected based on a separate protocol, we excluded those from all data summaries and analyses and provide a separate species list for detections collected during 2016, 2017, and 2019-2021 BBS surveys. No BBS surveys were conducted in 2018 due to fire closures in the Valles Caldera National Preserve and the Santa Fe National Forest.

RESULTS

Cumulatively from 2012-2021, we documented 134 bird species and 31,343 total bird detections (Appendix 8.1). Western Tanager (*Piranga ludoviciana*, 6.49% of all detections), Yellow-rumped Warbler (*Setophaga coronata*, 5.86%), and Pygmy Nuthatch (*Sitta pygmaea*, 5.64%) were the most common species detected. No federal or state listed bird species were detected during surveys. We detected seven species of conservation concern as listed by the U.S. Fish and Wildlife Service (2008): Grace's Warbler (*Setophaga graciae*; N = 1,145), Cassin's Finch (*Haemorhous cassinii*; N = 32), Juniper Titmouse (*Baeolophus ridgwayi*; N = 16), Brewer's Sparrow (*Spizella breweri*; N = 8), Pinyon Jay (*Gymnorhinus cyanocephalus*; N = 7), Peregrine Falcon (*Falco peregrinus*; N = 3), and Flammulated Owl (*Psiloscops flammeolus*; N = 2). In addition, we detected 57 species of conservation concern as identified by relevant entities in New Mexico. These entities include New Mexico Avian Conservation Partners (2019; formerly New Mexico Partners in Flight), the New Mexico Department of Game and Fish (Bison-M 2021) and Natural Heritage New Mexico (2020).

Among habitat types, mean cumulative avian density was highest in mixed conifer (2.30 birds/ha) and burned mixed conifer (2.12 birds/ha), and lowest in burned mountain valley grassland (1.16 birds/ha) and mountain valley grassland (1.22 birds/ha; Table 8.1). Avian density was significantly higher in mixed conifer forest than all other habitat types with sufficient sample sizes except for mixed conifer burn (Tukey-Kramer test). Further, avian density was significantly higher in all forest types (unburned and burned) and riparian habitat than mountain valley grassland and burned mountain valley grassland. But avian density in unburned ponderosa pine was significantly lower than all other forest types. Among years, avian density was significantly higher in 2020 than all other years except 2018 and 2021, and density in 2018 and 2021 was significantly higher than all years from 2014-2017 and 2019 (Tukey-Kramer test; Table 8.2). Avian density was significantly lower in 2014-2017 than all other years except 2019.

The most abundant species by habitat were: mixed conifer forest - Mountain Chickadee (*Poecile gambeli*, 8.96% of all detections), Yellow-rumped Warbler (8.33%), and Western Tanager (8.20%); mixed conifer burn - Chipping Sparrow (*Spizella passerina*, 7.92%), House Wren (*Troglodytes aedon*, 7.45%), and American Robin (*Turdus migratorius*, 7.17%); mountain meadow - Western Meadowlark (*Sturnella neglecta*, 28.30%), Savannah Sparrow (*Passerculus sandwichensis*, 25.47%), and Vesper Sparrow (*Pooecetes gramineus*, 16.04%); mountain valley grassland - Vesper Sparrow (28.65%), Western Meadowlark (24.67%), and Eastern Meadowlark (*Sturnella magna*, 16.18%); mountain valley grassland burn - Vesper Sparrow (24.84%), Western Meadowlark (12.11%) and Eastern Meadowlark (10.74%); ponderosa pine forest - Pygmy Nuthatch (12.06%), Western Tanager (8.27%), and Yellow-rumped Warbler (7.47%); ponderosa pine burn - Western Tanager (7.76%), Chipping Sparrow (6.05%), and Pygmy Nuthatch (6.01%); riparian - Yellow-breasted Chat (*Icteria virens*; 10.87%), Western Wood-Pewee (*Contopus sordidulus*, 5.91%), and American Robin (5.53%).

Cumulative avian richness was highest in riparian habitat (104 species) and ponderosa pine forest (84 species; Table 8.3). Avian richness was lowest in mountain meadow (14 species) and mountain valley grassland (33 species). By year, avian richness was highest in 2018 (97 species) and lowest in 2015 (70 species; Table 8.4).

Through the 2019 survey season, Banco Bonito (classified as ponderosa pine forest) was the only survey route where prescribed understory thinning treatments had occurred. Cumulative avian density from 2012-2021 was significantly higher at thinned points (2.14 birds/ha) than at unthinned points (1.58 birds/ha; Tukey-Kramer test). Further breakdown of data from Banco Bonito based on both thinning treatments and prescribed fire revealed that avian density was highest at points subjected to thinning and prescribed fire (2.28 birds/ha; N = 154 visits), followed by points where only thinning had occurred (1.97 birds/ha; N = 87 visits), a single burned control point (1.89 birds/ha; N = 12 visits), and unburned control points (1.57 birds/visit; N = 300 visits). Cumulative avian density at points that were thinned and burned was significantly higher than density at points where only thinning had occurred and density at unburned control points was significantly lower than points where only thinning had occurred (Tukey-Kramer test).

Among points where data were collected before and after thinning (N = 5), cumulative avian density through 2021 was higher at four points after thinning and higher at one point before thinning (Table 8.5). There were no significant differences in density before and after thinning at any of these five points (Tukey-Kramer test). Avian density was highest after both thinning and prescribed fire at all five points, with density being second-highest at three points after only thinning had occurred and density being second-highest at two points before any treatments occurred (Table 8.6). Avian density after thinning and burning was significantly higher at one point (BB14) than before any treatment occurred (Tukey-Kramer test).

Cumulative avian richness (2012-2021) at Banco Bonito was higher at unthinned points (53 species) than thinned points (52 species; Table 8.7). Avian richness in 2021 was higher at thinned points (35 species) than unthinned points (31 species). The most common species at unthinned points were Pygmy Nuthatch (15.47% of detections), Western Tanager (9.23%), and Yellow-rumped Warbler (9.10%). The most common species at thinned points were Western Wood-Pewee (10.00% of detections), Pygmy Nuthatch (8.89%), and Western Tanager (8.57%).

Prescribed thinning of ponderosa pine forest also occurred at the six USFS Area 3 points and two points on the USFS Paliza South route prior to the 2020 survey season. Because surveys were initiated at USFS Area 3 in 2019, the sample size for pre-thinning data is very small (n = 18 total surveys). Avian density was lowest in 2019 (0.68 birds/ha) and increased in 2020 (1.00 birds/ha) and 2021 (1.12 birds/ha), but there were no significant differences in density between years (Tukey-Kramer test). Avian richness was lowest in 2019 (17 species) and slightly increased in 2020 (18 species) and 2021 (20 species). With only two thinned points on the USFS Paliza South route, the sample size for that area also is small (n = 16 total pre-thinning surveys, n = 12 post-thinning surveys). Pre-thinning surveys at USFS Paliza South were conducted in 2014-2016, but not all scheduled surveys were completed during those years due to fire restrictions. Cumulative avian density at the two USFS Paliza South points was higher during post-thinning years (2.14 birds/ha) than pre-thinning (1.82 birds/ha), while avian richness was the same (30 species) for both pre- and post-thinning.

During the first five years of data collection on the three North American Breeding Bird Survey

(BBS) routes established in 2016, a total of 102 species were detected. Cumulatively, the most common species were Violet-green Swallow (*Tachycineta thalassina*, 7.36% of all detections), Western Tanager (7.12%), and Common Raven (*Corvus corax*; 5.80%). On the Redondo Border route, the most common species were Western Tanager (10.23% of all detections), Violet-green Swallow (8.96%), and Chipping Sparrow (5.75%). On Route 10, the most common species were Violet-green Swallow (7.71% of all detections), Western Tanager (7.30%), and Pygmy Nuthatch (6.06%). On the Valle Grande route, the most common species were Eastern Meadowlark (10.76% of all detections), Vesper Sparrow (9.33%), and Common Raven (8.85%). The BBS routes were not surveyed in 2018 due to closures of the study area related to fire danger throughout the survey window.

DISCUSSION

Among the more important outcomes of the Southwest Jemez CFLRP will be an increased knowledge of avian trends at both the community and individual species levels and a better understanding of how catastrophic fire and habitat thinning affects birds. This knowledge is particularly important given the large number of species of conservation concern that occur within the study area. A number of these species are common within the habitats we surveyed, but have experienced steep declines in population trends (e.g., Broad-tailed Hummingbird [*Selasphorus platycercus*], Chipping Sparrow, Mountain Chickadee, Townsend's Solitaire [*Myadestes townsendi*], Violet-green Swallow, Western Bluebird [*Sialia mexicana*], Vesper Sparrow) or are faced with substantial deterioration of habitat or other negative impacts related to climate change (e.g., Brown Creeper [*Certhia americana*]). Some species are facing both of these issues (e.g., Grace's Warbler, Mountain Bluebird [*Sialia currucoides*], Pygmy Nuthatch, Steller's Jay [*Cyanocitta stelleri*], Virginia's Warbler [*Leiothlypis virginiae*]; New Mexico Avian Conservation Partners 2019).

Cumulatively, there was no significant difference in avian density between unburned mixed conifer forest and burned mixed conifer forest. Mixed conifer forest has supported the highest avian density over the first 10 years of this study. Density in unburned mixed conifer forest was slightly higher than burned mixed conifer. Among 36 species of conservation concern, 21 were documented at higher densities in mixed conifer forest and 15 were at higher densities in burned mixed conifer. Most notably, Grace’s Warbler density was significantly higher in unburned mixed conifer than burned mixed conifer, where it was virtually absent. The status of Grace's Warbler is particularly important because of its high priority as a species of conservation concern due to a range limited to forests with a substantial pine component in the southwestern U.S. and prevalence within the study area (Stacier and Guzy 2002, USFWS 2008, New Mexico Avian Conservation Partners 2019, Bison-M 2021). Among relatively common species of conservation concern, densities of Mountain Chickadee, Pygmy Nuthatch, Steller's Jay, Townsend’s Solitaire, Evening Grosbeak (*Coccothraustes vespertinus*), Golden-crowned Kinglet (*Regulus satrapa*), and Williamson’s Sapsucker (*Sphyrapicus thyroideus*) also were significantly higher in unburned mixed conifer than burned mixed conifer, while Broad-tailed Hummingbird and Red-naped Sapsucker (*Sphyrapicus nuchalis*) densities were substantially (but not significantly) higher in unburned mixed conifer. In contrast, American Three-toed Woodpecker (*Picoides dorsalis*), Chipping Sparrow, House Wren, Mountain Bluebird, Violet-green Swallow, and Western Bluebird densities were significantly higher in burned mixed conifer than unburned mixed conifer.

In contrast to mixed conifer forest, density in burned ponderosa pine forest was significantly higher than unburned ponderosa pine forest. But among 40 species of conservation concern, 22 were present in higher densities in unburned ponderosa pine forest and 18 were at higher densities in burned ponderosa pine forest. Cumulatively, Grace's Warbler density was significantly higher in unburned ponderosa pine forest than all other habitat types. Mountain Chickadee, Pygmy Nuthatch, Steller's Jay, Gray Flycatcher (*Empidonax wrightii*), Townsend's Solitaire, and Virginia’s Warbler were other species of concern that we documented at significantly higher densities in unburned ponderosa pine forest than burned ponderosa pine (Tukey-Kramer tests). Additional, relatively common species of concern documented at substantially higher (but not significantly different) densities in unburned ponderosa pine than burned ponderosa pine included Black-throated Gray Warbler (*Setophaga nigrescens*), Brown Creeper, Golden-crowned Kinglet, and Evening Grosbeak.

But species preferring more open habitat and most woodpeckers were more abundant in burned ponderosa pine. For example, we documented American Three-toed Woodpeckers during all ten years of surveys. To our knowledge, American Three-toed Woodpecker had not been documented breeding in the Valles Caldera National Preserve prior to our 2012 observations. This woodpecker is particularly attracted to disturbed and/or recently burned conifer forests with insect infested snags (Leonard, Jr. 2001). Other woodpecker species exhibit a similar, but lower attraction to burned forest. American Three-toed Woodpecker density was significantly higher in burned ponderosa pine forest than unburned. Among relatively common species of concern, Chipping Sparrow, House Wren, Mountain Bluebird, Violet-green Swallow, and Western Bluebird also were documented at significantly higher densities in burned ponderosa pine than unburned ponderosa pine (Tukey-Kramer tests). The stark contrast in the impact of fire on these species of conservation concern in both mixed conifer and ponderosa pine forest illustrates the complexities of the forest ecosystem and the challenges presented in attempting to manage the forests appropriately.

The cumulative difference in avian density between unburned and burned mixed conifer forest plots was relatively small through 2021, while burned ponderosa pine plots supported a significantly higher avian density than unburned ponderosa pine plots. The influx of bird species preferring more open habitat into burned areas helped offset the decrease in numbers of birds less tolerant of fire in mixed conifer plots and resulted in increased avian use in burned ponderosa pine plots. But it is important to note that we lack the ability to reliably quantify different ways in which fire impacted burned points. Any point count plot that showed extensive evidence of fire was classified as burned. The intensity and amount of burn, however, varied widely among plots. Fire impact ranged from 100% consumption of woody vegetation at some plots to other plots where fire primarily stayed out of the canopy and most mature trees survived. In general, tree survival was higher in burned ponderosa pine plots than burned mixed conifer plots, primarily due to the resistance of ponderosa pine to fire. Avian use was substantially reduced at points where all vegetation was consumed compared to points where fire was largely excluded from the canopy. The gradients of fire impact at different points between these two extremes left detailed quantification beyond our scope of work. Additionally, any attempt at detailed categorization of burn levels would reduce sample sizes to statistically meaningless and largely anecdotal levels.

Cumulative data from mountain valley grassland plots indicated little difference in overall avian density between burned and unburned plots, but there were notable differences among regularly occurring individual species. The two species of conservation concern most dependent on grassland habitat, Savannah Sparrow and Vesper Sparrow, exhibited differing trends relative to preference of unburned vs. burned grassland. Vesper Sparrow was documented at a significantly higher cumulative density in unburned mountain valley grassland than burned mountain valley grassland. Savannah Sparrow density was significantly higher in burned grassland than unburned grassland. The response of Savannah Sparrow illustrates how quickly species may return to burned grassland habitat. In 2012, the first year after the Las Conchas fire, no Savannah Sparrows were documented in burned grassland. In contrast, during all years from 2013-2016, Savannah Sparrow density was higher in burned grassland than unburned grassland. Avian populations in burned grassland tend to stabilize within three or four years after a fire, likely in response to relatively rapid changes in food availability and other resources (Roberts et al. 2012). This is the scenario that played out on the grassland points. Avian density was higher in unburned grassland during 2012-2014, but was higher in burned grassland in 2015 and 2016.

Cumulative avian density among years was significantly higher in 2020 than all other years except for 2018 and 2021, and density in 2014-2017 was significantly lower than all other years except for 2019. There likely were several contributing factors to the variation in density between years. First, it appears that there was a steady decrease in overall bird numbers during the first six years of the study. One observer conducted a substantial number of surveys during all years from 2013-2016, and his detection rates showed small, but steady decreases each year.

The cumulative impact of long-term drought also may have played a factor in decreased bird numbers. Drought can reduce abundance and species richness in avian communities (Albright et al. 2010a, 2010b), with the negative impacts becoming increasingly pronounced during long-term drought and recovery taking a number of years (George et al. 1992, Bock and Bock 1999). The four-year period from 2010-2014 was the fifth driest on record for northern New Mexico (30.2 cm below normal; NOAA National Centers for Environmental Information 2022). This helps explain the steady decrease in overall avian density during the first five years (2012-2016) of this study. The 7-month period prior to the 2015 breeding season (November 2014-May 2015) was the 9th wettest on record in the northern mountains (8.23 cm above average). Nevertheless, overall avian density in 2015 was the lowest of the first four project years. This makes sense, however, because the short-term alleviation of drought conditions following a long period of drought would not be sufficient to allow for the avian community to experience any immediate recovery. The precipitation level in the 7-month period prior to the 2016 breeding season was close to average (0.13 cm above normal), but overall avian density in 2016 was the lowest documented during this study. This provides evidence that avian recovery from long-term drought is a long-term process that requires more than a few months of wet conditions and a return to normal precipitation levels.

It appears there is at least a one-year lag in avian density relative to precipitation levels. A longer-term trend of above average precipitation may have played a role in the high avian density documented in 2018 (2nd-highest among all years). The 48-month period prior to the 2018 breeding season was the 36th wettest on record and 8.43 cm above average (NOAA

National Centers for Environmental Information 2022). But, the increase in avian density in 2018 occurred despite the presence of exceptional drought conditions immediately prior to that breeding season. The 7-month period prior to the 2018 breeding season was the driest on record (11.56 cm below normal). That period of exceptional drought was probably a key factor in 2019 avian density being significantly lower than 2018, despite precipitation during the 7-month period immediately prior to the 2019 breeding season being substantially higher than normal (23rd wettest, 4.80 cm above normal). In turn, the wet conditions prior to the 2019 breeding season likely played a role in 2020 avian density being higher than all other years of this study, despite the 7-month period immediately prior to the 2020 breeding season being the 33rd driest on record (3.99 cm below normal). True to form, avian density in 2021 was lower than 2020, despite precipitation levels during the 7-month period immediately prior to the 2021 breeding season being lower than prior to the 2020 breeding season.

The timing of surveys also may impact avian density among years. This was likely the primary factor in the high density documented in 2018. Surveys in 2018 were initiated earlier than normal due to the dry conditions and likelihood of fire danger closing the study area. Subsequently, the study area was inaccessible throughout June of 2018, forcing the second and third rounds of surveys to be conducted in July and pushing the survey period later than other years. Due to the lateness of the second and third rounds, as well as the early initiation of surveys in May, more migrants were detected in 2018 than other years. Additionally, late season surveys likely resulted in increased detections of females who were no longer sitting on nests and newly-fledged young. Both of these factors likely contributed to the higher densities documented in 2018.

Another factor likely impacting avian density among years is variation in the points surveyed between years. For example, mixed conifer forest has consistently supported the highest avian density throughout the study. But, a lower percentage of the surveys in 2014-2016 were conducted in mixed conifer (range = 3-14%) than in 2012, 2013, and 2017-2021 (range = 22-28%). Correspondingly, cumulative avian density was lower in 2014-2016 than all other years except 2017, while 2012, 2013, and 2018-2021 were the six years with the highest cumulative avian density. Similarly, the percentage of surveys conducted in ponderosa pine, the forest type consistently supporting the lowest avian densities, was higher in 2014-2016 (range = 40-48%) than during other years (range = 27-39%). Additionally, mountain meadow, mountain valley grassland, and burned mountain valley grassland, the three habitat types consistently supporting the lowest avian densities, were only surveyed in 2012-2016. The addition of those open habitats drove down the cumulative avian densities in 2012-2016 relative to 2017-2021.

Finally, observer bias may account for differences within the dataset. Sixteen different observers have conducted surveys during the course of this study. Although all were well qualified, some bias due to overall ability and protocol interpretation is almost inevitable. Additionally, the two observers with the highest cumulative detection rates were not involved with the project after 2013 and the observer with the third-highest detection rate conducted a majority of the surveys in 2020 and 2021. It is likely that a combination of all the above factors has impacted avian density documentation among years.

Data from the Banco Bonito route suggests that understory thinning in ponderosa pine forest may have a net benefit to the avian community. This is consistent with the findings in similar studies (e.g., Gaines et al. 2007, Kalies and Rosenstock 2013). Further, in 2020 we were able to begin comparing the impact of thinning at a total of eight points on USFS survey routes (all six points at USFS Area 3 and two points at USFS Paliza South). Although the sample sizes remain very small for the USFS routes, preliminary data followed a similar trend to what was documented at Banco Bonito, with avian density being higher post-thinning than pre-thinning.

But several important factors need to be considered before reaching any conclusions about the benefits of thinning in this study area. First, the data sample at thinned points remains relatively small. This is particularly true at the eight thinned USFS points, where we only have two years of post-thinning data. Additional years of data collection will add to the sample size and provide more definitive knowledge about the impact of treatment in ponderosa pine forest.

Second, the impact of prescribed fire at Banco Bonito must be considered. The difference in cumulative avian density between thinned and unthinned points at Banco Bonito was largely due to data collected during the most recent five years, four of which occurred after the use of prescribed fire at the thinned points. Avian density at thinned plots was substantially higher after burning than before burning. Similarly, the single burned, unthinned point at Banco Bonito also supported a higher avian density than the unburned and unthinned control points. The positive impact on overall bird numbers following prescribed fire at Banco Bonito mirrors the overall trend we have documented of ponderosa pine forest burned during unintentional wildfires supporting a significantly higher avian density than unburned ponderosa pine forest.

Finally, the impact of treatment on specific bird species needs to be considered. Understanding the impact on species of conservation concern is particularly important. Among the 15 most common species of conservation concern at Banco Bonito, nine were present at higher densities at thinned points (Grace's Warbler, Chipping Sparrow, Mountain Chickadee, Violet-green Swallow, Western Bluebird, Broad-tailed Hummingbird, House Wren, Pine Siskin [*Spinus pinus*], and Williamson’s Sapsucker), while six were present at higher densities at unthinned points (Pygmy Nuthatch, Steller's Jay, Townsend's Solitaire, Brown Creeper, Clark’s Nutcracker [*Nucifraga columbiana*], and Golden-crowned Kinglet). Gaines et al. (2007) found similar results in terms of the impact differing among bird species following thinning in ponderosa pine forest. Thus, from an avian perspective the value of ponderosa pine thinning may depend on the species of interest.

Data from the first 10 years of surveys have revealed a number of interesting trends at both the avian community and individual species levels. But it is likely that avian population dynamics will continue to change as the number of post-fire years increase (Raphael et al. 1987, Smucker et al. 2005). Habitat structure and food resources change rapidly following a fire and those changes continue as burned areas undergo succession. The initial response of many bird species may be mediated by either short-term increases or decreases in food availability. For example, the availability of seeds from cones, early-successional forbs and grasses, and easy access to invertebrates beneath the bark of fire-killed standing trees may increase post-fire, providing increased food availability for species that exploit such resources (Hutto 1995, Brawn et. al. 2001). In contrast, short-term decreases in food availability, such as reductions in arthropod abundance (e.g., grasshoppers or moths) in burned grasslands or foraging opportunities within burned forest may negatively affect other species (Hobson and Schieck 1999).

In addition to food availability, architectural differences in habitat, such as reduced litter, changes in standing dead trees, nest site availability, vegetation regeneration, and predator coverage are among the key factors regulating avian abundance and richness (MacArthur and MacArthur 1961, Raphael et al. 1987, Hobson and Schieck 1999). These longer-lasting impacts are likely key factors in the reduction in numbers of species such as Brown Creeper, Pygmy Nuthatch, Steller's Jay, and Townsend's Solitaire in burned plots and thinned plots. The contrasts in avian response to both fire and habitat thinning illustrate the complexity of the habitat types being monitored within the study area as a whole and the challenges of appropriate management. Additional years of surveys will allow us to more reliably evaluate avian trends and response to wildfire and habitat treatment at both the community and species levels within the study area.

Collaborators: Hawks Aloft (Trevor Fetz, Gail Garber, Mike Hill).

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Table 8.1. Cumulative avian density (mean number of birds/ha) and statistical significance by habitat type, Jemez CFLRP, 2012-2021. Habitat types not connected by a common letter are significantly different (Tukey-Kramer test).

Habitat	**# Surveys**	**Statistical Significance**				**# Birds/ha**
Mixed Conifer	646	A				2.30
Mixed Conifer Burn	283	A	B			2.12
Riparian	574		B			1.97
Ponderosa Pine Burn	478		B			1.95
Ponderosa Pine	1167			C		1.70
Mountain Meadow	14	A	B	C	D	1.54
Mountain Valley Grassland	63				D	1.22
Mountain Valley Grassland Burn	141				D	1.16

Table 8.2. Cumulative avian density (mean number of birds/ha) and statistical significance by year, Jemez CFLRP, 2012-2021. Years not connected by a common letter are significantly different (Tukey-Kramer test).

Year	**# Routes**	**# Surveys**	**Statistical Significance**				**# Birds/ha**
2020	11	351	A				2.33
2018	10	294	A	B			2.27
2021	12	360	A	B			2.25
2012	10	334		B			2.09
2013	11	273		B			2.03
2019	11	357			C		1.79
2014	11	354			C	D	1.65
2015	10	328			C	D	1.61
2017	10	339				D	1.54
2016	11	376				D	1.53

Table 8.3. Cumulative avian richness (total number of species detected within 125 m of points) by habitat type, Jemez CFLRP, 2012-2021.

Habitat	**# Surveys**	**# Species**
Riparian	574	104
Ponderosa Pine	1167	84
Ponderosa Pine Burn	478	79
Mixed Conifer	646	73
Mixed Conifer Burn	283	70
Mountain Valley Grassland Burn	141	48
Mountain Valley Grassland	63	33
Mountain Meadow	14	14

Table 8.4. Avian richness (total number of species detected within 125 m of points) by year, Jemez CFLRP, 2012-2021.

Year	**# Surveys**	**# Species**
2018	294	97
2020	351	94
2021	360	92
2019	357	86
2014	354	84
2013	273	78
2017	339	78
2016	376	74
2012	334	72
2015	328	70

Table 8.5. Comparison of mean avian density (# birds/ha) before and after thinning at five points in ponderosa pine forest, Banco Bonito survey route, Valles Caldera National Preserve, Jemez CFLRP, 2012-2021.

Point & Treatment Type	# Surveys	# Birds/ha
BB08 Treatment	22	2.22
BB08 Control	7	1.89
BB10 Treatment	22	2.70
BB10 Control	7	2.62
BB12 Treatment	23	2.23
BB12 Control	5	1.35
BB14 Treatment	21	2.29
BB14 Control	8	1.48
BB16 Control	8	1.76
BB16 Treatment	21	1.71

Table 8.6. Comparison of mean avian density (# birds/ha) before and after thinning and prescribed burning at five points in ponderosa pine forest, Banco Bonito survey route, Valles Caldera National Preserve, Jemez CFLRP, 2012-2021.

Point & Treatment Type	# Surveys	# Birds/ha
BB08 PP Burn Treatment	12	2.23
BB08 PP Treatment	10	2.22
BB08 PP Control	7	1.89
BB10 PP Burn Treatment	12	2.89
BB10 PP Control	7	2.62
BB10 PP Treatment	10	2.47
BB12 PP Burn Treatment	12	2.48
BB12 PP Treatment	11	1.96
BB12 PP Control	5	1.35
BB14 PP Burn Treatment	12	2.31
BB14 PP Treatment	9	2.26
BB14 PP Control	8	1.48
BB16 PP Burn Treatment	12	1.94
BB16 PP Control	8	1.76
BB16 PP Treatment	9	1.40

Table 8.7. Comparison of species richness (total number of species detected w/in 125 m) at 22 unthinned and thinned points in ponderosa pine forest by year, Banco Bonito survey route, Valles Caldera National Preserve, Jemez CFLRP, 2012-2021.

Year	**Type**	**# Points**	**# Visits**	**# Species**
2012	Control	13	39	31
2012	Thinned	3	9	18
2013*	Control	13	26	32
2013*	Thinned	3	6	16
2014	Control	12**	34	31
2014	Thinned	6**	13***	27
2015	Control	8	24	26
2015	Thinned	8	24	28
2016	Control	8	24	24
2016	Thinned	8	24	27
2017	Control	11	33	26
2017	Thinned	11	33	29
2018	Control	11	33	32
2018	Thinned	11	33	35
2019	Control	11	33	24
2019	Thinned	11	33	30
2020	Control	11	33	34
2020	Thinned	11	33	34
2021	Control	11	33	31
2021	Thinned	11	33	35
Totals	Control	11	312	53
	Thinned	11	241	52
	All	22	553	63

*Only two surveys occurred at each point in 2013 due to accessibility limitations.

**Two points changed from Control to Treated for the 3rd survey in 2014.

***No first period survey occurred at BB12 in 2014 due to thinning activity.

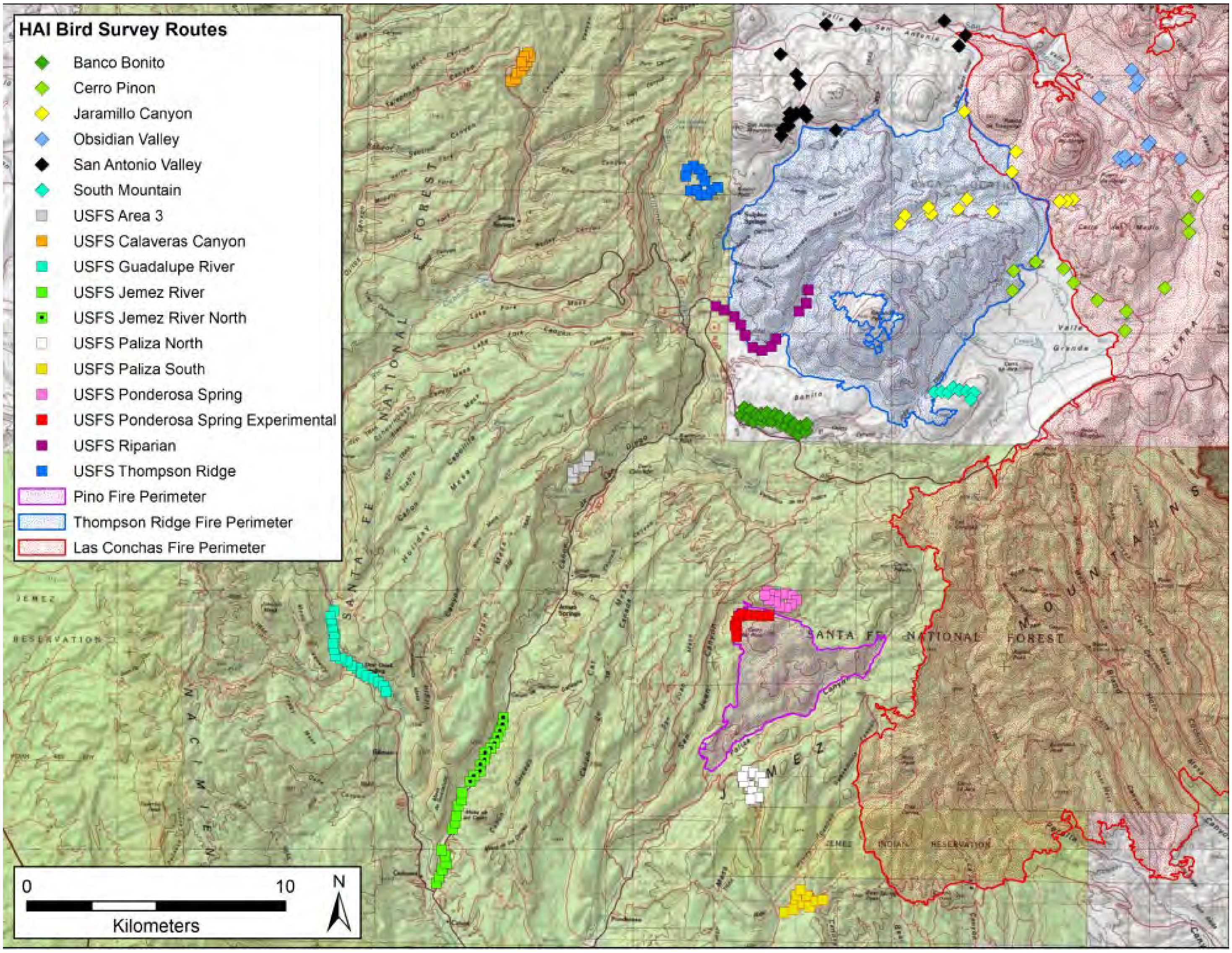


Fig. 8.1. Map of point count routes in the Valles Caldera National Preserve and Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico. Colored squares represent specific point count locations.

Fig. 8.2. Point locations for the Banco Bonito survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

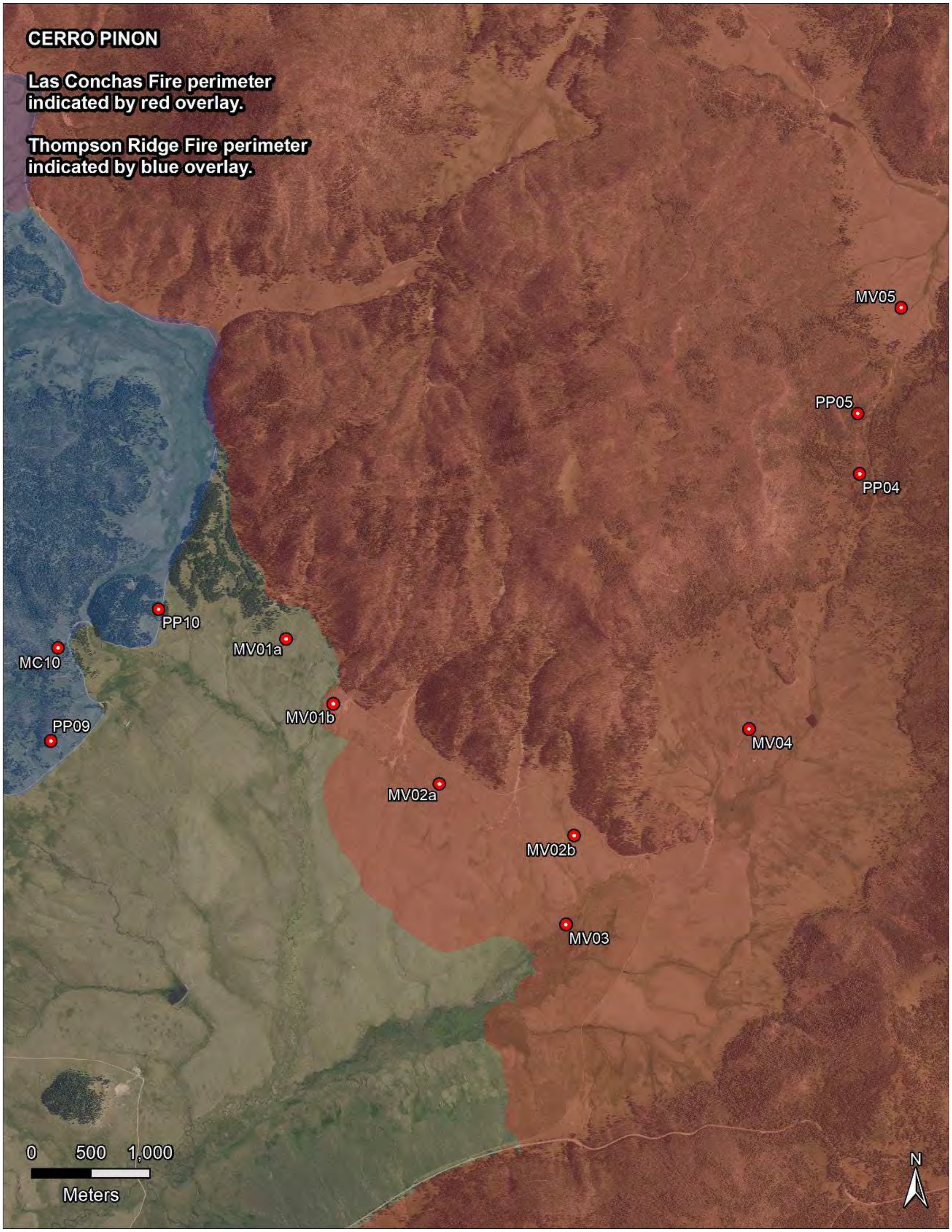


Fig. 8.3. Point locations for the Cerro Pinon survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

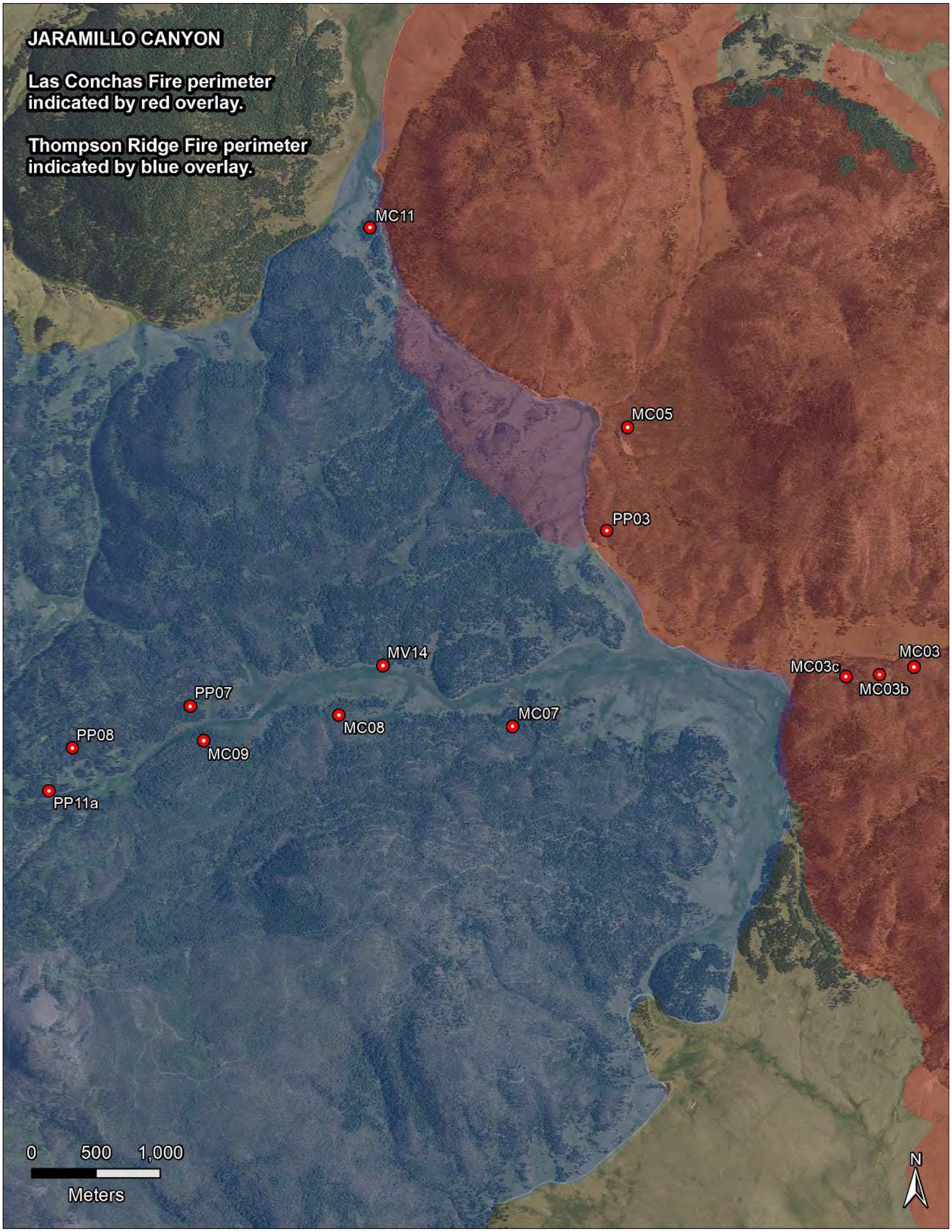


Fig. 8.4. Point locations for the Jaramillo Canyon survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

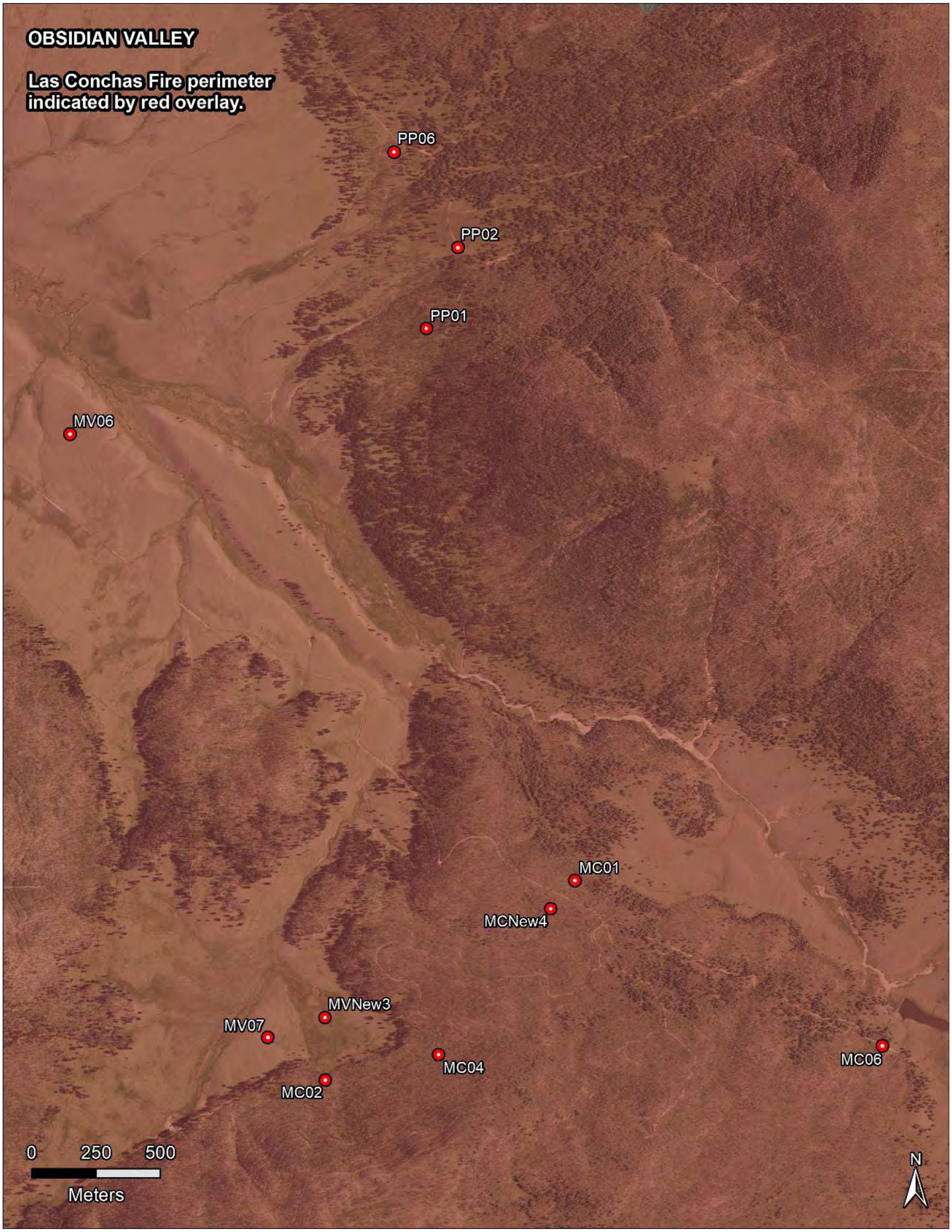


Fig. 8.5. Point locations for the Obsidian Valley survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

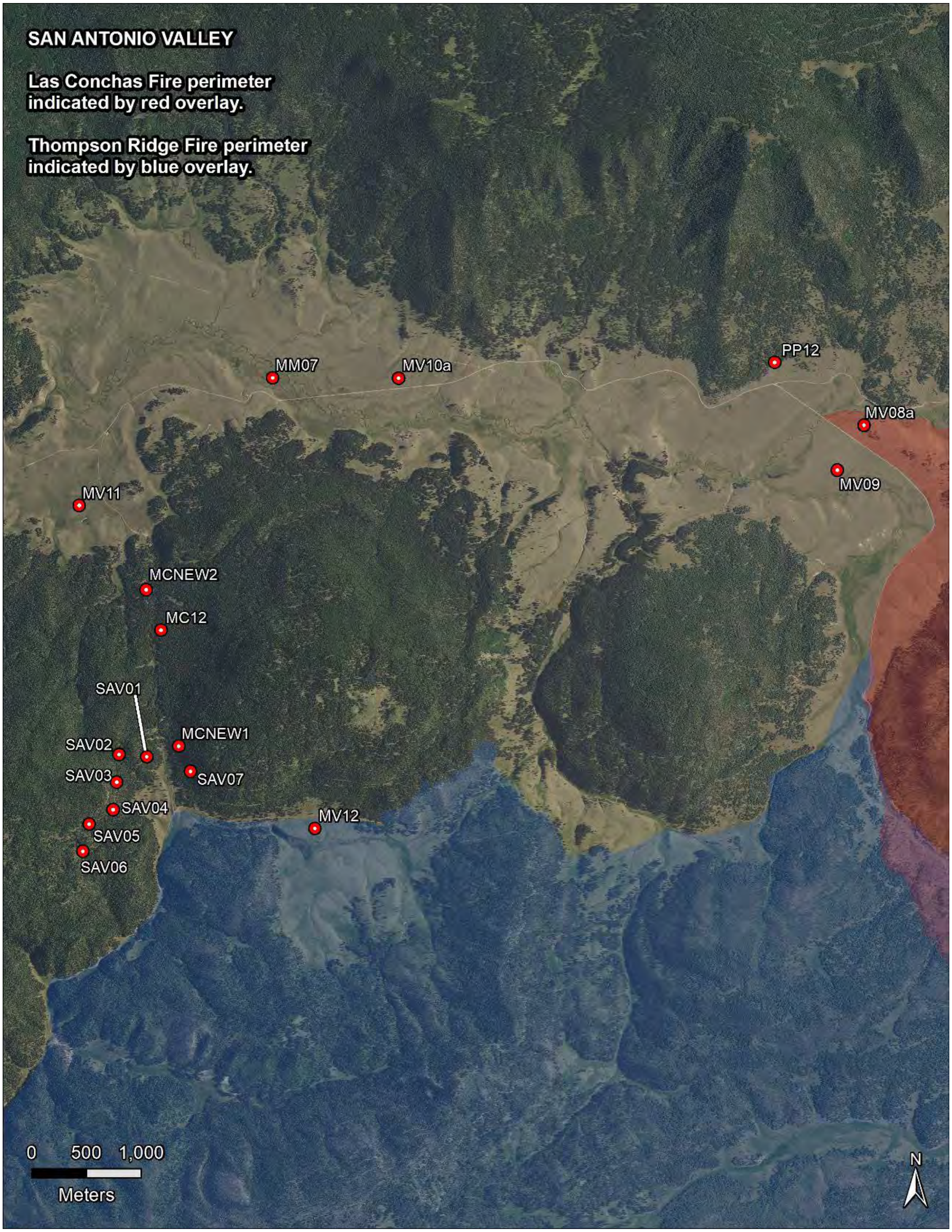


Fig. 8.6. Point locations for the San Antonio survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

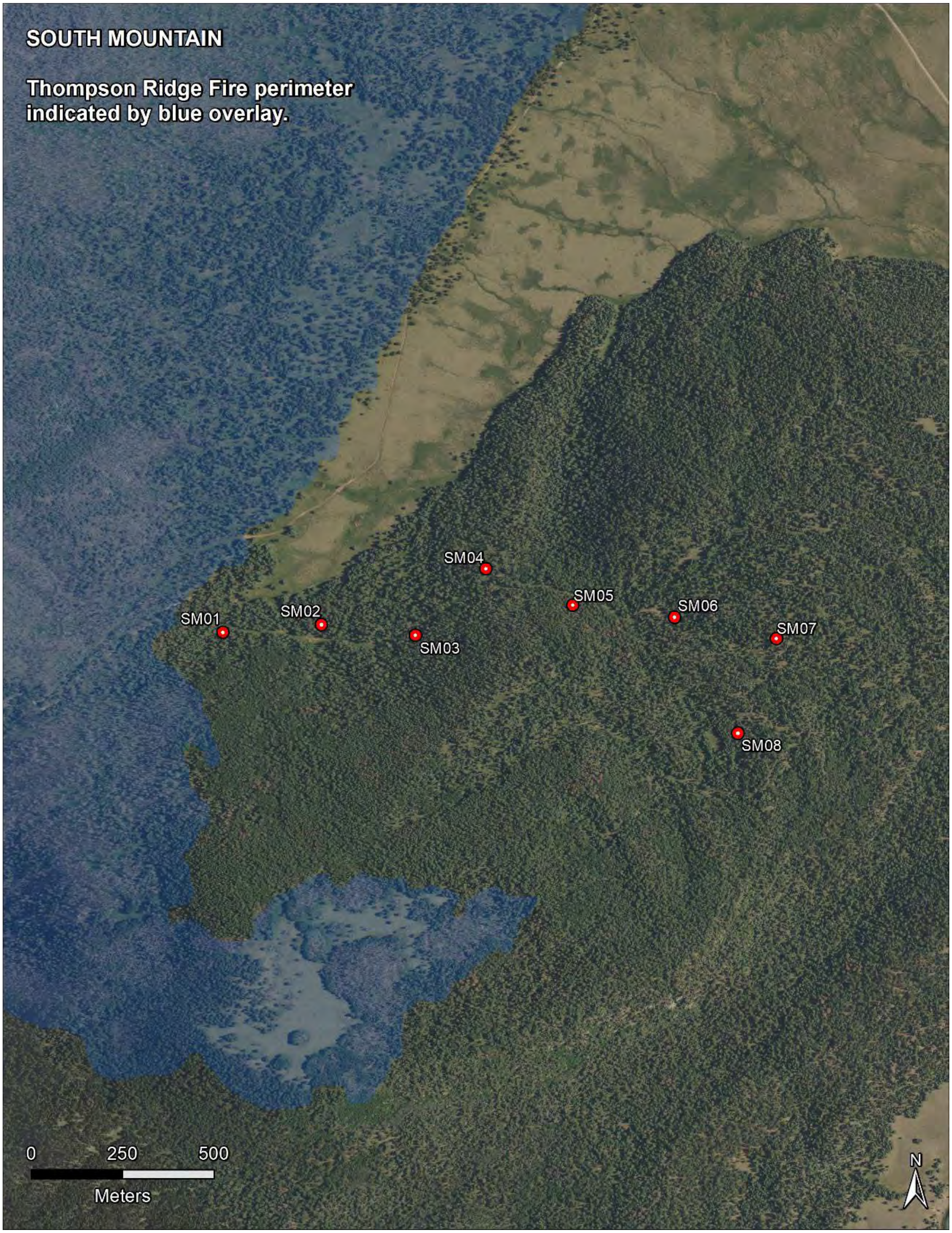
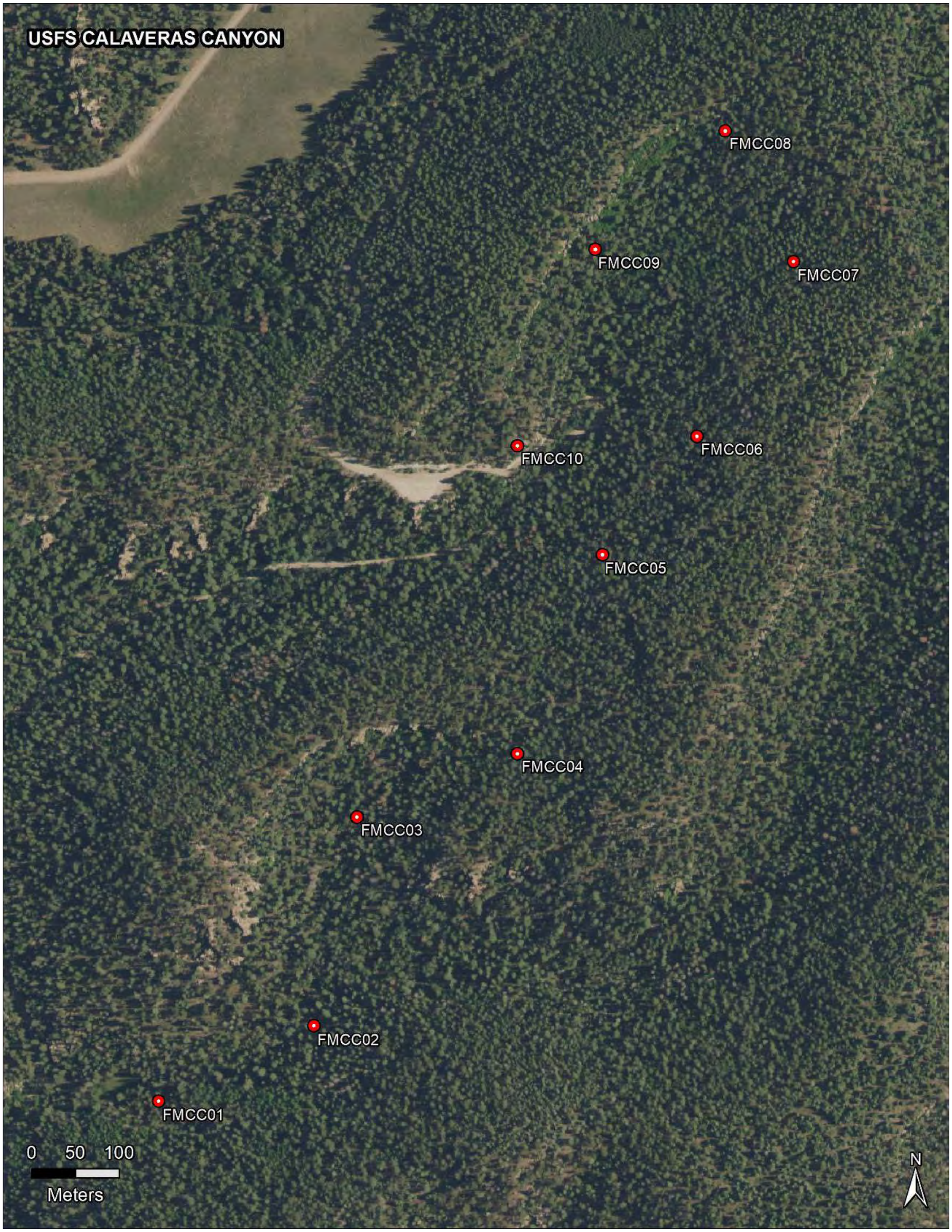


Fig. 8.7. Point locations for the South Mountain survey route, Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

Fig. 8.8. Point locations for the USFS Area 3 survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

Fig. 8.9. Point locations for the USFS Calaveras Canyon survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.



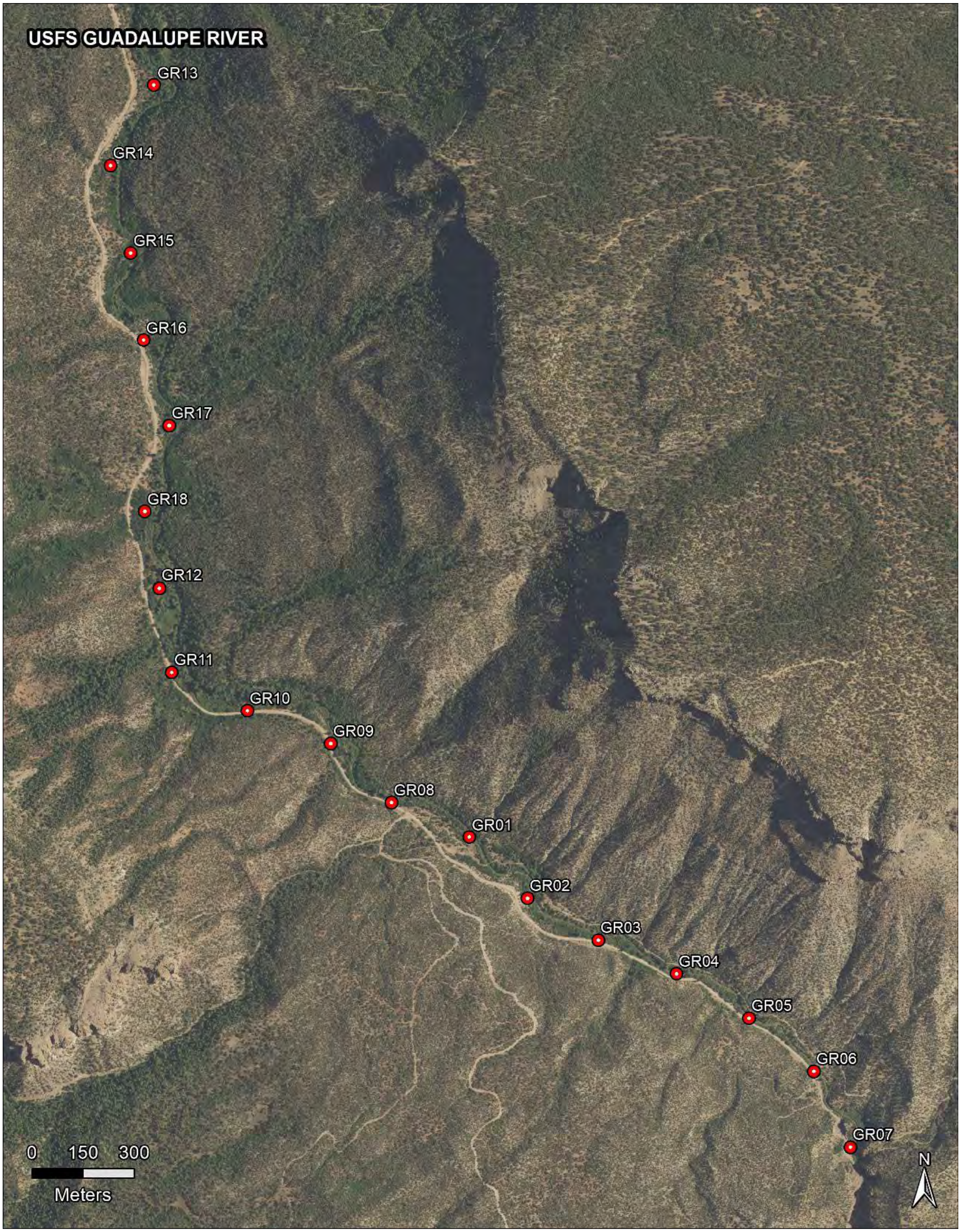


Fig. 8.10. Point locations for the USFS Guadalupe River survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico. Points GR13-GR18 were established in 2016 and replaced points GR02-GR07.

Fig. 8.11. Point locations for the USFS Jemez River survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

Fig. 8.12. Point locations for the USFS Jemez River North survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

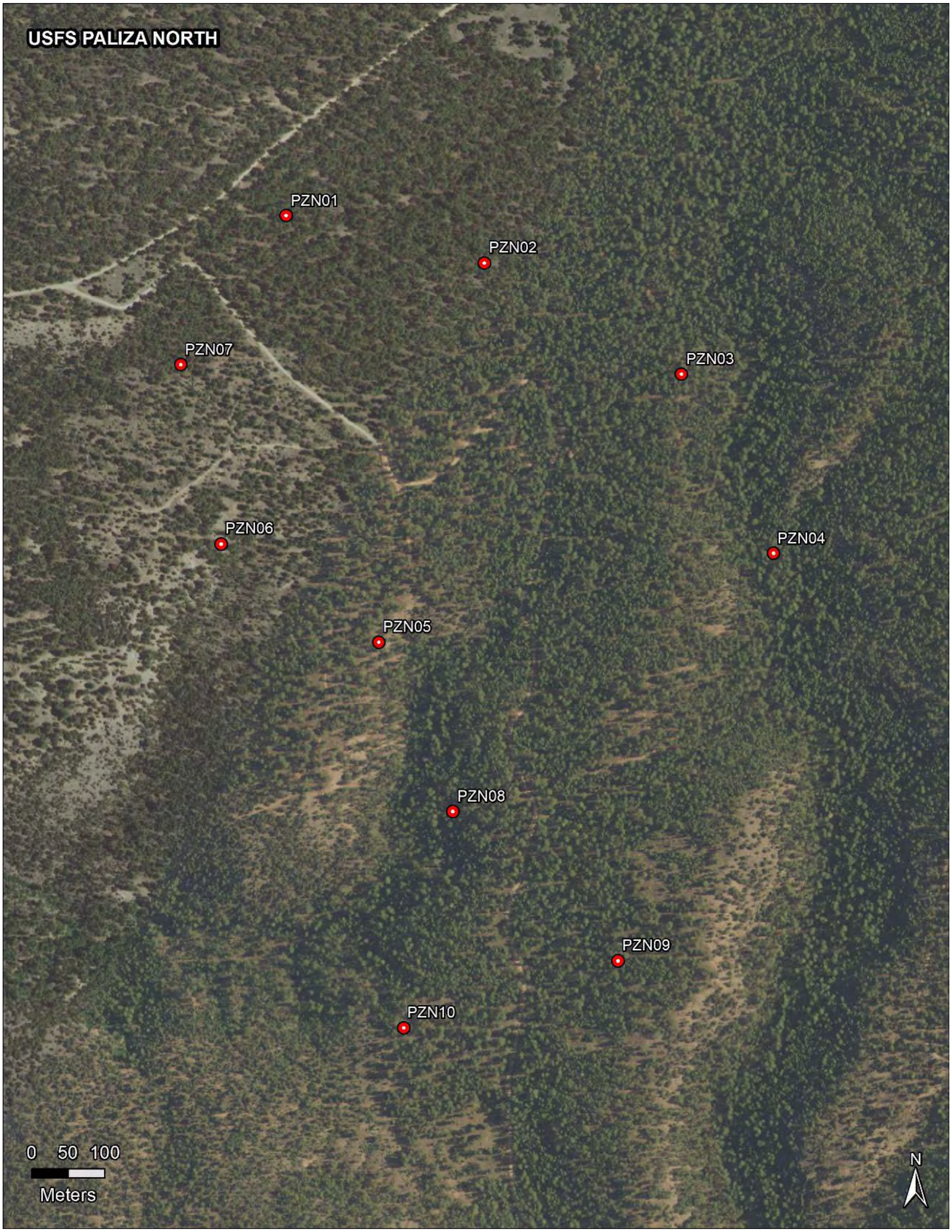


Fig. 8.13. Point locations for the USFS Paliza North survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

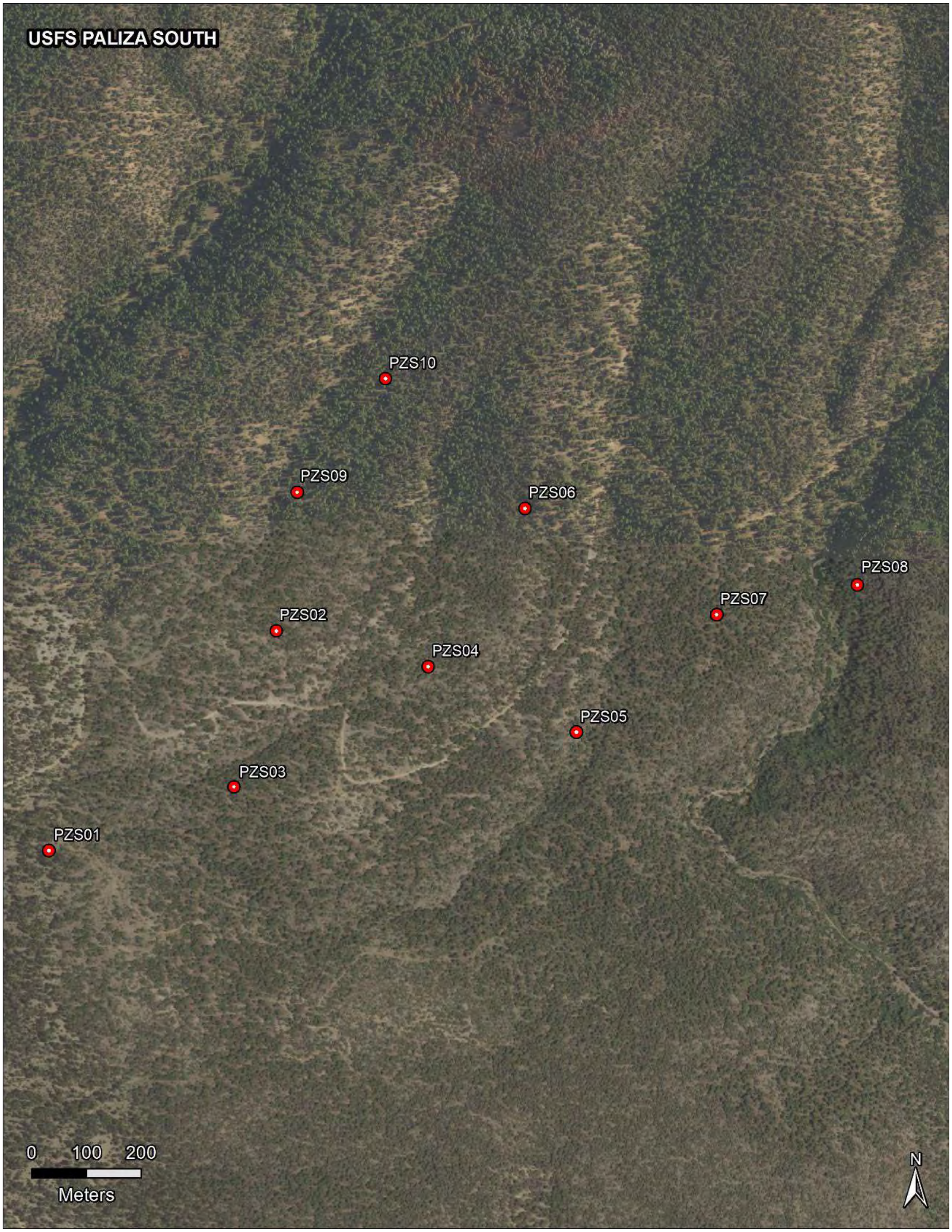


Fig. 8.14. Point locations for the USFS Paliza South survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

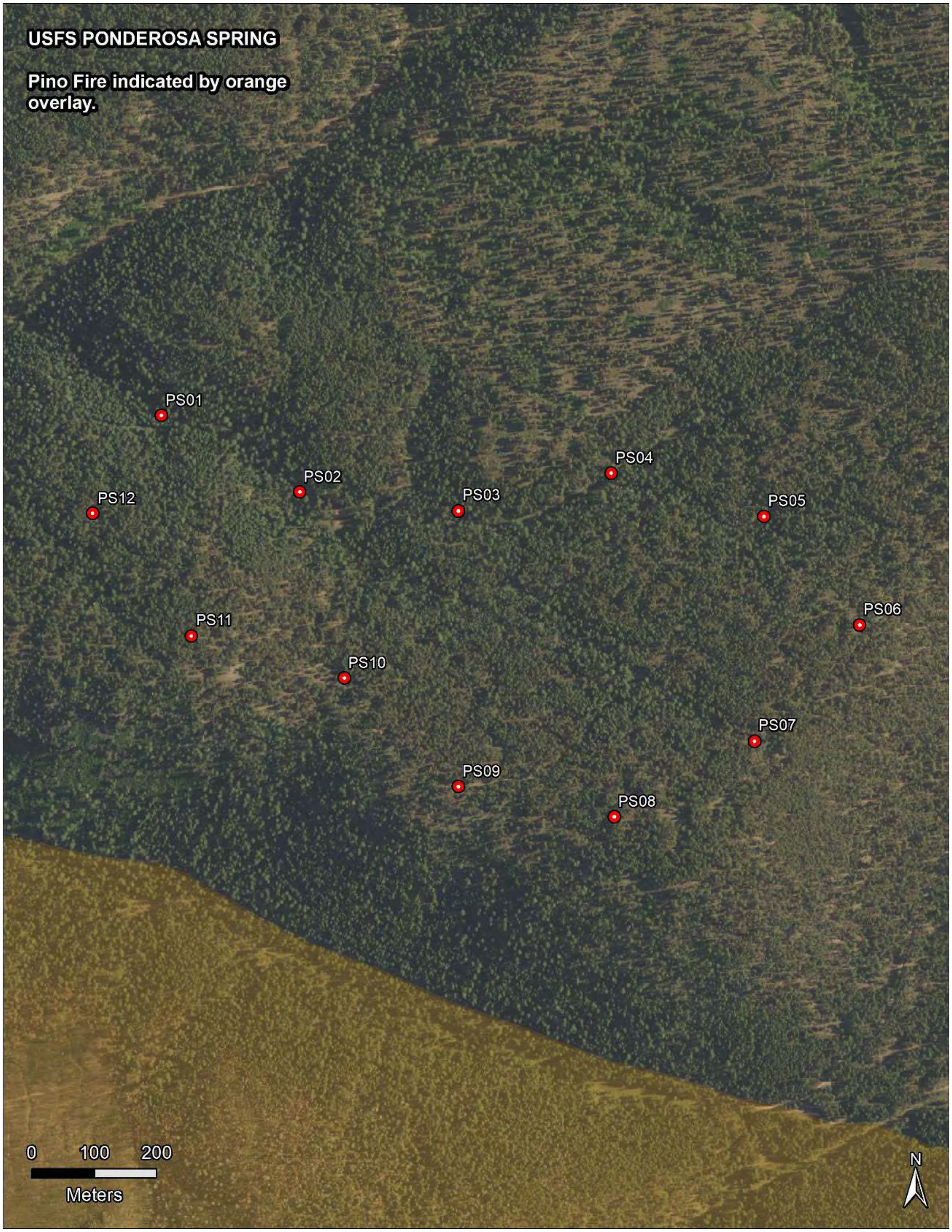


Fig. 8.15. Point locations for the USFS Ponderosa Spring survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

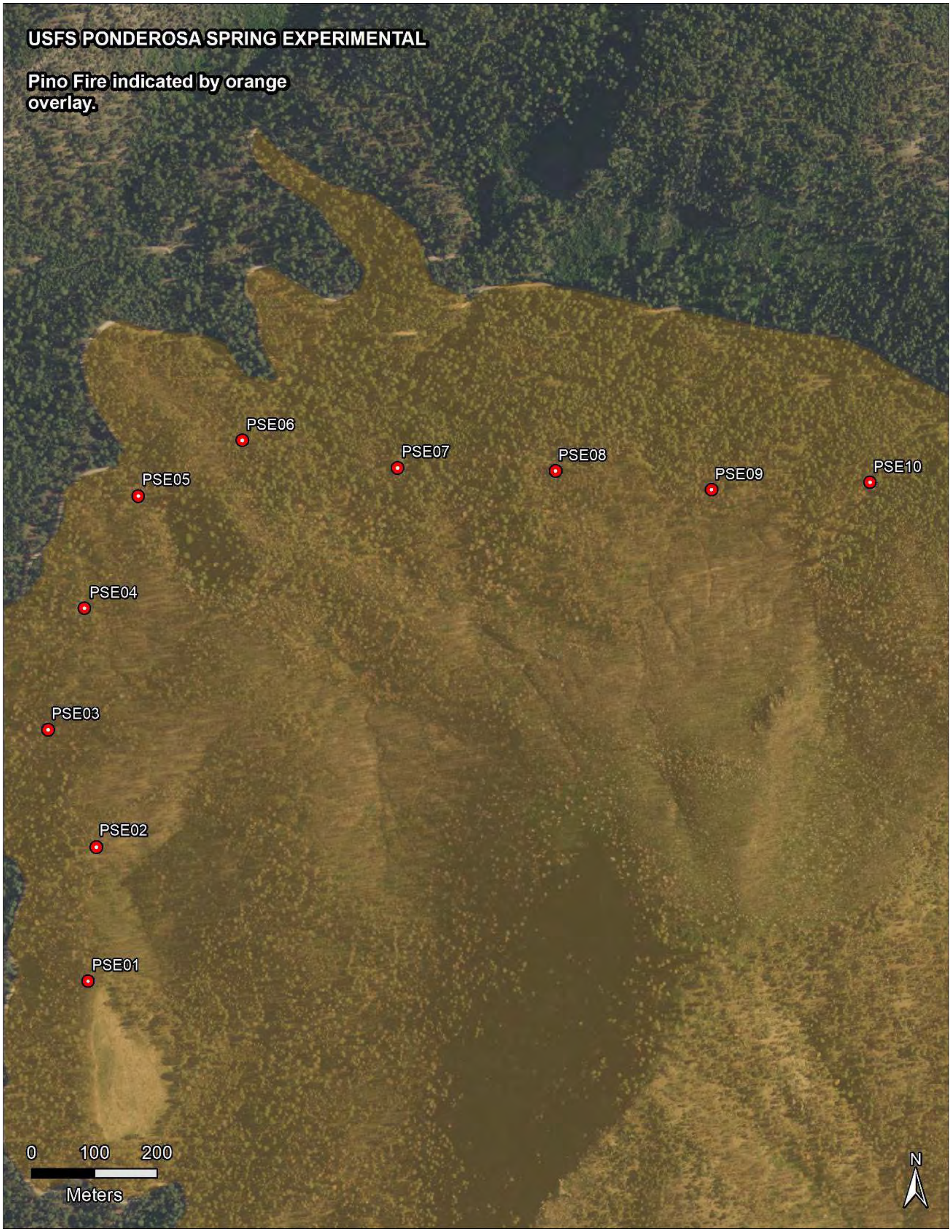


Fig. 8.16. Point locations for the USFS Ponderosa Spring Experimental survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

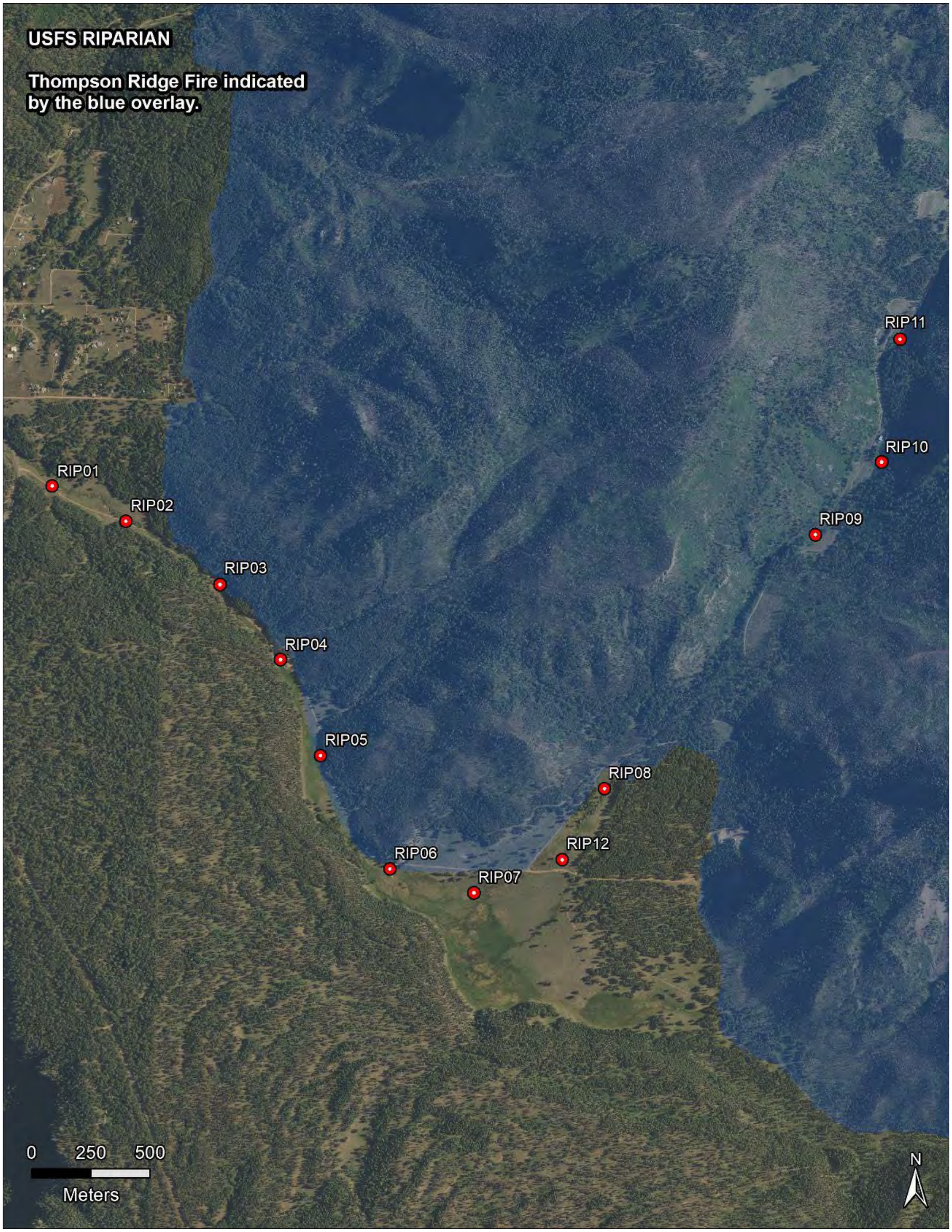
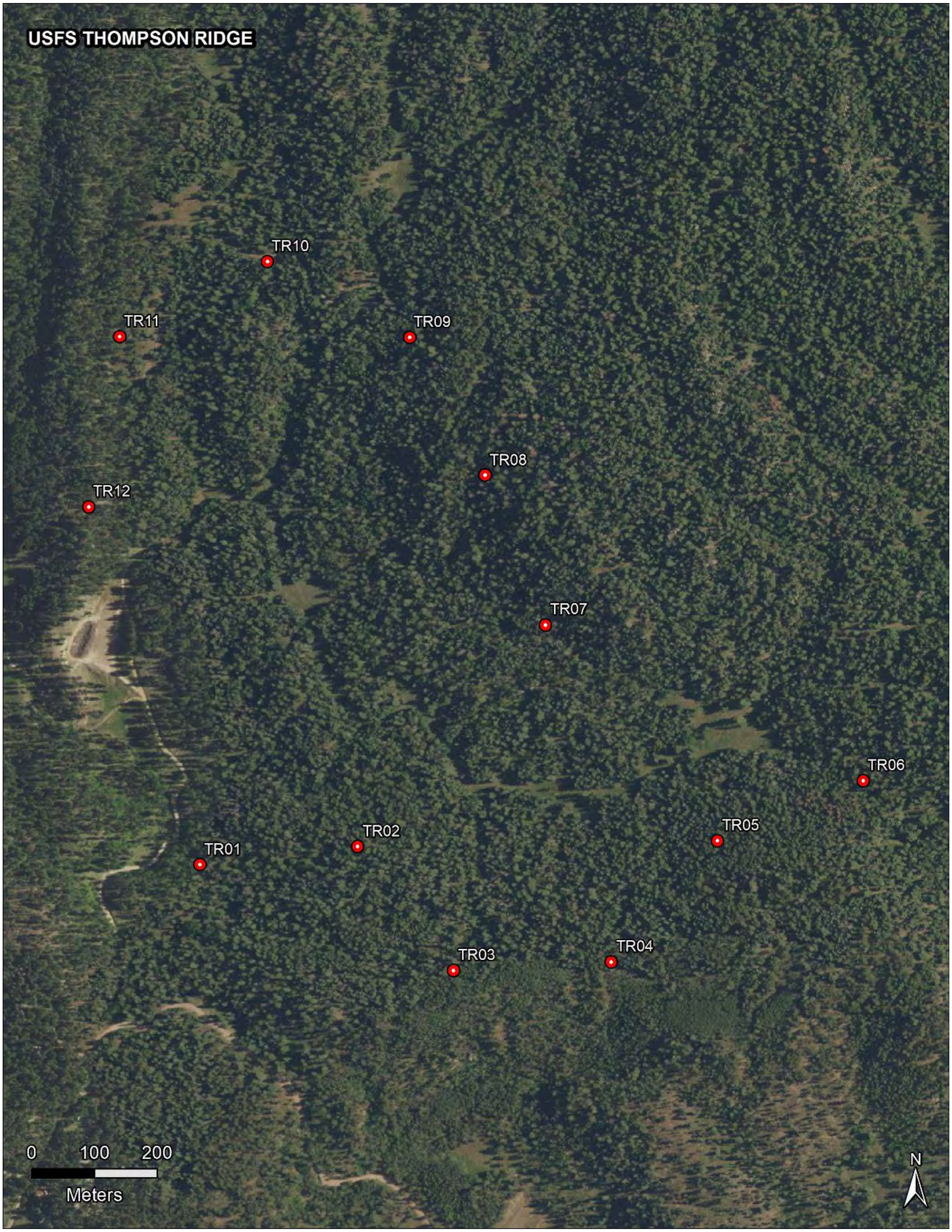


Fig. 8.17. Point locations for the USFS Riparian survey route, Santa Fe National Forest and Valles Caldera National Preserve, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

Fig. 8.18. Point locations for the USFS Thompson Ridge survey route, Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.



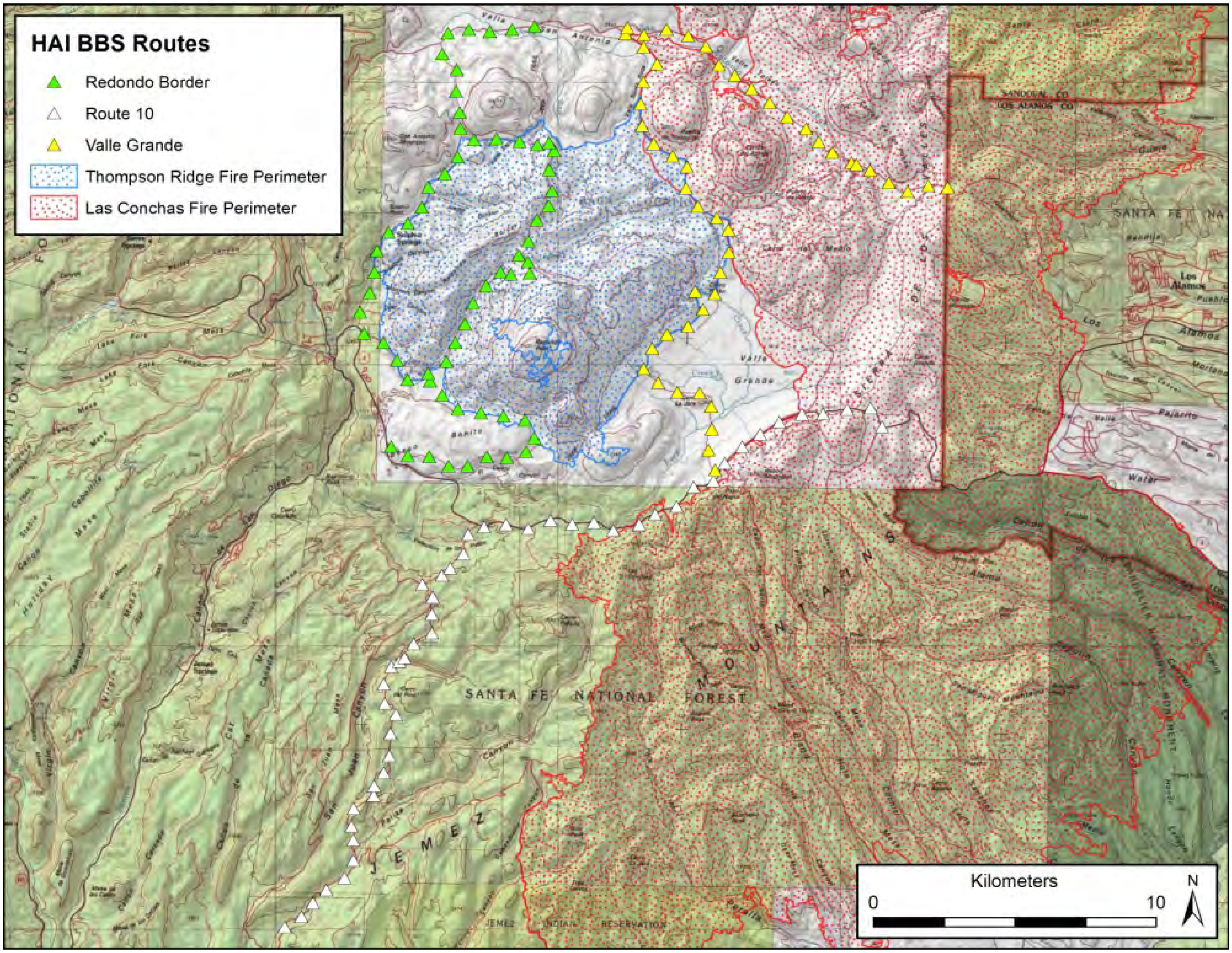


Fig. 8.19. Map of North American Breeding Bird Survey (BBS) routes in the Valles Caldera National Preserve and Santa Fe National Forest, Southwest Jemez Mountains CFLRP, Sandoval County, New Mexico.

Appendix 8.1. Alphabetical list and total numbers of 134 bird species detected within 125 m of point count locations, Santa Fe National Forest (USFS) and Valles Caldera National Preserve (VC), Jemez CFLRP, 2012-2021. Species with an asterisk (*) were detected only as flyovers. Species of conservation concern are listed in bold print.

Species	**USFS**	**VC**	**Total Detections**
American Crow	33	53	86
American Kestrel	1	44	45
American Pipit*	0	0	0
American Robin	475	858	1333
American Three-toed Woodpecker	14	70	84
Ash-throated Flycatcher	265	4	269
Band-tailed Pigeon	8	9	17
Bewick's Wren	8	7	15
Black Phoebe	10	0	10
Black-billed Magpie	0	4	4
Black-capped Chickadee	14	0	14
Black-chinned Hummingbird	278	8	286
Black-headed Grosbeak	203	102	305
Black-throated Gray Warbler	30	5	35
Blue Grosbeak	156	1	157
Blue-gray Gnatcatcher	223	1	224
Brewer's Blackbird	0	70	70
Brewer's Sparrow	2	6	8
Broad-tailed Hummingbird	196	184	380
Brown Creeper	96	62	158
Brown-headed Cowbird	34	5	39
Bullock's Oriole	6	0	6
Bushtit	183	0	183
Canada Jay	0	6	6
Canyon Wren	2	1	3
Cassin's Finch	14	18	32
Cassin's Kingbird	34	2	36
Cedar Waxwing	5	0	5
Chipping Sparrow	427	844	1,271
Clark's Nutcracker	78	85	163
Cliff Swallow	1	0	1
Common Nighthawk	6	3	9
Common Raven	86	168	254
Common Yellowthroat	15	0	15
Cooper's Hawk	8	3	11
Cordilleran Flycatcher	316	294	610

Appendix 8.1 continued.

Species	USFS	VC	Total Detections
Dark-eyed Junco	481	601	1082
Downy Woodpecker	37	23	60
Dusky Flycatcher	143	65	208
Dusky Grouse	0	10	10
Eastern Bluebird	3	0	3
Eastern Meadowlark	0	173	173
Empidonax spp.	6	11	17
Eurasian Collared-Dove	2	0	2
Evening Grosbeak	73	74	147
Flammulated Owl	0	2	2
Gambel's Quail	19	0	19
Golden-crowned Kinglet	40	73	113
Grace's Warbler	674	471	1,145
Gray Catbird	1	0	1
Gray Flycatcher	96	1	97
Gray Vireo	6	0	6
Great Blue Heron*	0	0	0
Great Horned Owl	2	8	10
Greater Roadrunner	1	0	1
Green-tailed Towhee	4	32	36
Hairy Woodpecker	315	416	731
Hammond's Flycatcher	222	154	376
Hepatic Tanager	11	2	13
Hermit Thrush	455	178	633
Horned Lark	0	78	78
House Finch	205	0	205
House Sparrow	1	0	1
House Wren	130	426	556
Indigo Bunting	0	1	1
Juniper Titmouse	16	0	16
Killdeer*	0	0	0
Ladder-backed Woodpecker	11	0	11
Lark Sparrow	3	5	8
Lazuli Bunting	5	3	8
Lesser Goldfinch	290	36	326
Lewis's Woodpecker	0	9	9
Lincoln's Sparrow	6	2	8
Lucy's Warbler	3	0	3
MacGillivray's Warbler	57	18	75

Appendix 8.1 continued.

Species	USFS	VC	Total Detections
Mallard	6	14	20
Marsh Wren	0	2	2
Mountain Bluebird	5	181	186
Mountain Chickadee	772	697	1,469
Mourning Dove	145	84	229
Nashville Warbler	3	9	12
Northern Flicker	208	487	695
Northern Goshawk	3	5	8
Northern Mockingbird	6	2	8
Northern Pygmy-Owl	0	4	4
Northern Rough-winged Swallow	12	5	17
Olive-sided Flycatcher	9	12	21
Orange-crowned Warbler	111	93	204
Peregrine Falcon	3	0	3
Pine Siskin	209	425	634
Pinyon Jay	7	0	7
Plumbeous Vireo	433	304	737
Pygmy Nuthatch	1,005	763	1,768
Red Crossbill	52	60	112
Red-breasted Nuthatch	67	177	244
Red-naped Sapsucker	9	25	34
Red-tailed Hawk	2	11	13
Red-winged Blackbird	2	2	4
Rock Wren	0	7	7
Ruby-crowned Kinglet	282	510	792
Rufous Hummingbird	4	23	27
Savannah Sparrow	0	71	71
Say's Phoebe	4	0	4
Scaled Quail	2	0	2
Sharp-shinned Hawk	1	3	4
Spotted Sandpiper	1	0	1
Spotted Towhee	387	30	417
Steller's Jay	402	390	792
Summer Tanager	73	1	74
Swainson's Hawk	0	1	1
Townsend's Solitaire	227	188	415
Townsend's Warbler	3	10	13
Tree Swallow	0	3	3
Turkey Vulture	10	0	10
Vesper Sparrow	5	356	361
Violet-green Swallow	175	562	737

Appendix 8.1 continued.

Species	**USFS**	**VC**	**Total Detections**
Virginia's Warbler	134	36	170
Warbling Vireo	670	344	1014
Western Bluebird	172	410	582
Western Kingbird	3	0	3
Western Meadowlark	0	246	246
Western Tanager	1,044	991	2,035
Western Wood-Pewee	448	546	994
White-breasted Nuthatch	440	387	827
White-crowned Sparrow	0	6	6
White-throated Swift	1	0	1
White-winged Dove	36	1	37
Wild Turkey	3	20	23
Williamson's Sapsucker	55	105	160
Wilson's Warbler	29	3	32
Woodhouse's Scrub-Jay	42	3	45
Yellow Warbler	229	1	230
Yellow-bellied Sapsucker	1	0	1
Yellow-breasted Chat	602	0	602
Yellow-rumped Warbler	935	902	1,837
unknown spp.	1	1	2
Totals	**16,035**	**15,308**	**31,343**

Chapter 9. Soils and Soil Biota Monitoring

The objective of this soils monitoring program was to determine the thresholds for impacts of logging machinery on soil nematodes and physical properties. Mechanized tree thinning causes considerable soil disturbance, but little information is available regarding thresholds for impacts on the dominant multicellular animals in soils: nematodes. These trophically diverse microfauna perform important ecological functions (for example, nitrogen mineralization, dispersal of microbes, and regulation of lower trophic levels) and are widely consumed by predatory and omnivorous mesofauna. Because nematodes are too small to physically modify soil pore structure, their movement is restricted to pores of sufficient size to accommodate them. Compaction from heavy logging machinery may thus reduce nematode abundances by decreasing available pore space. Nematodes also exhibit a wide range of life history characteristics, and some taxa are slow to recover from disturbance due to relatively long generation times and low reproductive output. We examined responses of nematode assemblages and soil physical characteristics to increasing number of passes (one, three, or nine) by a tracked harvester (a feller buncher) during thinning of a xeric mixed conifer forest at unit Seco 5 in VALL. Within and between the harvester tracks (Fig. 9.1), we measured soil surface penetration resistance and shear strength, quantified bulk density at four depth increments to a maximum depth of 27 cm, and characterized nematode assemblages in the upper 10 cm. We hypothesized that nematode responses to harvester traffic would vary according to their life history characteristics (i.e., whether they were *r*- or *K*-strategists *sensu lato*, as designated by the colonizer-persister (cp) classification system (Bongers, 1990)) and feeding habits, and that compaction would disproportionately affect large bodied taxa.

Eight months after treatment, we found that nematode communities were less impacted than soil physical properties by harvester passes (Gibson et al. 2022). Soil compaction was evident with a single pass and extended deep into the soil profile to at least 23-27 cm (Fig. 9.2). Total nematodes, herbivores (Fig. 9.3.A), nematodes in the family Tylenchidae (which includes herbivorous and fungivorous taxa) (Fig. 9.3.B), *r*-strategist bacterivores (Fig. 9.3.C), and *r*-strategist fungivores (Fig. 9.3.D) were unaffected by any level of disturbance. However, densities of *K*-strategist nematodes (Fig. 9.3.E, Fig. 9.3.D) were reduced following nine harvester passes. Abundances of sensitive nematode groups were correlated weakly with bulk density at the 9-13 cm depth interval (R^2=0.074, p=0.064), but this relationship was stronger for slender taxa (*K*-strategist bacterivores: R^2=0.070, p=0.073) compared to large-diameter taxa (*K*-strategist omnivores, predators, and fungivores in the order Dorylaimida: R^2=0.029, p=0.251), suggesting that harvester disturbance did not limit pores accessible to nematodes. We note that the harvester produced complex soil disturbance, with surface soil mixing and subsurface compaction, which may have obscured relationships between bulk density and nematode abundances. Our results indicate that nematode communities are unlikely to be affected by low levels of soil disturbance from heavy logging machinery, but nevertheless emphasize the importance of minimizing areas subjected to logging machinery traffic, especially in Jemez Mountains Salamander habitat.

Modulation of the Gadgil effect by soil mesofauna in thinned/burned and untreated ponderosa pine forests

Soil mesofauna likely influence the distribution and associated functions of fungal communities, but few manipulative studies have parsed the direct and indirect contributions of mesofauna to fungal-mediated ecosystem processes in the field. We used mesocosms of novel design to untangle relationships among microarthropods, fungal communities, and decomposition of labile (cellulose) and recalcitrant (wood) substrates in contrasting ecological contexts: thinned/burned and untreated ponderosa pine forest management units (Fig. 9.4, Fig. 9.5) at Banco North in VALL. Our study took place over two growing seasons and concluded five years after the prescribed fire in the thinned/burned management unit. Our mesocosms were engineered to manipulate microarthropod communities via mesh treatments while minimizing—and enabling measurement of—mesh treatment side effects. Because fungivorous microarthropods may preferentially graze saprotrophic hyphae over ectomycorrhizal hyphae, we hypothesized that they could influence decomposition indirectly by modulating the Gadgil effect (where ectomycorrhizal fungi decelerate decomposition by outcompeting saprotrophic fungi for nitrogen). This experiment also provided an opportunity to test the resource-ratio theory-based prediction of Smith and Wan (2019) that the Gadgil effect should occur in recalcitrant—but not labile—substrates. We anticipated, however, that decomposition of a labile substrate would be directly increased by comminuting (or fragmenting) microarthropods. We used multi-group structural equation modeling (SEM) to quantify direct and indirect effects of mesofauna on decomposition. Our SEM indicated that medium and large mesofauna (> 150 µm) increased the ratio of ectomycorrhizal (EcM) fungi to litter and wood saprotrophic (LWS) fungi, but only in the thinned/burned management unit. This EcM:LWS ratio was the best predictor of wood decomposition in the thinned/burned forest, where higher ratios were correlated with reduced decomposition, consistent with the Gadgil effect (Fig. 9.6). However, we found no evidence of the Gadgil effect in the untreated forest, despite higher EcM:LWS ratios and higher densities of microarthropods there. Decomposition of the labile substrate was unaffected by the EcM:LWS ratio, as resource-ratio theory would predict. We also observed no effect of microarthropods on decomposition of the labile substrate, a result consistent with other reports from moisture-limited systems. Our findings suggest that the Gadgil effect may play out differently in contrasting ecological theaters, with decomposition rates determined by the stage (abiotic context and substrate recalcitrance) as well as the cast (communities of microarthropods and fungi; Fig. 9.7).

References

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Gibson, K. S., N. C. Johnson, C. Laturno, R. R. Parmenter, and A. Antoninka. 2022. Abundance of mites, but not of collembolans or nematodes, is reduced by restoration of a Pinus ponderosa forest with thinning, mastication, and prescribed fire. Forest, Trees and People. 7:100190 https://doi.org/10.1016/j.tfp.2022.100190

Smith, G.R., and J. Wan. 2019. Resource-ratio theory predicts mycorrhizal control of litter decomposition. New Phytol. 223:1595–1606.

Collaborators: Northern Arizona University (Dr. Anita Antoninka and Dr. Kara Gibson).

Fig. 9.1. One of three experimental feller buncher disturbance transects. Flags represent sampling points within and between the tracks (each cluster of three flags represents one sampling location). Each of the three transect blocks included three sections treated with 1, 3, and 9 passes, respectively. Samples and measurements were taken at three points per track and intertrack transect section (N=54 sampling locations).

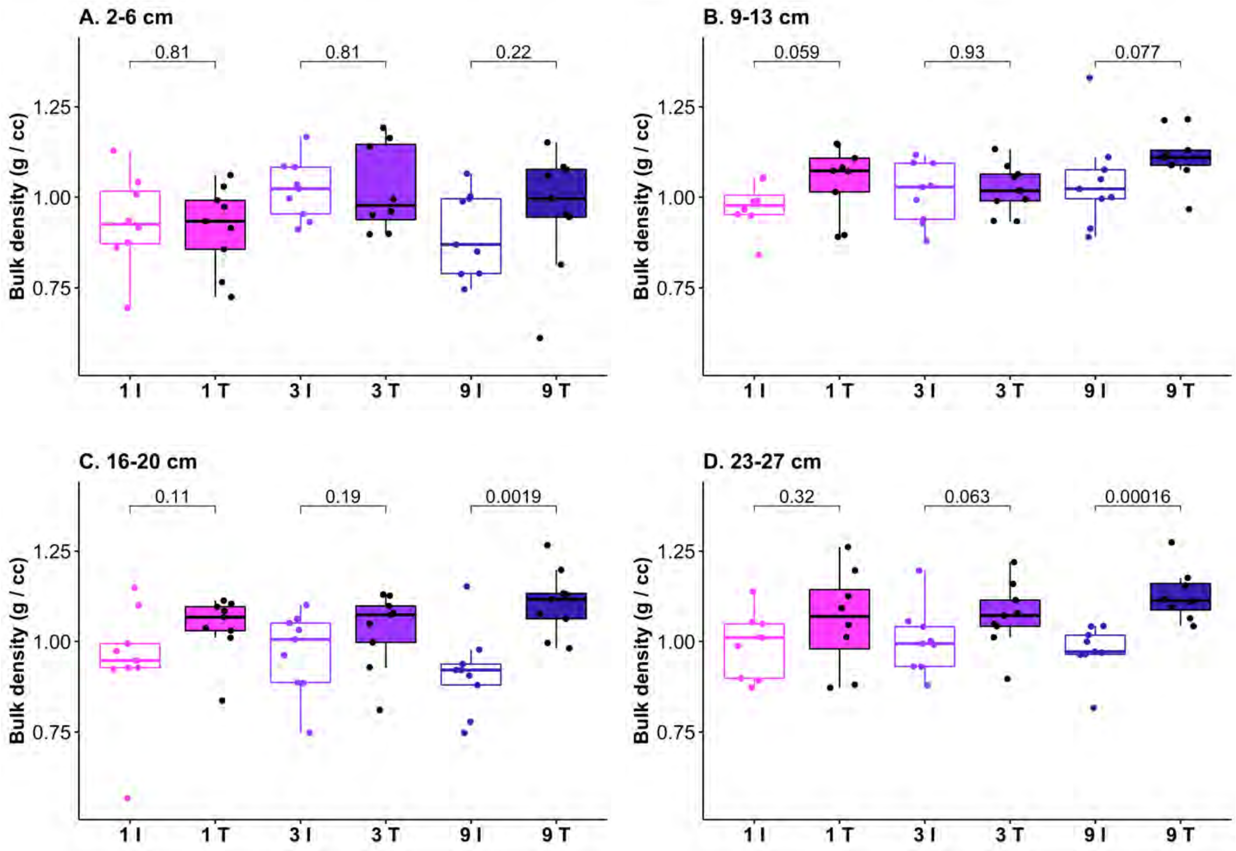


Fig. 9.2. Soil bulk densities (g/cm^3) from track (T) and intertrack (I) sampling locations that received 1, 3, or 9 passes from a feller buncher. (A) 2-6 cm sampling depth; (B) 9-13 cm sampling depth; (C) 16-20 cm sampling depth; (D) 23-27 cm sampling depth. *P*-values above brackets are calculated from Wilcoxon rank sum tests and have not been corrected for multiple comparisons. Open boxplots show data from between the feller buncher tracks, and filled boxplots show data from the tracks. Pink, purple, and blue represent one, three, and nine passes, respectively. The line within each box shows the median for that treatment, and the lower and upper bounds of the box indicate the 25th and 75th percentiles, respectively. Whiskers extend to 1.5 x the interquartile range from the lower and upper box bounds. Individual observations are plotted as dots.

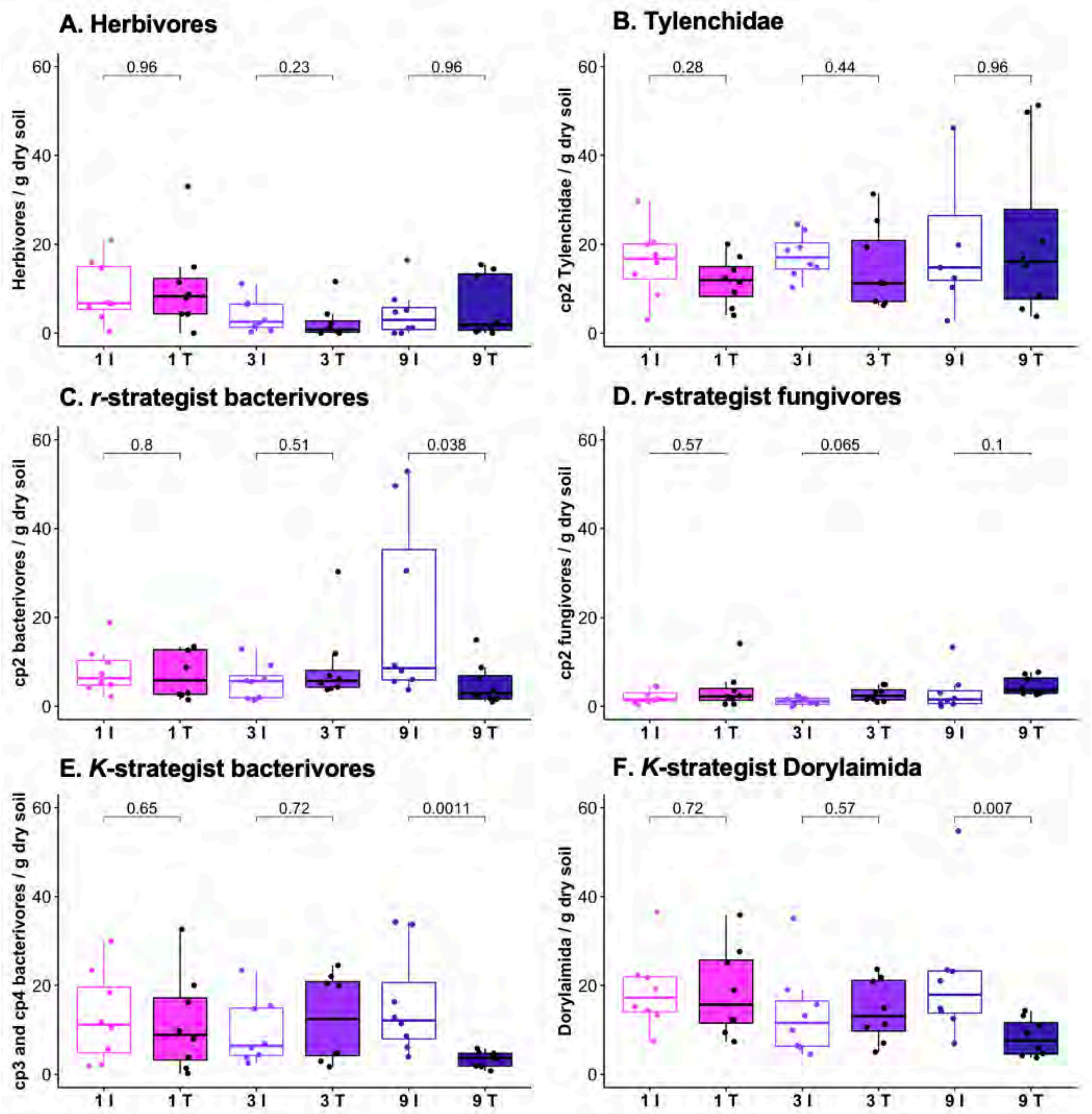


Fig. 9.3. Abundances of nematode groups in (T) and intertrack (I) sampling locations that received 1, 3, or 9 passes from a feller buncher. (**A**) Herbivorous nematodes; (**B**) nematodes in the family Tylenchidae (one observation of 174 Tylenchidae / g dry soil in a 9-intertrack treatment is not shown); (**C**) *r*-strategist bacterivores; (**D**) *r*-strategist fungivores; (**E**) *K*-strategist bacterivores (slender nematodes); (**F**) *K*-strategist omnivores, predators, and fungivores in the order Dorylaimida (large-bodied nematodes). 23-27 cm sampling depth. *P*-values above brackets are calculated from Wilcoxon rank sum tests and have not been corrected for multiple comparisons. Open boxplots show data from between the feller buncher tracks, and filled boxplots show data from the tracks. Pink, purple, and blue represent one, three, and nine passes, respectively. The line within each box shows the median for that treatment, and the lower and upper bounds of the box indicate the 25th and 75th percentiles, respectively. Whiskers extend to 1.5 x the interquartile range from the lower and upper box bounds. Individual observations are plotted as dots.

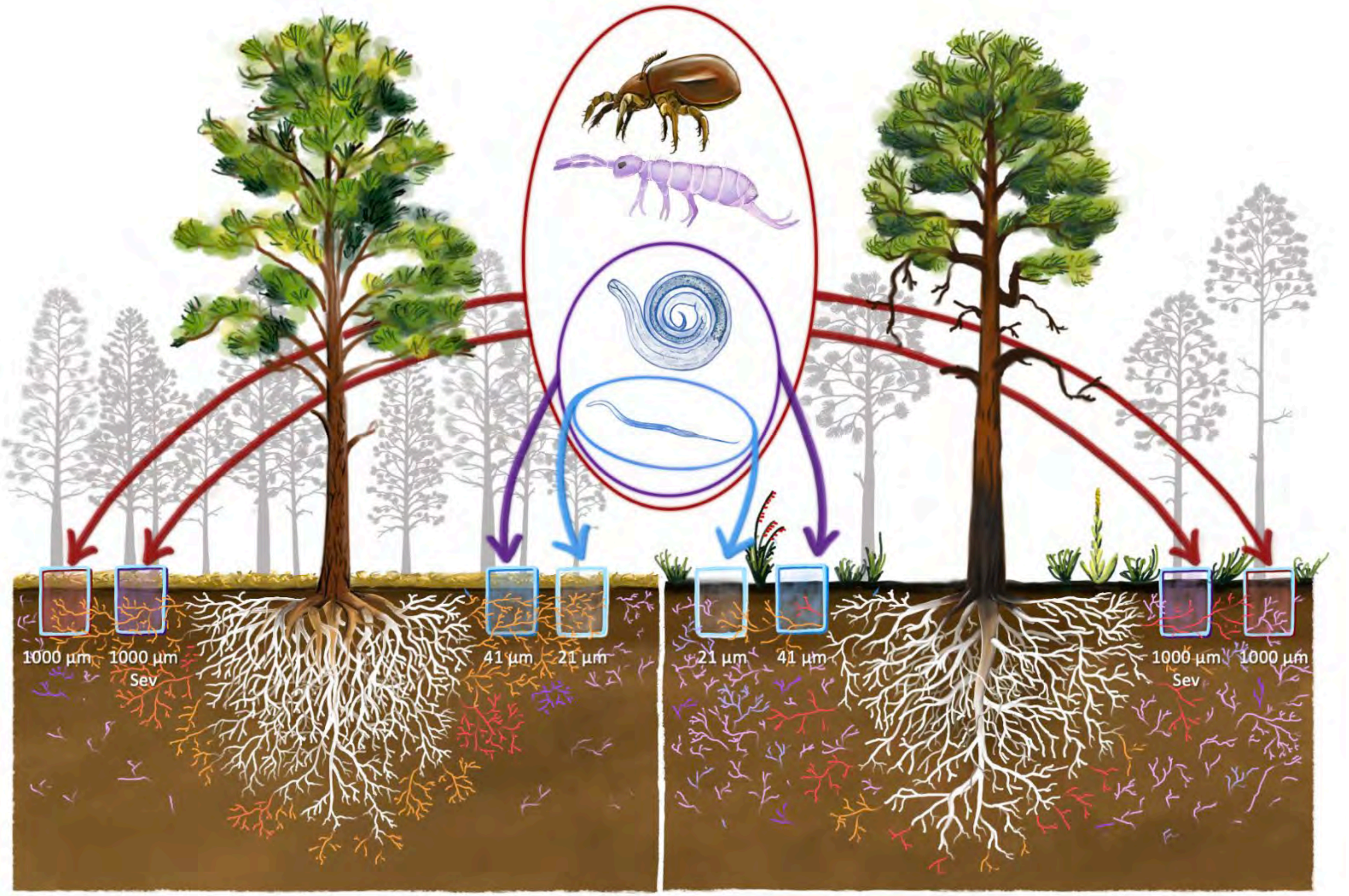


Fig. 9.4. Overview of our field mesocosm treatments. At ponderosa pine driplines in untreated (left) and thinned/burned (right) forest management units, we installed mesocosms designed to allow colonization by microfauna only (21 µm mesh and 41 µm mesh) or by microfauna and mesofauna (1000 µm mesh). Because roots could access the 1000 µm mesh mesocosms, we also included a fourth treatment of 1000 µm mesh treatment with root severing (1000 µm Sev).

Fig. 9.5. Experimental and sacrificial mesocosms at the dripline of a tree in the thinned/burned management unit. Other trees in the study, flagged with orange tape and marked with stars, are visible in the background.

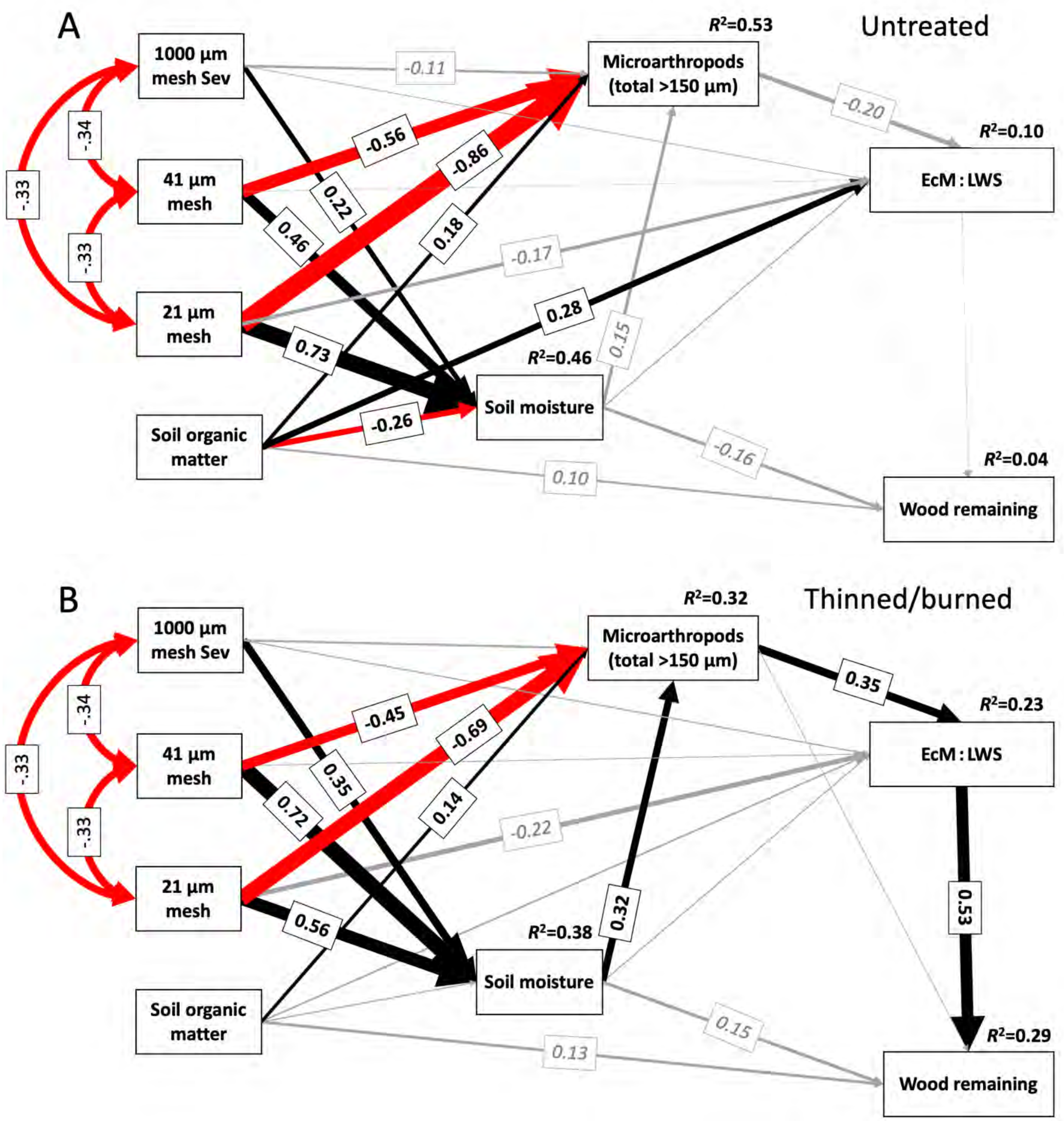


Fig. 9.6. Multigroup structural equation model of wood decomposition. (A) Untreated management unit. (B) Thinned/burned management unit. Soil moisture=mean Z scores of soil moisture measurements taken at five timepoints. Significant standardized path coefficients (λ) with $p < 0.05$ are shown in bolded black text; all other path coefficients are shown in gray italics where $\lambda \geq 0.1$ or are omitted if $\lambda < 0.1$. Black arrows indicate significant positive paths, red arrows represent significant negative paths. Arrow widths are scaled according to the standardized path coefficients. EcM:LWS =ratio of ectomycorrhizal reads to litter and wood saprotroph reads. Percent soil organic matter, microarthropod abundances, and EcM:LWS were log transformed prior to analysis.

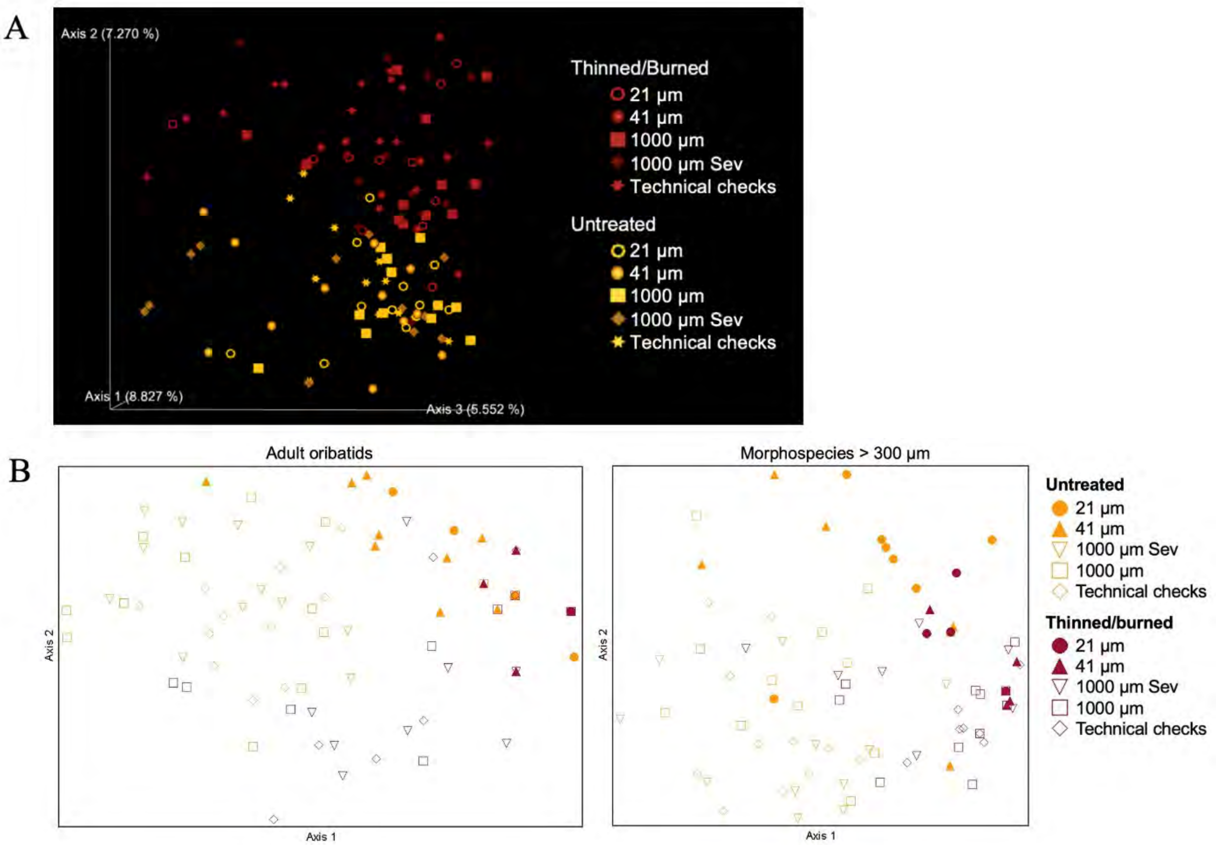


Fig. 9.7. Ordinations of fungal and faunal communities at the conclusion of the field mesocosm study. (A) Variation along axes two and three of a three-dimensional principal coordinate analysis (PCoA) ordination of fungal communities based on weighted Bray-Curtis distance, visualized with Emperor QIIME2View. Colors correspond to ponderosa restoration treatment, and shapes designate mesh treatment: 21 µm, 41 µm, 1 mm with root severing (1 mm Sev), 1 mm without root severing (1 mm), and technical checks without mesh or pipe. (B) Nonmetric multidimensional scaling (NMDS) ordinations of (left) adult oribatid mites > 150 µm (final stress= 9.37; two-dimensional ordination) and (right) abundances of all microarthropod morphospecies > 300 µm (final stress=12.21; axes 1 and 2 shown of three-dimensional ordination). Note that mesh treatments are equally replicated (N=12), but many of the fine mesh mesocosms with few or no large fauna or oribatids are plotted atop one another in the NMDS.

Chapter 10. Jemez Mountains Salamander Microhabitat

The Jemez Mountains Salamander (*Plethodon neomexicanus*) is endemic to the Jemez Mountains, and appears to have been declining in abundance over the past 70-80 years; as a result, the species has been listed as *endangered* under the Endangered Species Act. The salamander is terrestrial (i.e., doesn't live or breed in streams or other water bodies), inhabits coniferous forests at mid- to high-elevations, and appears to be active on the ground's surface only during the summer monsoons (July to mid-September) when temperatures are higher and moisture is abundant. During the day, salamanders shelter beneath or inside of logs, under stones/rocks, or underground in the soil.

The CFLRP and LRMP forest restoration activities involve thinning forests and introducing more frequent low-intensity fires to prevent high-severity stand-replacing fires from destroying salamander habitat. However, the implementation of forest thinning and subsequent broadcast burning reduces the forest canopy and exposes the ground to greater sunlight, potentially heating up and drying out the surface soil and litter layers; this may affect the microhabitat and microclimate of the salamander. Hence, the objectives of this monitoring effort were to address the following questions:

(1) What are the soil temperature and soil moisture profiles beneath a *log* compared to "*non-log*" microsites?
(2) To what degree do these profiles change with forest restoration actions (thinning and subsequent ground fire)?

To assess the subsoil temperature and moisture regimes and dynamics, we established four instrumented study sites in the Cerro Seco Unit 5 project area (see site description and treatments in Chapter 3, Vegetation Monitoring). Two of these sites were in areas that were treated (thinned and then burned) and two sites served as "controls" in untreated forest stands. Each site comprised an existing log in the forest, with "non-log" micro-habitat on either side, extending outward a distance of 2 meters. Five columns of soil probes were installed in the soil beneath the log and at 1 and 2 meters distance on both sides (see design schematic in Fig. 10.1). Three sets of soil sensors were installed at 10, 20 and 30 cm depth; each sensor set included a temperature probe, a volumetric soil moisture probe (Time Domain Reflectometry, or TDR probe), and a soil water matrix potential probe (Fig. 10.2). These probes were wired to a data logger, and measurements were recorded every 15 minutes. In addition, a meteorological (weather) station was installed at each log to record atmospheric temperature, relative humidity, rainfall, wind speed and direction, and total solar radiation. Each weather station and soil probe data loggers were protected from elk and bear interference by a surrounding metal panel fence. Instruments were installed and began operations in the fall of 2015; the treatment sites were thinned over the winter of 2017-2018, and the sites were burned in a planned (prescribed) fire in October 2019. The instruments continued to operate through 2022. Fig. 10.3 shows the North Treatment Log site prior to and after the thinning treatment and prescribed fire.

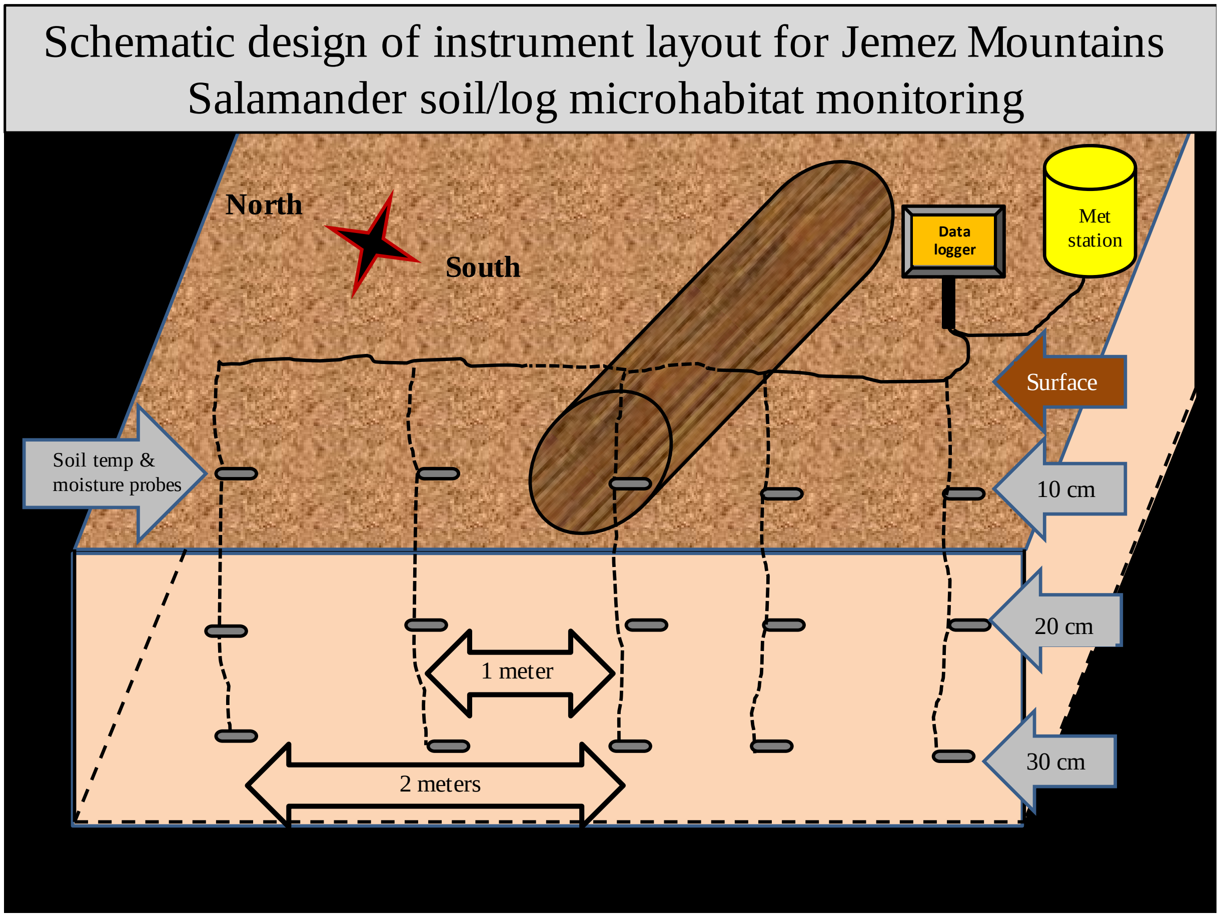


Fig. 10.1. Schematic of log/soil monitoring site.

Fig. 10.2. Soil monitoring probes: (Left) Matric Potential Probe; (Right) TDR soil moisture and temperature probe.

Fig. 10.3. North Treatment Log: (Top) Pre-thinning 2016; (Middle) Post-thinning, pre-fire 2018; (Bottom) Post-fire 2020.

Results of the monitoring have shown that thinning increases soil temperatures by 0.8 to 1.9º C (Fig. 10.4). These results are based on comparing the annual median temperatures during 2015-2017 (pre-thinning) with the same measures taken during 2018-2019 (the year after thinning); both of these data sets were scaled against the control (untreated) log sites. At the North Log Treatment site, soil temperatures increased at all depths under the log by 1 to 1.5º C, and by 1.7 to 1.9º C at two meters away from the log (Fig. 10.4). At the South Log Treatment site, which retained more canopy cover than the North Log Treatment site, the temperature increases were more modest (0.8 to 1.2º C) (Fig. 10.4).

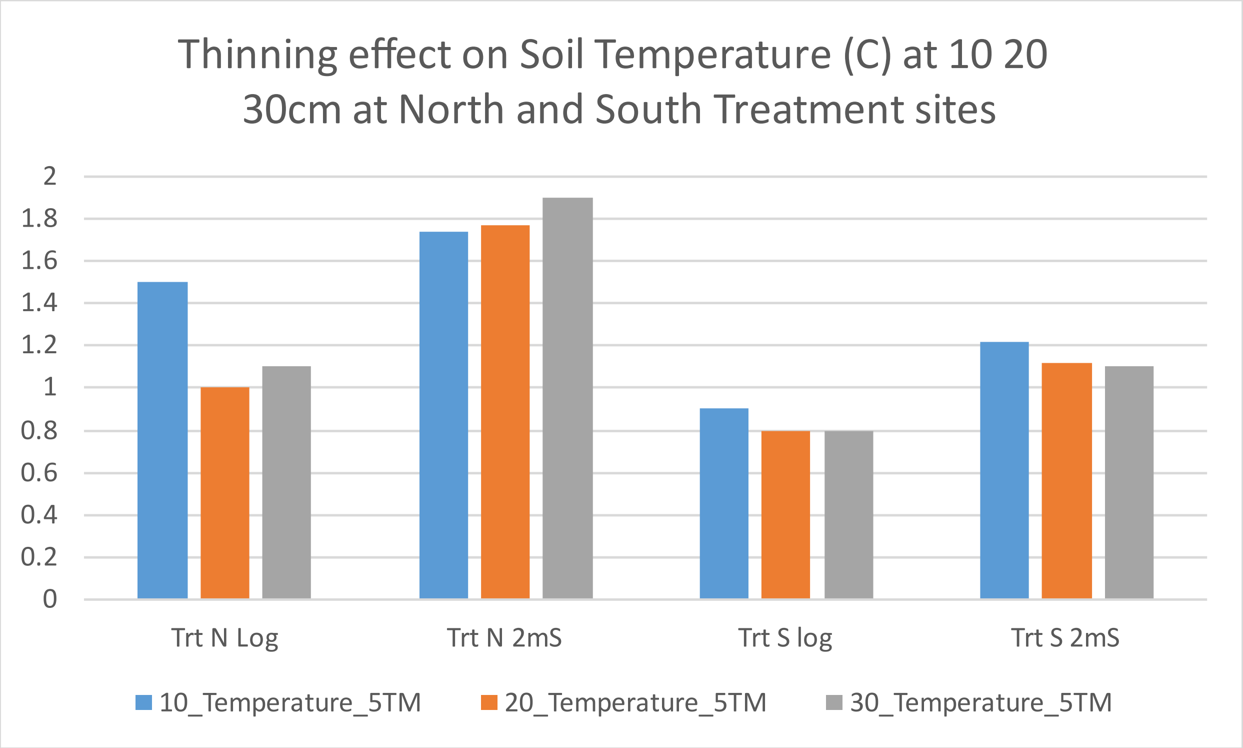


Fig. 10.4. Temperature (º C) results for thinning treatment logs and open spaces.
Histograms show net increases in temperature at different locations (beneath the log and 2 meters away) and depths (colored histograms, 10, 20 and 30 cm deep).

The effects for forest thinning on soil moisture were also evident in the pre- and post-thinning data for volumetric water measurements. Averaged over the year following thinning, and scaled against the control (untreated) sites, soil moisture near the surface (10 cm deep) decreased by 7.4% immediately under the North Treatment log, and 4.9% under the South Treatment log (Fig. 10.5). Soil moisture changes at the deeper depths were smaller. Open areas away from the logs also showed declines in soil moisture, with similar differences among soil depths.

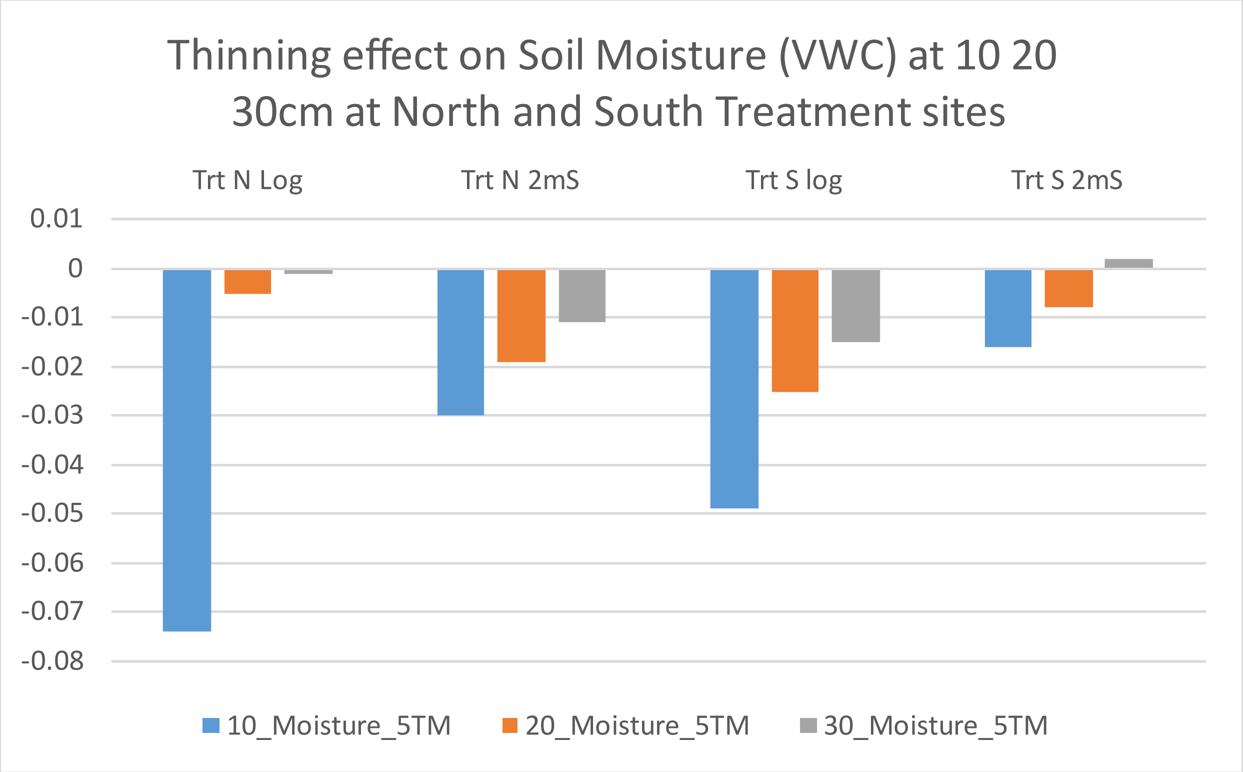
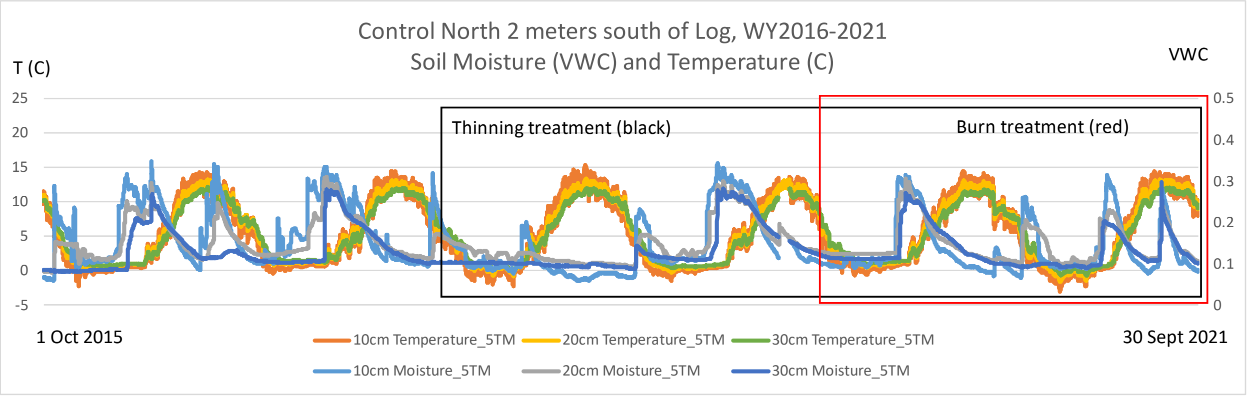


Fig. 10.5. Soil moisture (Volumetric Water Content, VWC, as a percent of soil volume) results for thinning treatment logs and open spaces. Histograms show net decreases in VWC at different locations (beneath the log and 2 meters away) and depths (colored histograms, 10, 20 and 30 cm deep).

The effects of the October, 2019, prescribed fire were evident, but of less magnitude than the thinning effect. The burn effect was to decrease median soil moisture (VWC) by up to 1.5% and increase median soil temperature by 0.3 to 0.5º C. This was likely due to the removal of herbaceous vegetation cover by burning, which would have exposed the soil to warming by the sun in the spring and summer until grass and forb canopies had recovered. Fig. 10.6 shows an example time series of soil temperature and moisture for the Control North open space (2 meters south of the log) and the Treatment North open space. Note that the temperature profiles in the control site are fairly consistent over the 6 years of the study; moisture dynamics are dependent on snowpack and summer rainfall. In contrast, at the Treatment site, there is a clear increase in temperatures following the thinning operation, but a much less noticeable change following the fire. Soil moisture in the treated site shows more variability compared to the control, with spring snowmelt spikes leading to greater soil moisture early in the year (likely due to more snow accumulating on the ground, instead of being intercepted by tree branches and sublimating back to the atmosphere).



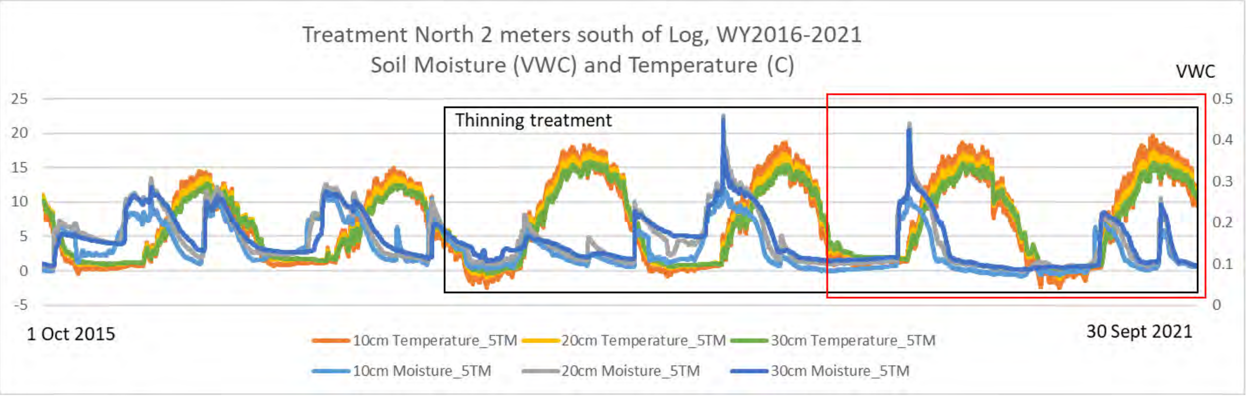


Fig. 10.6. Soil temperature and moisture dynamics at different soil depths during 2015-2021.

Thus, overall, the thinning and burning operations create conditions that expose the soil beneath and adjacent to forest logs that increase temperatures by 1 to 2º C averaged across the year, and decrease soil moisture by 1.5% to 7.5% over the year, depending on location and depth.

Chapter 11. Socio-Economics Monitoring

The Santa Fe National Forest, the Forest Stewards Guild, and project partners continued to collect socioeconomic data for TREAT as well as for the additional socioeconomic monitoring that occurs every project year. In gathering the numbers and percentages for use in TREAT, the Guild contacted all available relevant entities and asked for direct and specific information. To capture the social and economic effects of treatments on private land, we interviewed and surveyed additional project partners. The data gathering and associated interviews were consistent with previous year's methods. Data collected in interviews was shared with Forest Service Economists as "local economic data" as per TREAT instructions (see Appendix 11.1).

Due to the Mexican Spotted Owl injunction, which ended on October 28th, 2020, treatments were stalled on federal land in the early part of FY 2021. Logs were not able to be removed during this time. Wood processing partners reported that increased time for drying reduced log weights and log values, which are tied to weight.

The local sawmill supported by treatments within the SW Jemez CFLRP landscape provides employment to Jemez Pueblo and other rural communities surrounding the project landscape. The majority of the Walatowa workforce is from Jemez Pueblo. All of the sawmills surrounding the project landscape are small, locally-owned businesses that provide important jobs and economic stability to these rural communities. It is important to view the employment supported by the SW Jemez Mountains CFLR within the context of the economically disadvantaged rural communities where this employment is located. It is challenging to find stable, proximate, full-time employment in the Jemez Pueblo and surrounding communities. Jemez Pueblo has a poverty rate of 24.79%, which is more than double the national average of 11.4% in 2020. Furthermore, in communities with small populations the impact of a few stable jobs has a greater economic impact than the same number of jobs in areas with higher populations.

Table 11.1 FY 2021 Modelled Jobs Supported/Maintained (CFLN and matching funding); totals from the All Funds tab of the TREAT spreadsheet provided from EMC Economics Team.

FY 2021 Jobs Supported/Maintained	**Jobs (Full and Part-Time) (Direct)**	**Jobs (Full and Part-Time) (Total)**	**Labor Income (Direct)**	**Labor Income (Total)**
Timber harvesting component	6	31	$224,640	$1,335,038
Forest and watershed restoration component	6	11	$302,542	$479,144
Mill processing component	16	55	$599,040	$2,047,953
Implementation and monitoring		10	$381,900	$445,979
Other Project Activities		2		$40,602
TOTALS:	**28**	**108**	**$1,508,122**	**$4,348,717**

In addition to TREAT, the Forest Stewards Guild also track jobs directly through surveys and interviews with contractors and other employers working on restoration in the landscape. Full time equivalent (FTE) does not always tell the whole story regarding jobs and economic impact.

With a single FTE multiple people may have benefited from the wages and training that one FTE represents. The Forest Stewards Youth Corps (FSYC) is a good example of this. While the program only accounted for 1 FTE due to its seasonal nature, four young people were employed and gained skills and experience working in the SW Jemez Mountains CLFR landscape that will help them find employment in the future. Furthermore, this 1 FTE is supported by leveraged funding from the state of New Mexico and private foundations.

When you compare the total FTE accounted for in surveys and interviews in the table below, in many sectors there were more than four times as many people as there are indicated by the FTE. It is also encouraging that the ratio of FTE to individuals employed is the highest for the mill processing and harvesting & trucking sectors. This indicates that those jobs are closer to full time as opposed to seasonal, which provides more stable employment and better economic conditions for local workers. Furthermore, "individuals employed" does not take into account staff turnover meaning that if the ratio were calculated using FTE to positions the ratio would likely be higher and further indicate more stable employment in those sectors.

Table 11.2. Summary of FY2021 CFLRP-related jobs and wages.

Employment Sector	Full-Time Equivalent	Wages	Number of People Employed	Ratio of Jobs to FTE
Harvesting and Trucking	6	$224,640	6	1
Youth	1	$35,000	4	0.25
Mill Processing	16	$599,040	16	1
Monitoring	1	$30,773	6	0.15
Total	**24**	**$889,453**	**32**	**.75**

The SW Jemez CFLRP continued to provide important training and workforce development opportunities in FY 2021. As stated above, the Forest Stewards Youth Corps (FSYC) on Jemez Pueblo provides natural resource management training to youth between the ages of 15-25 as well as a valuable workforce to projects within the SW Jemez Mtns. landscape. The Summer FSYC program provides valuable employment and professional development opportunities for high school- aged youth. The program teaches crewmembers a variety of natural resource management skills and introduces them to land management officers within Jemez Pueblo and the adjacent Santa Fe National Forest. The Fall FSYC provides employment and professional development opportunities for youth that have recently graduated from high school. The Fall program provides crewmembers with wildland firefighter training and experience with fire through implementation of prescribed fire on their ancestral lands.

The efficient and creative use of small diameter wood in the SW Jemez Mountains continued in FY 2021. Each of these divisions is supported by and in turn supports utilization of woody biomass generated by restoration work in the CFLR. The pie chart below (Fig. 11.1) provides a breakdown of the types of products being created.

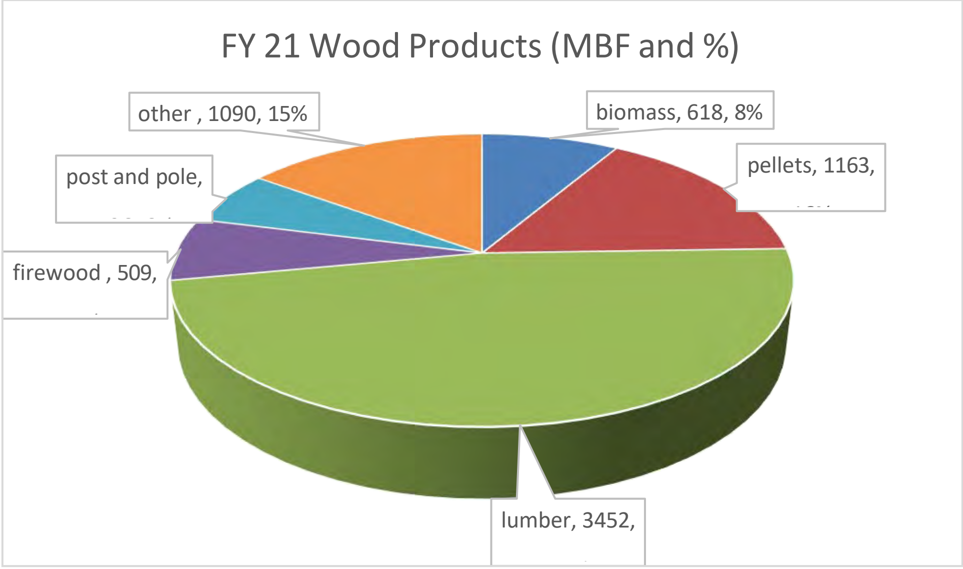


Fig. 11.1. Pie-chart of wood products manufactured during FY2021.

The network of partnerships and collaboration developed through the SW Jemez Mountains CFLRP helps to fill capacity gaps within the project landscape by connecting the right resources at the right places for project monitoring and implementation. Increased communication and cooperation amongst local agency representatives, academic institutions, and organizations is a valuable improvement to the socioeconomic conditions surrounding the SW Jemez Mountains project area. VCNP partnered with the research and academic community, and was able to establish important working relationships with researchers that will improve the use of best available science in collaborative work. These institutions include: University of New Mexico, New Mexico State University, Northern Arizona University, and the University of Nevada. Furthermore, partnerships between Valles Caldera and academic institutions often provide leveraged funding. Graduate student workers, like one 2019 student from Northern Arizona University, often have part of their project funding contributed through another source than the CFLRP. Another example of this academic leverage, is that New Mexico State University brought 2 PHD students that were paid by outside sources to help work on large mammal monitoring associated with the SW Jemez CFLR.

Project partners participate in an annual “all hands” meetings each year that include a review and update of project monitoring components. Capacity for certain monitoring components changes from year to year and annual meetings are important for catching and adapting to these changes.

Monitoring categories include: the National Forest Foundation’s outcomes and indicators, hydrology and climate, vegetation, fish and wildlife habitat, wildfire effects, wood utilization, wildfire suppression cost savings, livestock grazing, cultural resource protection, restoration business stabilization, job sustainability, training and outreach, ecosystem services, recreation, and tourism.

Multiparty monitoring will continue in the project landscape for five years after the project ended in 2020. The Guild is working with the Santa Fe National Forest to secure annual funding for socioeconomic monitoring in 2023, 2024, and 2025.

Collaborators: Forest Stewards Guild, Valles Caldera National Preserve, the Santa Fe National Forest, Trout Unlimited, NM Trout, The Nature Conservancy, WildEarth Guardians, New Mexico Forest and Watershed Restoration Institute, University of Nevada, University of Arizona, Hawks Aloft, University of New Mexico, New Mexico State University, Northern Arizona University, Santa Clara Pueblo, Walatowa Timber, and Jemez Pueblo.

Appendix 11.1. Project list for CFLRP-related economic analyses. Total partner in-kind contributions for implementation and monitoring of a CFLR project across all lands within the CFLRP landscape. For CFLRP projects under the CFLRP Common Monitoring Strategy, note that this table addresses the core CFLRP common monitoring strategy question, "If and to what extent has CFLRP investments attracted partner investments across the landscapes?"

Fund Source – (Partner Match)	In-Kind Contribution or Funding Provided?	Total Estimated Funds/Value for FY21	Description of CFLRP implementation or monitoring activity	Where activity/item is located or impacted area
Forest Stewards Youth Corps – Jemez Pueblo Crew	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$35,000	9 weeks of conservation projects (fire line, tree marking, trails, recreation, etc.) in the landscape	☒ National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera
Weather stations and data management	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$11,683.98	At 9 weather station locations throughout the CFLRP boundary	☒ National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera
Jemez Mountain Salamander Monitoring	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$25,195	Cerro Seco on Valles Caldera Preserve – Monitoring log Microhabitats through forest thinning and RX fire	☐ National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera
Avian Monitoring	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$32,009.35	Avian monitoring throughout the CFLRP landscape	☒ National Forest System Lands ☐ Other lands within CFLRP landscape:

Fund Source – (Partner Match)	In-Kind Contribution or Funding Provided?	Total Estimated Funds/Value for FY21	Description of CFLRP implementation or monitoring activity	Where activity/item is located or impacted area
	☐ Funding Budget Line Item, if relevant:		National Forest and Valles Caldera – East fork Jemez River, Indios Creek, San Antonio Creek, Rio San Antonio, 2 on Rio Cebolla and 2 on battleship rock	☒ Other lands within CFLRP landscape: Valles Caldera
Large mammal monitoring	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$100,285	Large mammal surveys for the entire project boundary.	☒National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera
Soils monitoring	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$149,945	Valles Caldera Preserve South Mountain, Seco 5, and Banco Bonito	☒National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera NP
Etymology monitoring	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$15,000	Systematic entomology and classification of pest and beneficial insects on the Valles Caldera National Preserve	☐ National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera NP
Forest thinning	☒ In-kind contribution ☐ Funding Budget Line Item, if relevant: [1]	$96,600	Forest thinning by Santa Clara pueblo on Cerro Pinon	☐ National Forest System Lands ☒ Other lands within CFLRP landscape: Valles Caldera NP
TOTALS	Total In-Kind Contributions: $519,474.15			