Cerro de la Olla

2016

Inventory and Monitoring Report

Submitted by

Kathryn R Mahan, Ecological Monitoring Specialist,

New Mexico Forest and Watershed Restoration Institute

New Mexico Highlands University

January 2017

for

Bureau of Land Management, Farmington District, Taos Field Office

Contents

List of Figures

List of Tables

Acronyms, Abbreviations or Terms used in this document

Acronym, Abbreviation, or Term	Explanation or Definition as used by NMFWRI
BLM	Bureau of Land Management
NMFWRI	New Mexico Forest and Watershed Restoration Institute
FFI	FEAT/ FIREMON Integrated
FEAT	Fire Ecology Assessment Tool
FHTET NIDRM	Forest Health Technology Enterprise Team National Insect and Disease Risk Maps (part of USDA – Forest Service's Forest Health Program)
FIREMON	Fire Effects Monitoring and Inventory System
LANDFIRE EVT	Landscape Fire and Resource Management Planning Tools Project (national mapping program) Existing Vegetation Type
NOAA NWS COOP	National Oceanic and Atmospheric Administration's National Weather Service Cooperative Observer Program
PLANTS symbol	Abbreviation of scientific name used in Plant List of Accepted Nomenclature, Taxonomy & Symbols (USDA database)
WUI	Wildland-Urban Interface
AVE and AVG	Average
BA/AC	Basal area per acre
DBH	Diameter at breast height (4.5 feet)
DIA	Diameter
DRC	Diameter at root collar (used for woodland and multi-stemmed species e.g. *Juniperus*)
DWD	Down woody debris
HD	Herbaceous dead (dead non-woody species)
HL	Herbaceous live (live non-woody species; herbs)
HT	Height
HUC	Hydrologic Unit Code
LiCrBHt	Live Crown Base Height, distance from ground to start of live crown
PJ	Piñon-Juniper
QMD	Quadratic mean diameter, always equal to or greater than mean DBH
SD	Standing dead (dead woody species)
SL	Standing live (live woody species)
TPA	Trees per acre (Trees/acre)
Chain	66 feet
Sapling	Height is over 4.5 feet but DBH is under 1"
Seedling	Height is under 4.5 feet
"Tree"	Height is over 4.5 feet, with DBH over 1"; includes "live" and "sick" individuals

USDA PLANTS symbols

USDA PLANTS Symbol	Common & scientific names
GUSA2	Broom snakeweed, *Gutierrezia sarothrae*
JUMO	Oneseed juniper, *Juniperus monosperma*
JUSC2	Rocky Mountain juniper, *Juniperus scopulorum*
OPUNT	Pricklypear cactus, *Opuntia* Mill.
PIED	Two-needle piñon, *Pinus edulis*
PIEN	Engelmann spruce, *Picea engelmannii*
PIPO	Ponderosa pine, *Pinus ponderosa*
POTR5	Quaking aspen, *Populus tremuloides*
PSME	Douglas-fir, *Pseudotsuga menziesii*
QUGA	Gambel oak, *Quercus gambelii*
RIIN2	Gooseberry, *Ribes inerme*
SYRO	Roundleaf snowberry, *Symphoricarpos rotundifolius*
YUCCA	Yucca, *Yucca L.*

Project Setting

In August 2016, the New Mexico Forest and Watershed Restoration Institute (NMFWRI) inventory and monitoring crew sampled 29 plots across approximately 364 acres on the south side of Cerro de la Olla. Cerro de la Olla, also known by its English name Pot Mountain, is a Pliocene andesitic shield volcanic in the Taos Plateau Volcanic Field[1] with a peak at 9, 475 feet and a basal diameter of 5 to 6 miles. Three small craters are present on the summit, including one which serves as an intermittent lake; scoria is abundant.[2] Cerro de la Olla is located just across the Rio Grande Gorge from the communities of Cerro and Questa, in Taos County, New Mexico.

Land ownership on the mountain includes Bureau of Land Management (BLM) and State Lands. The mountain is located in the North Unit/Pot Mountain Forest Management Unit (FMU) of the 29, 000-acre Cerro Montoso Vegetation Treatment Project within the 83, 000-acre San Antonio Special Management Area, in the 783, 000-acre San Antonio/Pot Mountain Wildlife Habitat Management Area, which is managed by the Bureau of Land Management of the Farmington District, Taos Field Office.[3] The 29,000-acre Cerro Montoso Vegetation Treatment Project is trying to address an increase in piñon-juniper and big sagebrush stand density which has decreased graminoid and forb production, and decreased habitat and structural diversity.[4] Specific goals are to improve herbaceous understory growth and recovery and increase edge habitat and structural diversity, thereby improving winter range forage for livestock and wildlife species including pronghorn, elk, and mule deer[5]; to improve visual qualities of the landscape; to improve and enhance scenic qualities, and to remove trees as needed for hazardous fuel reduction and other goals, including contributing to overall watershed restoration.[6]

The 364-acre portion of Cerro de la Olla where monitoring was conducted in 2016 is planned for treatment under the BLM's Cerro Montoso Collaborative Forest Restoration Program (CFRP) grant. The monitoring area is in a predominantly piñon/juniper stand with secondary ponderosa and Douglas-fir components at around 8600 feet. The 2016 monitoring effort complements 2014 monitoring on the same mountain (report provided to BLM in 2014).

Maps of the overall restoration area, NMFWRI's study plots, and land ownership in the area follow.

Work on the thinning portion of the project is scheduled to begin at some point after monitoring data is provided, in 2017. (See Figure 3 for plot distributions).

---

[1] (New Mexico Bureau of Geology & Mineral Resources, 2014)
[2] (Lambert, 1966)
[3] (United States Department of the Interior, BLM, 2008) p 27-28
[4] (United States Department of the Interior, BLM, 2008), p 4
[5] (United States Department of the Interior, BLM, 2008), p 7
[6] (United States Department of the Interior, BLM, 2008), p 8

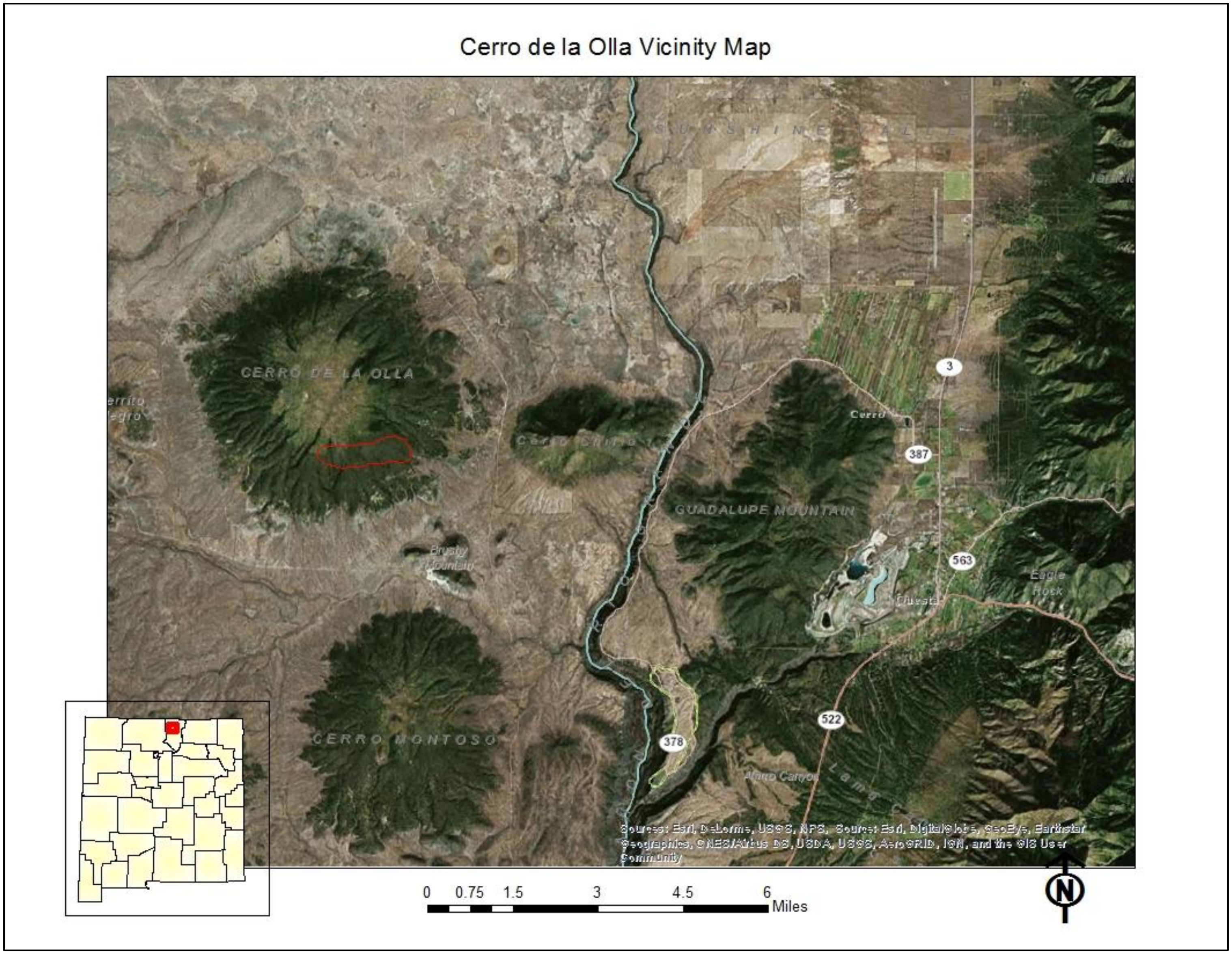


Figure 1. Cerro de la Olla Vicinity Map

Landscape Context

The 364 acres surveyed by NMFWRI are located in within the Cerrito Negrito watershed (HUC: 130201010405), which is a total of 61.1 square miles.[7] This watershed is part of the Upper Rio Grande watershed, the Rio Grande Region,[8] and the Southern Rocky Mountain Ecoregion. See Figure 4.

According to the New Mexico Department of Game and Fish, the Southern Rocky Mountain Ecoregion extends from the Colorado border to Santa Fe and includes the San Juan, Sangre de Cristo and Jemez Mountains. Rivers contained include the Rio Grande, San Juan, Vermejo, and Rio Chama, and is "one of the few areas that remains relatively intact and provides broad scale conservation opportunities."[9]

[7] (USDA NRCS Geospatial Data Gateway)
[8] (USDA NRCS Geospatial Data Gateway)
[9] (New Mexico Game and Fish), p 174

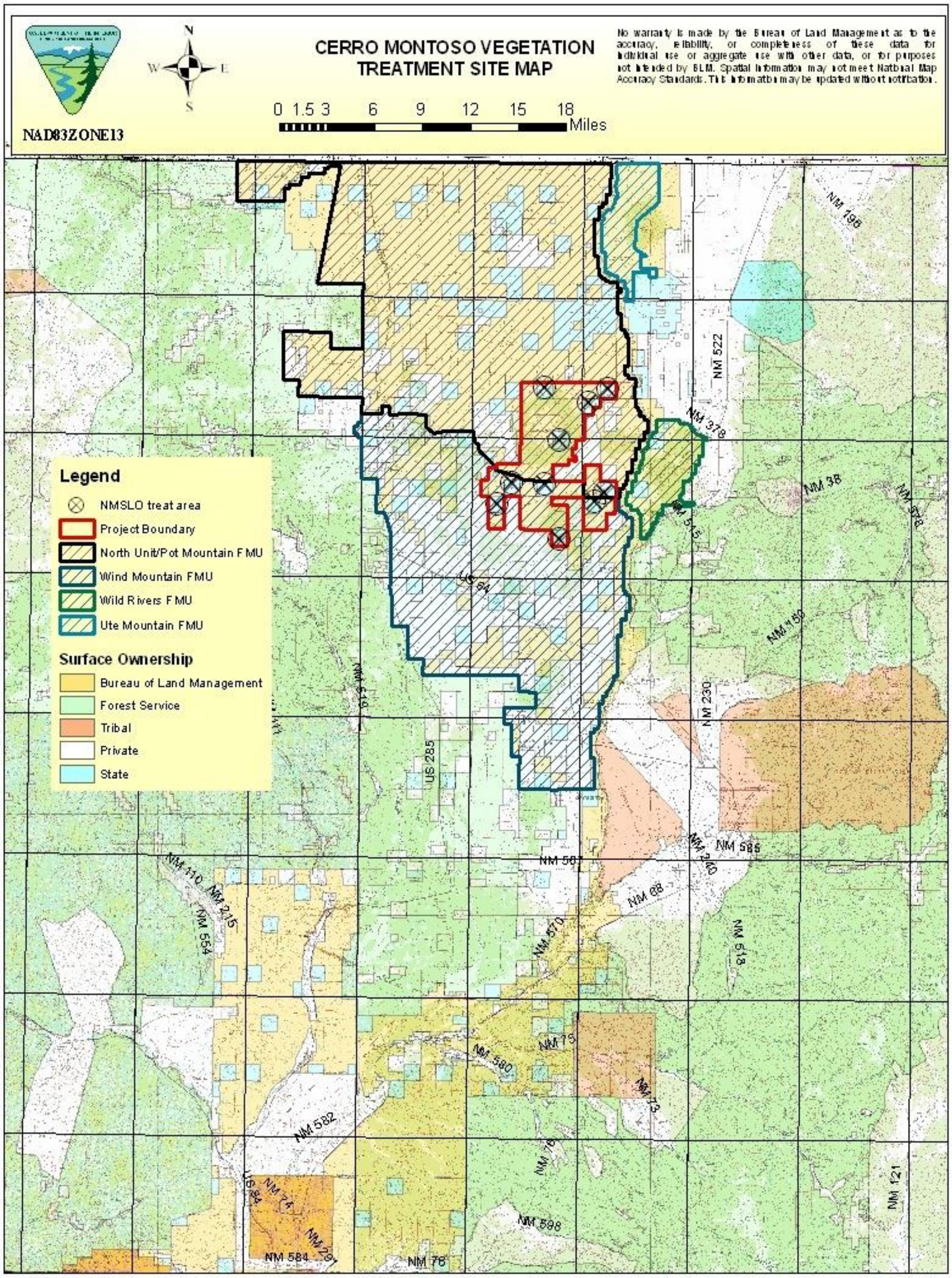


Figure 2. Cerro Montoso Vegetation Treatment Site Map (courtesy of BLM).

The red polygon indicates the location of the Cerro Monotoso Vegetation Treatment Project Area within and relative to other management units. Taken from the Cerro Monotoso EA, p 37

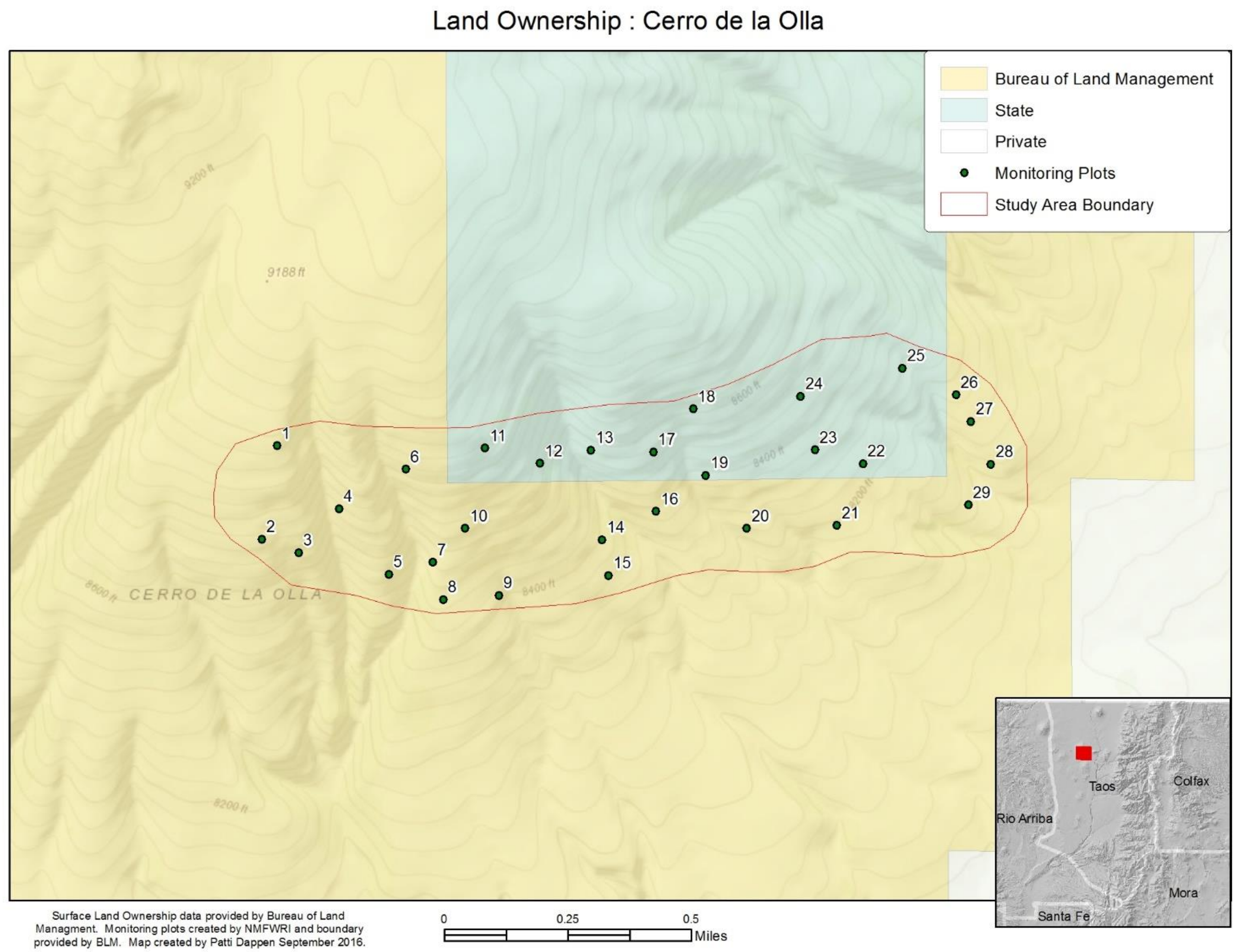


Figure 3. Land Ownership of 2016 Cerro de la Olla Monitoring Area.

Polygons were provided by the BLM, and NMFWRI distributed monitoring plots therein.

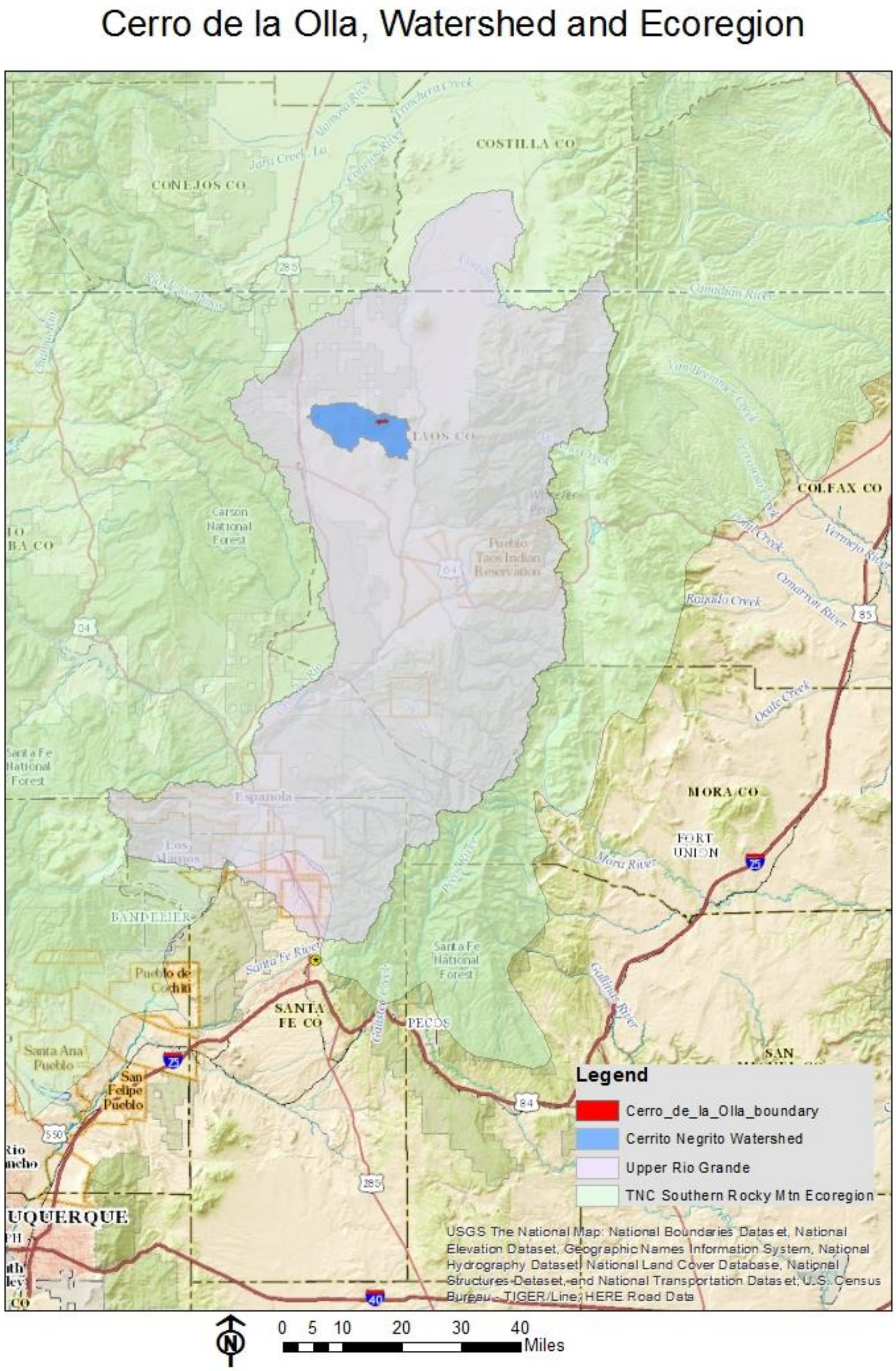


Figure 4. Cerro de la Olla Study Area in context of its watershed and ecoregion.

Climate

According to the Western Regional Climate Center, using an NOAA NWS COOP station in Cerro and monthly climate summaries collected from 1932 to 2005, the average summer high for the area is 77.4 degrees Fahrenheit; the average winter low is 12.2 degrees Fahrenheit. The average total precipitation is 12.68 inches/year, and the average total snowfall is 58.7 inches/year. Of this, the average precipitation January to May is 4.02 inches (primarily snow) and average precipitation during June and July is 2.68 inches (monsoon rains).[10] The community of Cerro is located immediately adjacent to the Guadalupe Mountains, approximately 9 miles away from Cerro de la Olla. Cerro is located at 7461 feet and the area surveyed by NMFWRI ranged in elevation from 8040 feet to 8960 feet.

According to US Climate Data, between January and May of 2015, Cerro received 6.16 inches of precipitation (56.48 inches of snow); during June and July the area received another 0.78 inches of precipitation.[11] Though we do not know exactly what effect this precipitation had on the data, it should be noted that both 2015[12] and 2016 levels are above the historical average.

Soils

Figure 5, below, shows the presence of various soil associations within the project unit. Table 1 quantifies the soil associations by percent occurrence within the polygon boundaries where NMFWRI plots were located. Soil series descriptions follow.

Table 1. Information for soil units in Cerro de la Olla study area. [13]

Map Unit Legend

Taos County and Parts of Rio Arriba and Mora Counties, New Mexico (NM670)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
RBE	Raton-Stunner association, moderately steep	40.8	10.6%
RRE	Rock outcrop-Raton complex, moderately steep	343.0	89.4%
Totals for Area of Interest		**383.8**	**100.0%**

[10] (Western Regional Climate Center, 2005)
[11] (US Climate Data, 2016)
[12] (US Climate Data, 2015)
[13] (NRCS: Web Soil Survey, 2015)

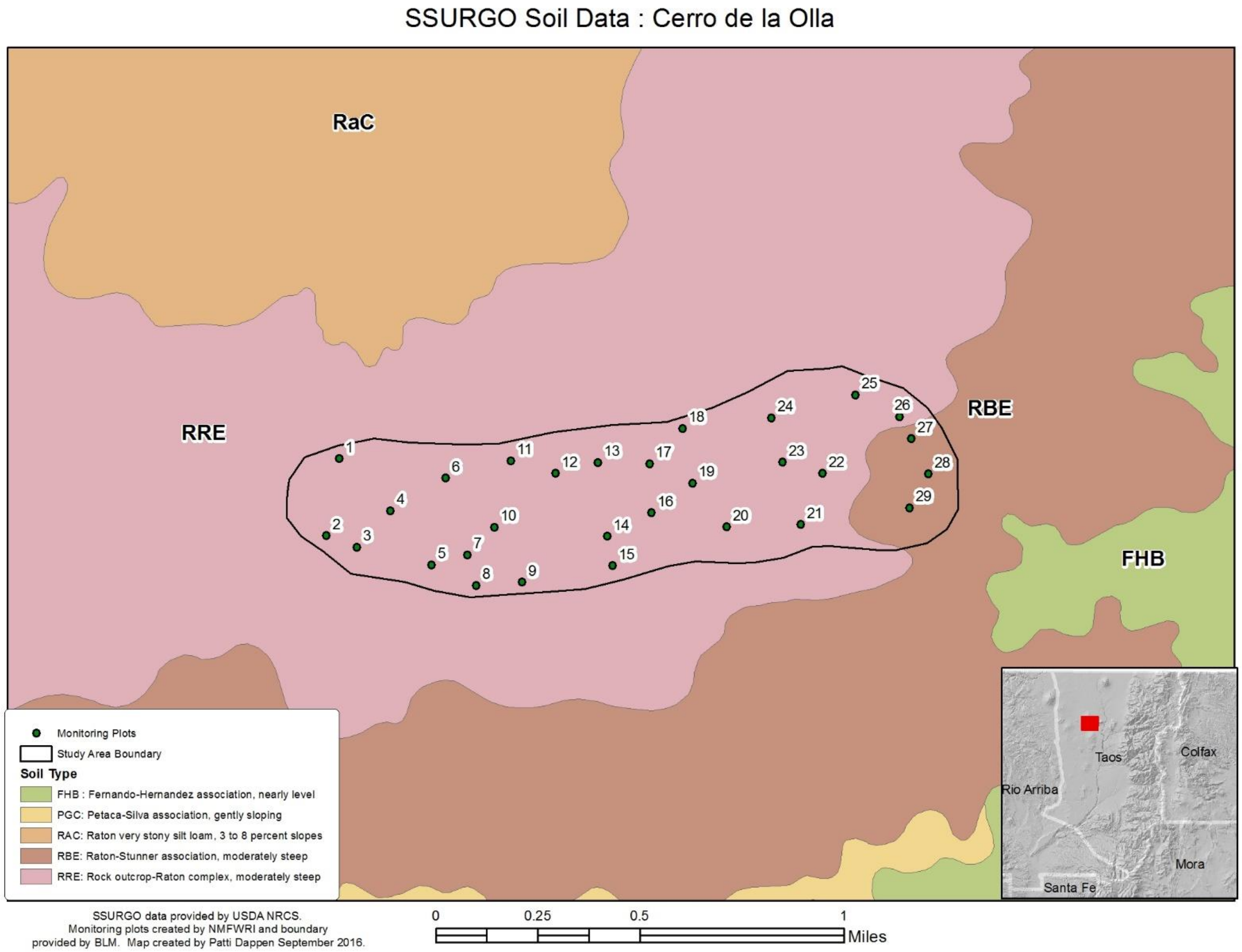


Figure 5. Soils map for surveyed area of Cerro de la Olla in 2016.

The majority of the plots are located in soil unit RRE, Rock Outcrop-Raton, which is a shallow, basalt-based, rocky soil unit. Raton soils are shallow to very shallow soils found on plateaus and basalt-capped mesas, ridges, and hills. They formed from colluvium (material accumulating at the base of slopes) and residuum of weathered basalt as well as other volcanic components such as ash and cinders. Slopes are commonly 1 to 60 percent, though higher slopes were recorded by the NMFWRI field crew, such as on Plot numbers 4 and 13. These soils are well-drained and support blue grama, Arizona fescue, western wheatgrass, big bluestem, little bluestem, mountain muhly, Gambel oak, ponderosa pine, Rocky Mountain juniper and piñon.[14] Raton soils are found within the Rock-outcrop-Raton complex (RRE) and the Raton-Stunner association (RBE), which together comprise the entire survey area (383.8 acres).

Stunner soils are very deep soils found on fans (alluvial, terrace or outwash), plateaus, and valley-filling sideslopes. They formed from alluvium (material left by flowing streams) and outwash (material carried from a glacier by meltwater) of granite, gneiss, and mica schist. Slopes are typically between 1 and 20%. They are well-drained and support blue grama, ring muhly, winterfat and snakeweed as well as pasture and irrigated crop uses. Stunner soils are found within the Raton-Stunner association (RBE), and make up approximately 40.8 acres of the surveyed area, or 10.6%.[15]

Rock outcrop does not have an official description, but was observed by field crews to be primarily basalt, with steep slopes. This component was present on approximately 343 acres of the surveyed area, or 89.4%.

[14] (National Cooperative Soil Survey, 2007)
[15] (National Cooperative Soil Survey, 2009)

Vegetation

According to the USDA Web Soil Survey, overall characteristic understory vegetation for the above soil units include Western wheatgrass, big sagebrush, galleta, blue grama, New Mexico feathergrass, sideoats grama, winterfat, needleandthread, fourwing saltbush, Indian ricegrass, Arizona fescue, mountain brome, and mountain muhly as well as ponderosa pine, Rocky Mountain juniper and piñon.

The Cerro Montoso EA states that "forest stands in the project area now have a high density of pinyon-juniper woodland species, with little grass and forb production, low regeneration of ponderosa pine, and continuous distribution of ladder fuels which could lead to a stand-replacing burn in the event of wildfire."[16] The NMFWRI field crew agreed that the density of piñon-juniper species was high, and adds that herbaceous vegetation seemed significantly limited by rock outcroppings. According to the EA, post-treatment vegetation increases may be expected "in approximately 10% of the area where woodland cover is greater than 5%."[17] Several of the native grasses identified by the USDA, small forbs, and cacti were observed.

Piñon-Juniper in New Mexico

A general overview of piñon-juniper woodland communities and conditions relevant to the study area is drawn from *New Mexico Vegetation: Past, Present, and Future* by William Dick-Peddie (1993). This overview is general by necessity: In New Mexico, piñon-juniper (PJ) woodlands are widespread (see Figure 6, below) and have a variety of soil types and plant community associations. In addition, they have received less study attention than other vegetation types such as coniferous forests and grasslands because they have less timber and grazing value.[18] As such, there is not presently an authoritative source for reference conditions. There are a number of piñon-juniper identification systems and keys, including those proposed by Moir and Carleton (1987), Dick-Peddie (1993) (which we mention here primarily for their succinct summary of the state), the NRCS (1997), Romme et al (2007), Jacobs et al (2008), the New Mexico Forest Restoration Principles Working Group (2007) and the New Mexico State Forestry Working Group (2007) (see Appendix II), and many others. NMFWRI has been involved with the latter two groups and can provide information on their proposed keys and frameworks upon request.

[16] (United States Department of the Interior, BLM, 2008), p 6
[17] (United States Department of the Interior, BLM, 2008), p 17
[18] (Dick-Peddie, 1993) p 86

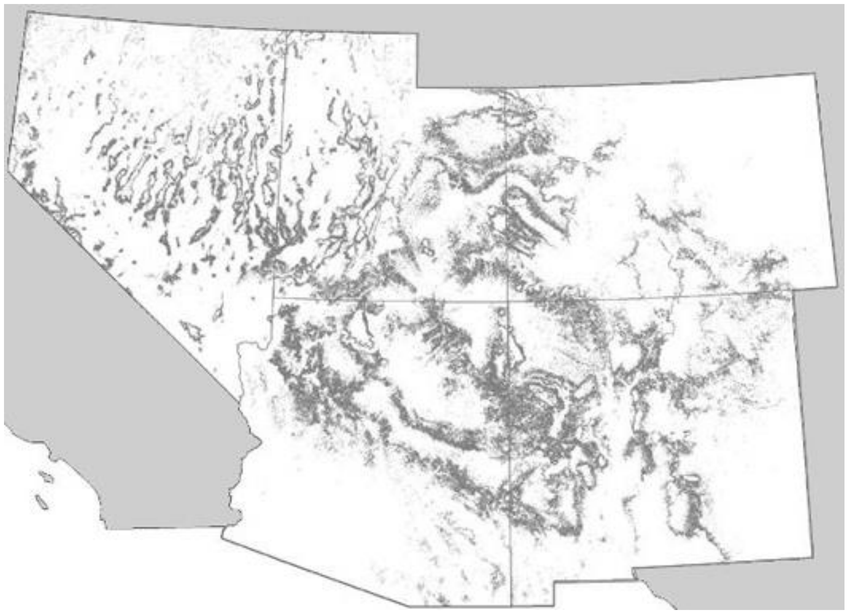


Figure 6. Piñon-Juniper distribution in NV, UT, CO, AZ and NM.[19]

According to Dick-Peddie (1993), "Moir and Carleton (1987) propose the following three elevational subzones for the woodland life zone of Region 3 (Arizona and New Mexico).

1. The aridic (warm, dry) juniper savannas
    a. Tree cover: 5-30%
    b. Height of tallest trees: <5m
2. Typical or model open woodland
    a. Tree cover: 30-50%
    b. Height of tallest trees: 4-8m
3. Mesic (cool, wet) closed woodlands
    a. Tree cover: 50-80%
    b. Height of tallest trees: 7-13m"[20]

One community noted by Dick-Peddie (1993) is scarp piñon-juniper. According to his text, this "is common along breaks associated with the rivers of northeastern and east-central New Mexico,"[21] which seems relevant for our study area given the proximity to the Rio Grande. In addition, Cerro

[19] (National Park Service, 2015)
[20] (Dick-Peddie, 1993), p 88
[21] (Dick-Peddie, 1993), p 88

Montoso EA makes note of the decreasing presence of piñon-juniper savanna within the project area,[22] which Dick-Peddie (1993) defines as fewer than 130 trees/acre.[23]

As for common vegetation components, "Colorado Pinyon (*Pinus edulis*) is by far the most common pinyon of the Pinyon-Juniper woodland vegetation of New Mexico…One-seed Juniper (*Juniperus monosperma)* is the most widespread juniper in New Mexico. It may share dominance with Rocky Mountain Juniper in the northern third of the state."[24]

An example of the variation in forest structure within PJ woodlands may be illustrated by this example: "Kennedy (1983) found an average tree density of 170/ac in the *Pinus edulis – Juniperus monosperma/S* [sparse shrub layer]*/Stipa Columbiana* communities of the Jicarilla and Sacramento mountains in south-central New Mexico. The Forest Service in New Mexico indicates that in closed *Pinus edulis – Juniperus/Artemisia tridentata/*MG-F [mixed grass and forb species] communities of north-central and northwestern New Mexico, tree densities may be 690 plus or minus 120 individuals per hectare (279 trees/ac plus or minus 49)."[25] The latter community also has potential presence on Cerro de la Olla based on field crew observations. Another potential classification for the area is as persistent woodland based on the dominance of rock outcropping in the area. (See Appendix II: New Mexico State Forestry Working Group PJ Key for more information.)

Dick-Peddie (1993) asserts that "it is not uncommon to find seral Pinyon – Juniper Woodland vegetation as a result of past disturbance of coniferous forest. In New Mexico, the disturbed forest has usually been ponderosa pine forest. The presence of young ponderosa pines in pinyon-juniper woodland could signify the successional nature of the stand….Young ponderosa […] could indicate ecotonal vegetation between coniferous woodland and montane coniferous forest or, more likely, imply a woodland sere on disturbed ponderosa pine sites."[26] In addition, he notes that many lower elevation PJ Woodlands were formerly Ponderosa Pine/Blue Grama habitats, which suggests that under warming climates, PJ may be the present/future vegetation potential for other ponderosa pine forests.[27] Additionally, Dick-Peddie (1993) notes that much discussion of PJ involves encroachment or expansion onto grassland (including in the Cerro Montoso EA[28]) but Sallach (1986) suggests that "much of the recent increase of pinyon-juniper woodland on grassland in the mountains of New Mexico is actually a

[22] (United States Department of the Interior, BLM, 2008), p 6
[23] (Dick-Peddie, 1993), p 87
[24] (Dick-Peddie, 1993), p 89
[25] (Dick-Peddie, 1993), p 87
[26] (Dick-Peddie, 1993), p 87
[27] (Dick-Peddie, 1993) p 68
[28] (United States Department of the Interior, BLM, 2008), p 10

return of woodland to sites that had previously been woodland."[29] NMFWRI takes the position that the PJ woodland expansion into grassland of the past 80 years is due to a combination of grazing practices and fire exclusion.

The respective contributions of climate change and management in shifting species composition is relevant because the Cerro Montoso EA (2008) states that the purpose of the treatments is to "augment understory and native grasses to benefit/improve existing habitat for wildlife and livestock whose habitats are being encroached by big sagebrush, pinyon pine, and juniper."[30] The implications of Dick-Peddie's observations are that over time, particularly with the impacts of climate change, the site may not maintain a desirable species balance through natural processes. The references in the Cerro Montoso EA to managing with wildfire are encouraging.

GIS Land Cover Classifications for the Study Area

Our GIS specialist used LANDFIRE to create an existing vegetation type map for the study area. LANDFIRE classified the area as predominantly Colorado Plateau Pinyon-Juniper Woodland with some Southern Rocky Mountain Ponderosa Pine Woodland, and minor components of the following: Rocky Mountain Montane Riparian Forest and Woodland, Introduced Upland Vegetation – Annual Grassland, Rocky Mountain Aspen Forest and Woodland, Rocky Mountain Lodgepole Pine Forest, Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland, Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland. See Figure 7, below.

[29] (Dick-Peddie, 1993), p 92
[30] (United States Department of the Interior, BLM, 2008), p 5

Table 2. Plots in various vegetation types.

LANDFIRE Vegetation Type	2016 monitoring plot numbers centered in this vegetation type
Colorado Plateau Pinyon-Juniper Woodland	1, 4-12, 14-24, 26-29
Southern Rocky Mountain Ponderosa Pine Woodland	2, 3, 13, 25
Rocky Mountain Montane Riparian Forest and Woodland	none
Introduced Upland Vegetation – Annual Grassland	none
Rocky Mountain Aspen Forest and Woodland	none
Rocky Mountain Lodgepole Pine Forest	none
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	none
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	none

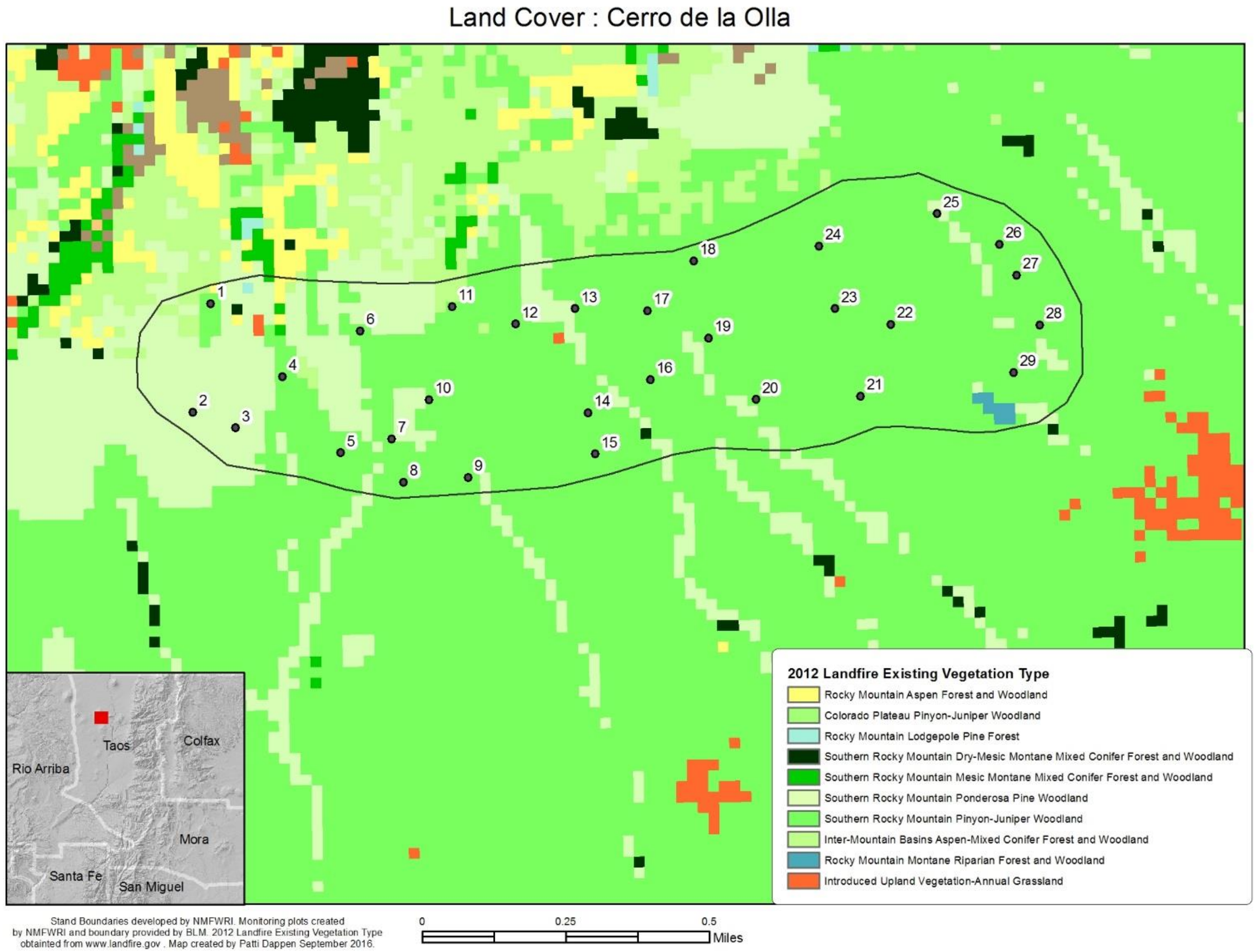


Figure 7. Land Cover Classifications.

Rare plants

According to the New Mexico Rare Plant Technical Council, rare plants existing in Taos County include Cyanic milkvetch (*Astragalus cyaneus)*, Taos milkvetch (*Astragalus puniceous var Gertrudis)*, Ripley's milkvetch (*Astragalus ripleyi)*, Taos springparsley (*Cymopterus spellenbergii),* Alpine larkspur (*Delphinium alpestre)*, Robust larkspar (*Delphinium robustum)*, Smith's whitlowgrass (*Draba smithii)*, Pecos fleabane (*Erigeron subglaber)*, Clipped wild buckwheat (*Eriogonum lachnogynum var colobum),* New Mexico stickseed (*Hackelia hirsuta)*, Small-headed goldenweed (*Lorandersonia microcephala)*, Vermejo phlox (*Phlox vermejoensis)*, and Arizona willow (*Salix arizonica).* [31]

The NMFWRI crew cannot comment on the presence of these plants in the study area as they were not trained in rare plant identification.

Insects and Diseases

According to National Insect and Disease Risk Map, Cerro de la Olla is projected to lose 1-35+% of its basal area to diseases, pests and other stressors between 2013 and 2027 (see Figure 8, below). In addition, Cerro de la Olla is in a watershed with 25% or greater of its treed area at risk from a variety of insects and diseases, including the Douglas-fir beetle, the Fir Engraver, the Western Spruce budworm, and unspecified root diseases. [32] In addition, as we will discuss later, the study area appears to have been impacted by the Piñon Ips following the drought of the early 2000s.

[31] (New Mexico Rare Plant Technical Council, 2005)
[32] (USDA Forest Service, n.d.)

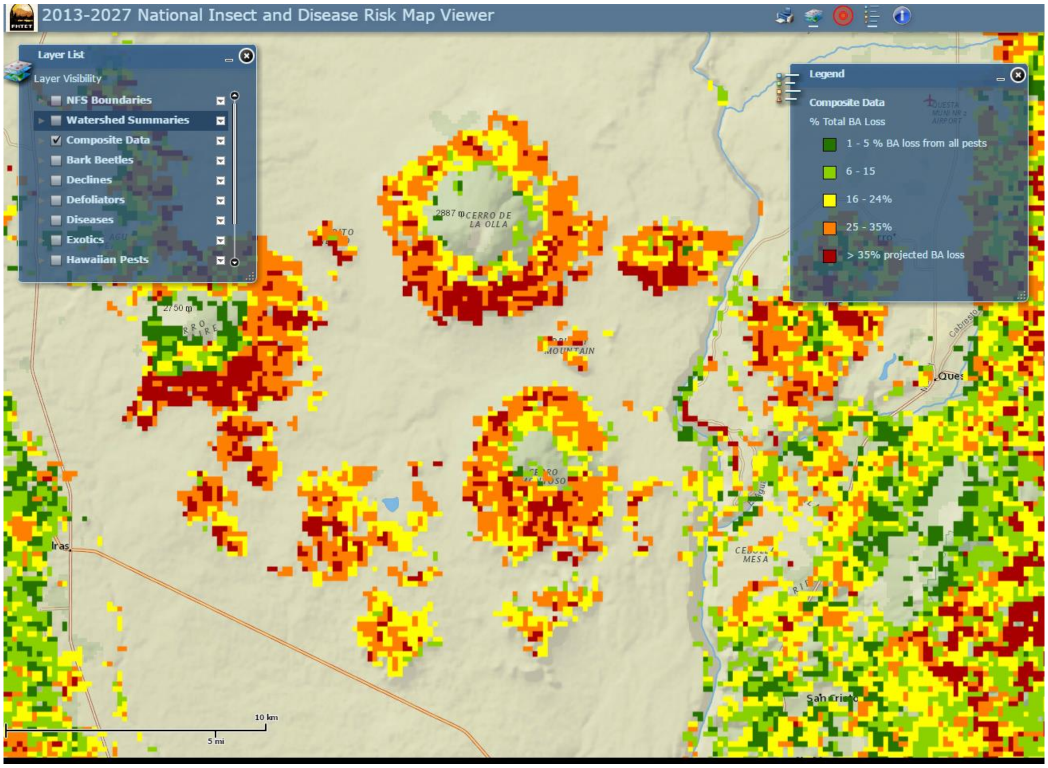


Figure 8. Composite disease and pest risks to treed area of the watershed surrounding Cerro de la Olla.

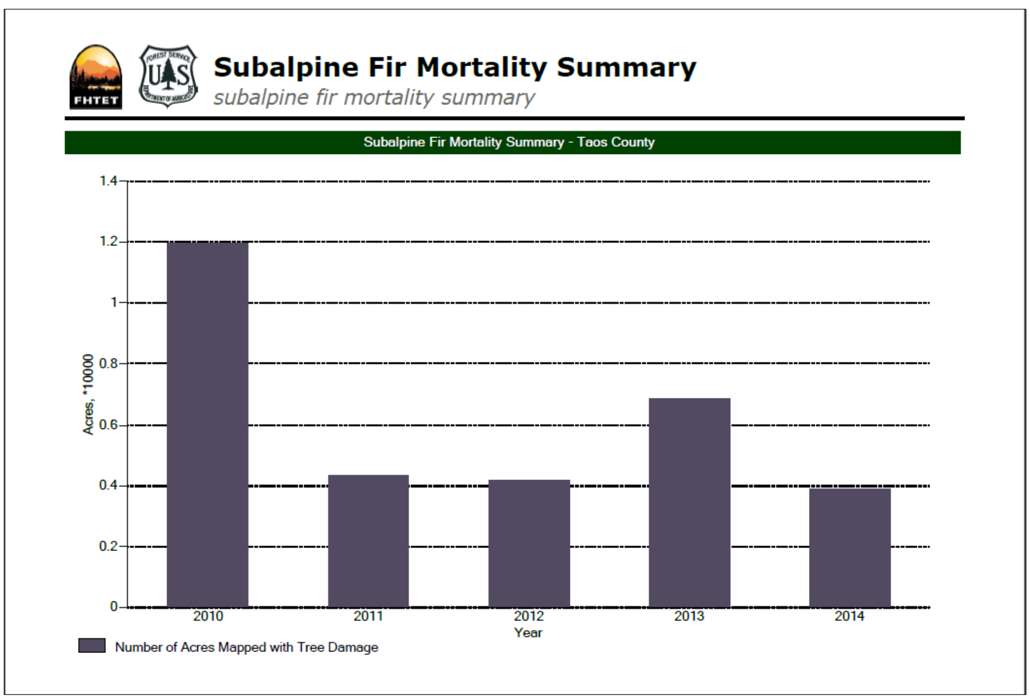


Figure 9. Subalpine Fir mortality from regional pests.[33]

[33] (USDA Forest Service, Forest Health Protection and its partners, 2014)

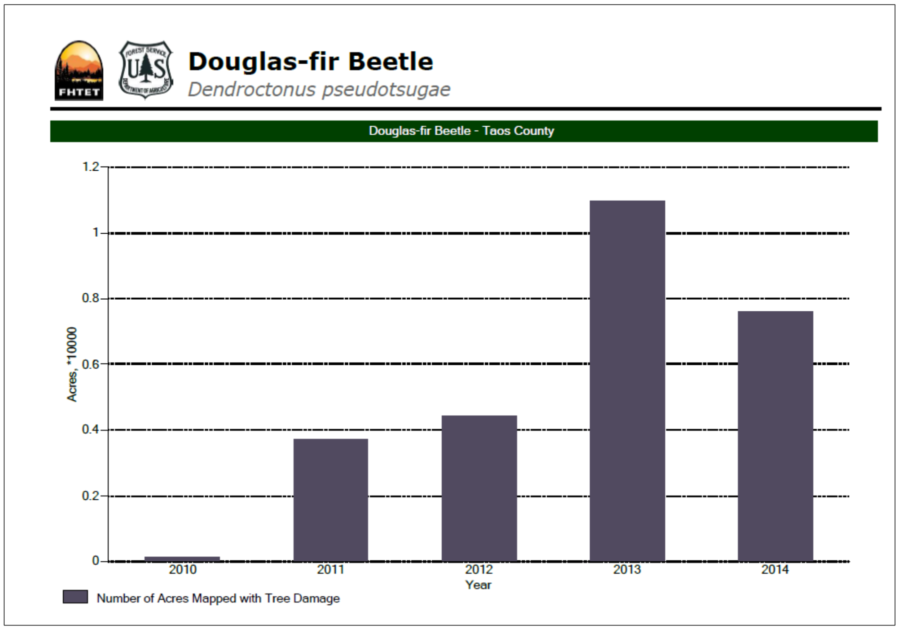


Figure 10. Acres of trees damaged in Taos County from Douglas-fir Beetle 2010-2014.[34]

Wildlife

NMFWRI did not perform wildlife surveys as part of the assessment, but the Cerro Montoso EA states that “management goals and objectives for wildlife in this area…include improving browse vigor and availability; increasing density and composition of cool season herbaceous species for deer, elk and antelope; and improving habitat for small mammals and big game by improving structural diversity and increasing edge and cover.”[35]

The Cerro Montoso EA reports the presence of Rocky Mountain elk, mule deer, antelope, Rocky Mountain bighorn sheep, black bear, and mountain lion; various bats, skunk, badger, fox, coyote, bobcat, squirrels, chipmunks, pocket gophers, Gunnison’s prairie dogs, various mice and rat species, porcupine, cottontail, jackrabbit; turkey vulture, Swainson’s hawk, band-tailed pigeon, black-chinned hummingbird, broad-tailed hummingbird, vesper sparrow, Bullock’s oriole, as well as various reptiles, amphibians, and insects.[36]

[34] (USDA Forest Service, Forest Health Protection and its partners, 2014)
[35] (United States Department of the Interior, BLM, 2008), p 21
[36] (United States Department of the Interior, BLM, 2008), p20-21

Threatened, Endangered, and Sensitive Wildlife Species

While there is no designated critical habitat within the project area according to USFWS maps,[37] the project is near the Central Flyway, a migratory bird path stretching from Mexico to Canada and crossing Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming, South Dakota, Montana, North Dakota, Saskatchewan, Alberta and the Northwest Territories.[38] According to BLM documents, there are threatened, endangered, candidate or otherwise sensitive species which may occur within the project area. These include several bat species, as well as a variety of migratory birds including the golden eagle, peregrine falcon, ferruginous hawk, prairie falcon, Western burrowing owl, black-throated gray warbler, juniper titmouse, mountain bluebird, olive-sided flycatcher, mountain plover, loggerhead shrike, mourning dove, piñon jay, Brewer's sparrow, and sage sparrow.[39]

Monitoring Methods

Methods

Stand Boundary Generation

NMFWRI generated stand boundaries for Guadalupe Mountain prior to field monitoring. The goal of generating stand boundaries for the Guadalupe Mountain study area was to aid in project planning and to help determine the location and placement of the field monitoring locations. Identifying these stands helped to ensure that NMFWRI's monitoring points were well distributed across the study area while capturing the variety found across the landscape.

Historically, stands formed the first level of organization in forest management and inventory. The Society of American Foresters defines a stand as "a contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit."[40] In the past, stands were manually interpreted using hard-copy stereo pairs, aerial photography and mylar overlays.

With the advent of Geographic Information Systems, stands could be digitized onscreen using digital imagery. While an improvement, digitizing is very time consuming and costly when working in large areas. Currently with enhanced computer technology, software and digital imagery, stands can be

[37] (USFWS, Esri, et al., 2016)
[38] (US Fish and Wildlife Service in collaboration with flyway and state waterfowl managers, n.d.)
[39] (United States Department of the Interior, BLM, 2008), p 22
[40] (The Society of American Foresters, 1998)

delineated using an automated process. This automated process utilizes image segmentation, an image processing technique available from Trimble eCognition Developer Software, known as eCognition.

To generate these stand boundaries we used two main base layers, a 10meter Digital Elevation Model (DEM) and 2014 NAIP ortho-imagery. The 10 meter DEM was downloaded from the NRCS geospatial gateway (https://gdg.sc.egov.usda.gov/), and was used to develop a 360 degree hillshade model. Using ERDAS Imagine software we created three hillshade images and then combined them into one layer. The three hillshades were generated at different solar azimuths, 120, 240 and 360 degrees. These were combined and the resulting image provided a topographic representation of the landscape without shadows.

The 2014 NAIP imagery was downloaded from RGIS (http://rgis.unm.edu/), as four band GeoTIff files. The four bands included Red, Green, Blue and Near Infrared. Because the 2014 NAIP imagery had the near infrared band we were able to calculate the Normalized Difference Vegetation Index (NDVI) to enhance vegetation.

Both the hillshade and the orthoimagery were resampled to 5 meter pixel size for the analysis so that it would be the same cell size. These data layers were loaded into eCognition and an image segmentation was performed. Segmentation is a process of partitioning a digital image into multiple segments, or groups of pixels. One result of this process is to simplify the image into something that is more meaningful or is easier to analyze.

eCognition offers many types of segmentation, but for this project a multiresolution segmentation was employed. The input data layers were set with appropriate weights, so that those layers with more influence were given a higher weight. In this case, the Bands Red and Near Infrared were given the highest weight since they provided the best indicator of healthy vegetation. In the multiresolution segmentation process, the user can define some aspects of the generated segments. Changing the scale parameter determines the average size of the resulting image objects or segments. (See Figure 11.) The smaller the scale parameter value, the smaller the resulting segments will become. For this study a scale parameter of 20 was used.

After the multiresolution segmentation was completed, a filter was applied to the image objects to remove some of the rough, pixel-shaped edges. The files were then exported as ESRI shapefiles and then further smoothing was performed to remove the pixilated polygon borders.

More information about our methodology can be found at the following website: http://nmfwri.org/resources/projects/project-resources-1/Automated_Stand_Delineation_for_FORVIS_NMFWRI_web.pdf

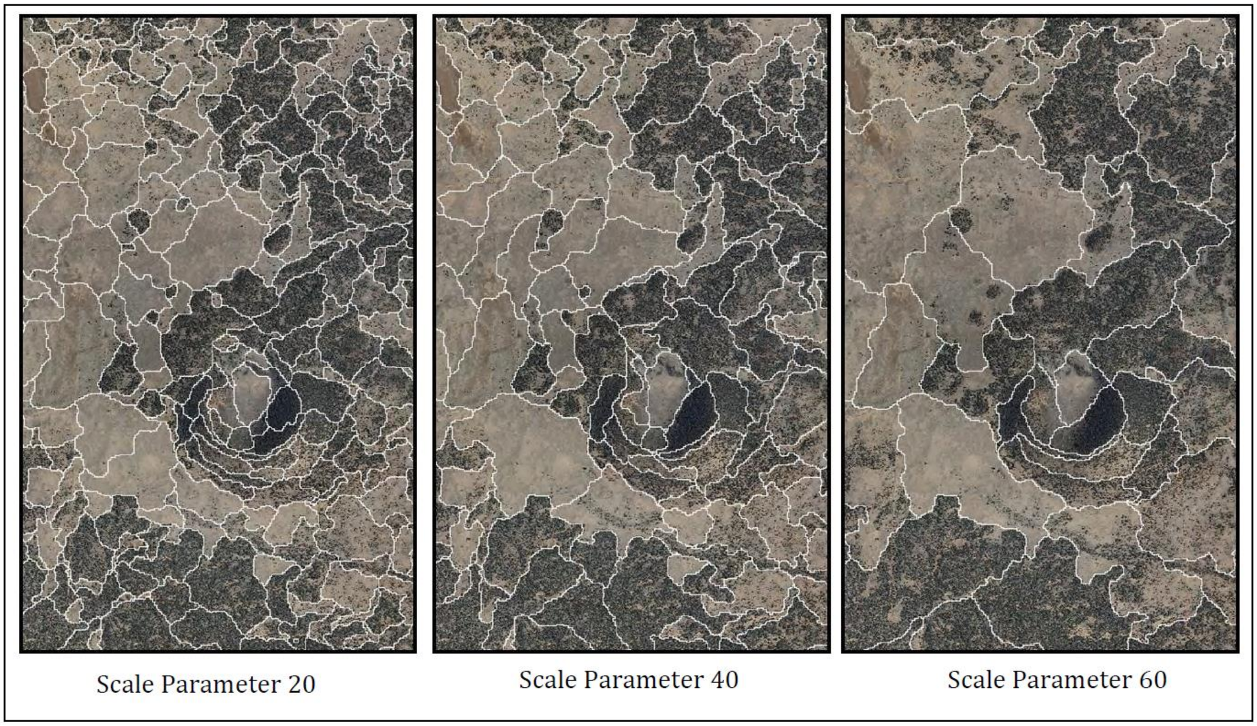
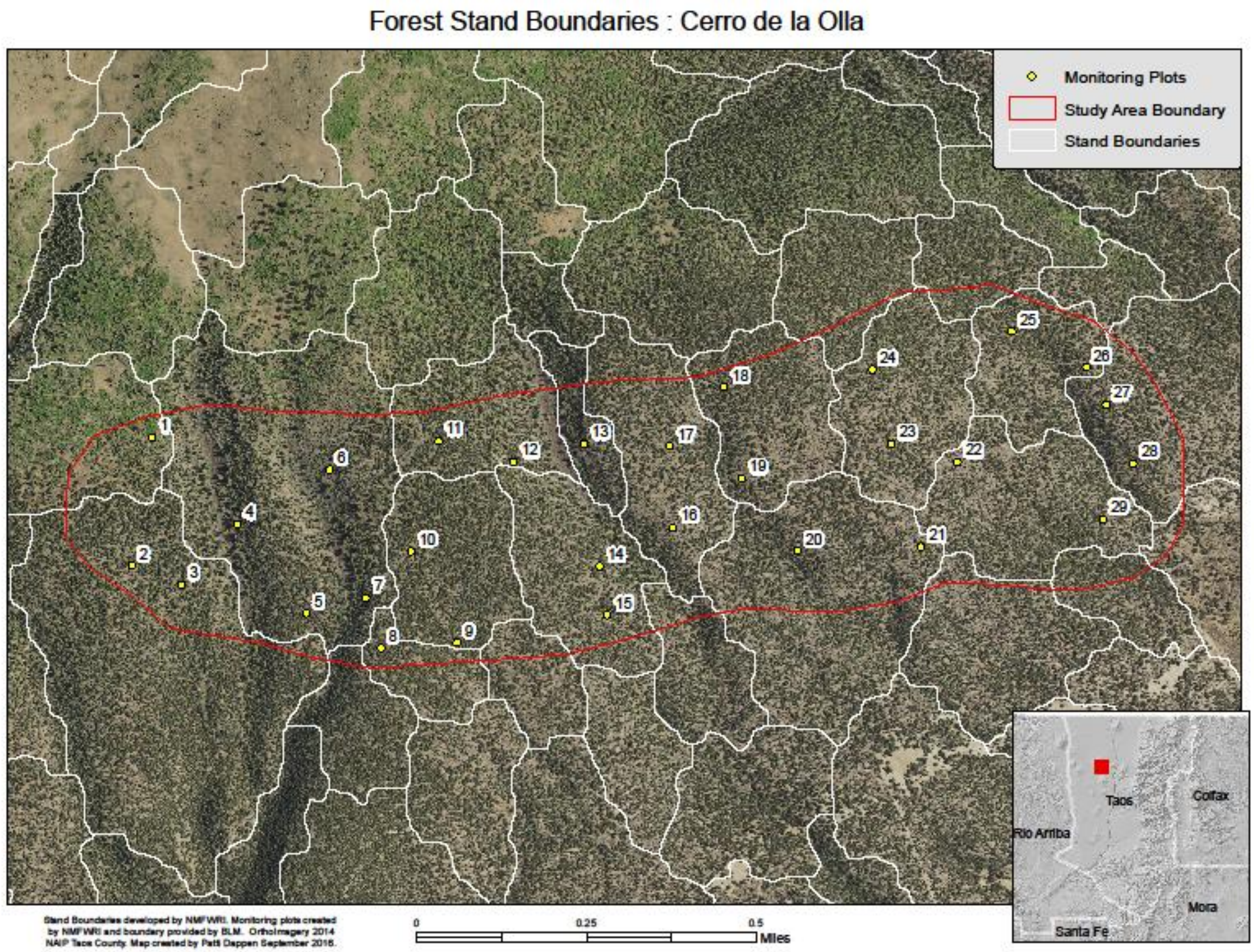


Figure 11. Examples of different scale parameter results within eCognition

The results of the stand delineation for Cerro de la Olla are presented in Figure 12.



.

Figure 12. Stand Boundaries for Cerro de la Olla.

Plot Distribution

29 plots were located across the study area. Each plot's location was established within the study area polygon provided by BLM. A stratified random sampling design was employed to assign the monitoring plot locations. These plot locations were stratified in that they needed to fall inside the study area boundary, be a set number of points, and be located no closer than 100 meters (328 feet) apart. Under a traditional forest cruise done to determine volume and value, the number of plots would be sufficient to sample an area not less than 1/10th of the total area. For example, if the study area were 640 acres we would ideally assign 64 1/10th acre plots. Due to time and budget constraints in this case, 29 plots were located across 364 acres, which is a ratio of 1 plot per 12.6 acres.

Within the study area these stratified randomly located plots were generated using GIS software from Spatial Ecology.com called Geospatial Modeling Environment. This specific command is called *Generate Stratified Random Points*; more information about this tool can be found at http://www.spatialecology.com/gme/genstratrandompnts.htm .

Coordinates of sample points are listed in Appendix II.

Field Methods

2016 Field Crew

- Zane Jones, monitoring technician
- Christopher Martinez, monitoring and data technician
- Kathryn Mahan, ecological monitoring specialist

On these 29 plots, the NMFWRI crew followed the Department of Interior's FEAT/FIREMON Integrated (FFI) sampling protocols and used 1/10th acre fixed plots to assess tree size (diameter and height) and density (trees/acre).

Plot layout and setup

Plots are most efficiently accomplished with a 3-person crew but can also be taken with 2 people.

Plots are established using a random point location with project-specific boundaries e.g. stand boundaries, treatment areas, vegetation types, etc. Maps and plot locations are generated with ArcGIS utilities and are loaded onto a Trimble and Garmin GPS units. Upon arrival at the point (navigation is typically accomplished through paper maps and the Garmin GPS units), the Trimble unit is used to accurately determine plot location. A marker (we typically use a 1-foot piece of ½ inch rebar) is hammered into the ground and capped, to serve as plot center. The Trimble unit is used to collect updated plot location coordinates which can later be post-processed for greater location accuracy. Plots must be moved one chain (66 ft) from their original, intended location if they are within 75 feet of a road.

Our plots are set up using 8 pin flags. Crew members walk cardinal azimuths (N, E, S, W) from plot center and place pin flags at 11.78ft (11' 9") and 37.24ft (37' 3") to give visual aids for the two plots (1/10th ac and 1/100th ac) whose purposes are described below.

Photographs & Other Plot data

Seven photographs are taken per plot. Typically, a white board with marker is used to tag each photo. The first photo taken at each plot is of the white board on the ground at plot center ("PC"). This ensures the data technicians are able to read the plot name and number and correctly identify the photos that follow. Additional photos include: "C," taken from 75 feet along the North azimuth looking at a crew member holding the white board at plot center, the Brown's transect photo, "B" taken from the random fuels azimuth looking at a crew member holding the white board at plot center, and "N," "E," "S," and "W" photos taken from plot center facing a crew member holding the white board 37.2' at each of the four cardinal azimuths. Additional photographs may be taken, but we recommend these be taken after the mandatory seven plot photos, and noted on the data sheets, so that there is no confusion for the data technicians.

Slope, aspect, coordinates, elevation, date, and time are recorded for each plot. Comment fields are available on all datasheets and we encourage all observations, including species, land use impacts, fire history, challenges in taking plot, etc to be documented here.

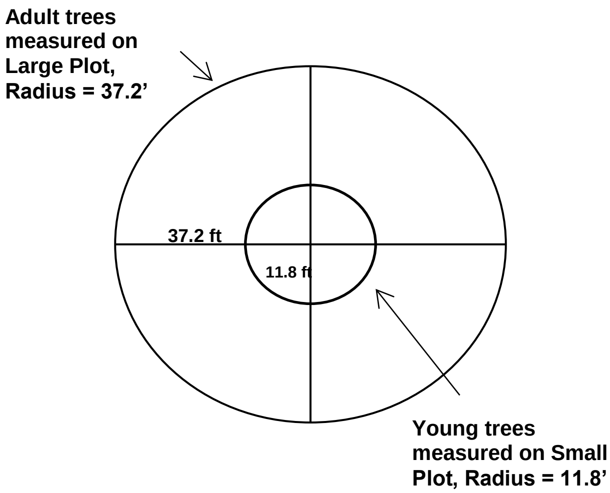
Overstory

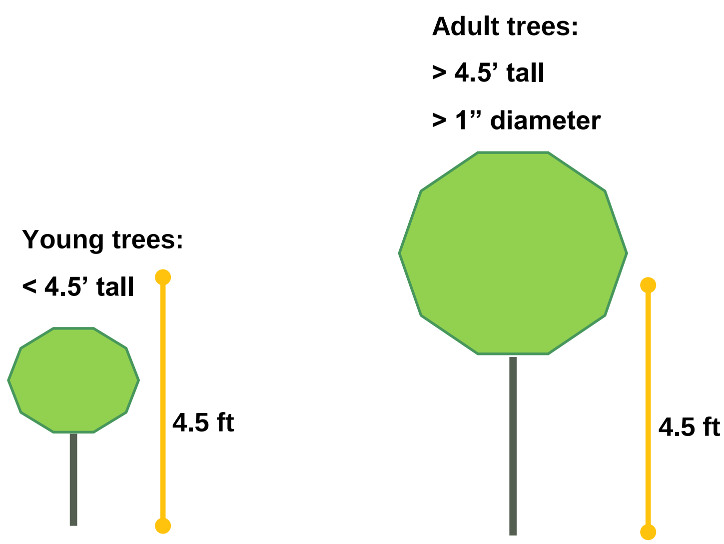
All trees taller than breast height (≥ 4.5 ft. and > 1.0 in dbh or drc, depending on species) are measured within the 1/10th acre plot (37.24 ft. radius) circular, fixed area sampling plot. Species, condition, diameter at breast height (dbh) for single stem species, diameter at root collar (drc) for multi-stem species (i.e. *Quercus* spp., *Juniperus* spp.), total height, and live crown base height are recorded for each tree located within the plot. Trees are recorded starting from the north azimuth line and moving clockwise, like spokes of a wheel from plot center. In dense stands, we find it helpful to flag the first tree measured to keep the crew oriented.

Tree regeneration (trees < 4.5 ft. or <1.0 in dbh/drc) is measured on a nested 1/100th acre circular plot (11.78 ft. radius) and species, condition, and height class (>0-0.5 ft; >0.5-1.5ft; >1.5-2.5ft; >2.5-3.5ft.; >3.5-4.5ft; and <4.5ft but <1.0in dbh/drc) are recorded for each seedling or sprout. Shrubs are measured on the same nested subplot and species, condition and height class (0-0.5 ft; >0.5-1.5ft;

>1.5-2.5ft; >2.5-3.5ft.; >3.5-4.5ft) are recorded for each stem. Canopy cover (density) is measured facing out at the four small-plot pin flags, along the perimeter of the nested subplot, using a spherical densitometer. In this way, each reading is spaced 90 degrees apart.

Trees and shrubs are typically recorded using their USDA PLANTS code, which is commonly a four letter code defined by the first two letters of the genus and first two letters of the species name (e.g. PIPO, ABCO, PIFL, PIED, JUDE, JUSC, etc).





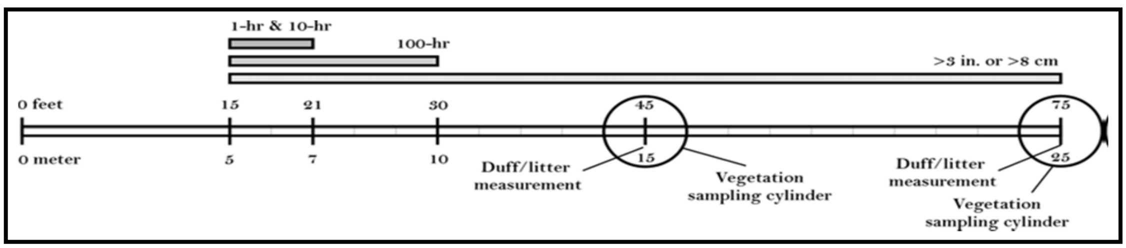
Fuels (Brown's)

Dead woody biomass and forest floor depth are measured using one 60 ft. planar Brown's transect (Brown 1974) located at a random azimuth. (Typically, one crew member spins a compass and another decides when to stop.) The tape is run from the plot center stake out 75 feet and the transect is measured from 15 to 75 feet to account for the expected foot traffic disturbance around plot center.

Parameters measured include 1, 10, 100, and 1,000 hour fuels (also called “time-lag fuels”). For more information, see Brown 1974. Note that in our protocol, a piece of coarse woody debris (CWD) must be >3” in diameter and at least 3 feet long to count as a 1000-hour fuel; if it is >3” in diameter, but under 3 feet long, we count it as a 100-hour fuel.

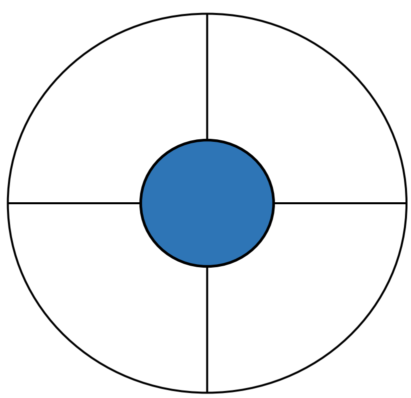
Percent cover and height of herbaceous live and dead material, percentage cover and height (up to 6 ft.) of woody live (excluding boles of trees) and dead material are estimated using the planar intersect method at 45 and 75 ft (Brown 1974). Litter and duff depths are measured at 45 and 75 ft.

A photograph is taken at each Brown’s transect from the 75 foot mark facing plot center, and slope is taken along the transect.



Understory

Vegetation and ground cover will be estimated within the nested 1/100th acre plot. Vegetation measurements will include aerial percent cover of seedling/saplings, shrubs, graminoids, and forbs, and may not total 100%. Ground cover measurements will include percentage of plant basal area (includes cacti), boles, litter, bare soil, rock, and gravel, and will total 100%.



Additional information can be found in the 2008 document authored by Derr, et. al., *Monitoring The Long Term Ecological Impacts Of New Mexico's Collaborative Forest Restoration Program, New Mexico Forest Restoration Series Working Paper 5*.

All raw data and photo points are provided to the BLM; the goal of this report is to summarize the monitoring results in a concise manner. Note that in our study, piñon, juniper and oak with more than 2 stems or whose branch structure made access difficult were measured at root collar (DRC) instead of breast height (DBH). Therefore, some portions of our data analysis include basal areas of piñon, juniper, and oak estimated from root collar diameters conversions using equations developed by Chojnacky and Roger (1999).

All results are typically reported to 2 significant digits, with exceptions for those metrics we know were measured with either more or less precision.

Disclaimer

NMFWRI provides this report and the data collected with the disclaimer that the information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and within the limitations of monitoring data in general, and these data in particular. NMFWRI gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. These data and related graphics are not legal documents and are not intended to be used as such. This includes but is not limited to using these data as the primary basis for the development of thinning prescriptions or especially timber sales. NMFWRI shall not be held liable for improper or incorrect use of the data described and/or contained in this report.

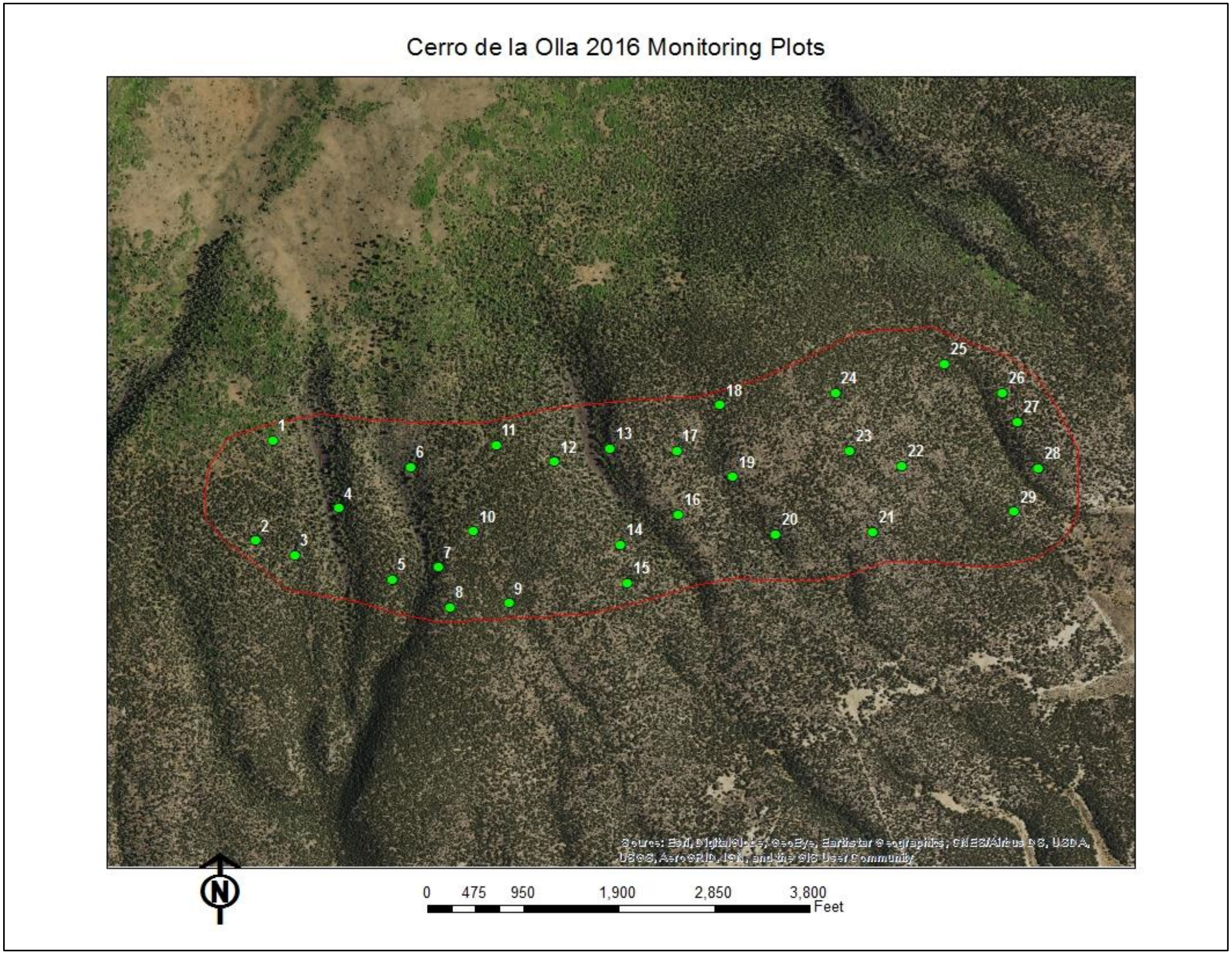


Figure 13. 2016 Monitoring Plot locations on Cerro de la Olla.

Monitoring Results

Tree Component

The study area on Cerro de la Olla had an average of 166 trees per acre (TPA), with individual plots ranging from 40 to 430 TPA. The study area had an average basal area (BA) of 91 ft^2 per acre, with individual plots ranging from 9.2 to 200 ft^2 per acre. See Figure 14.

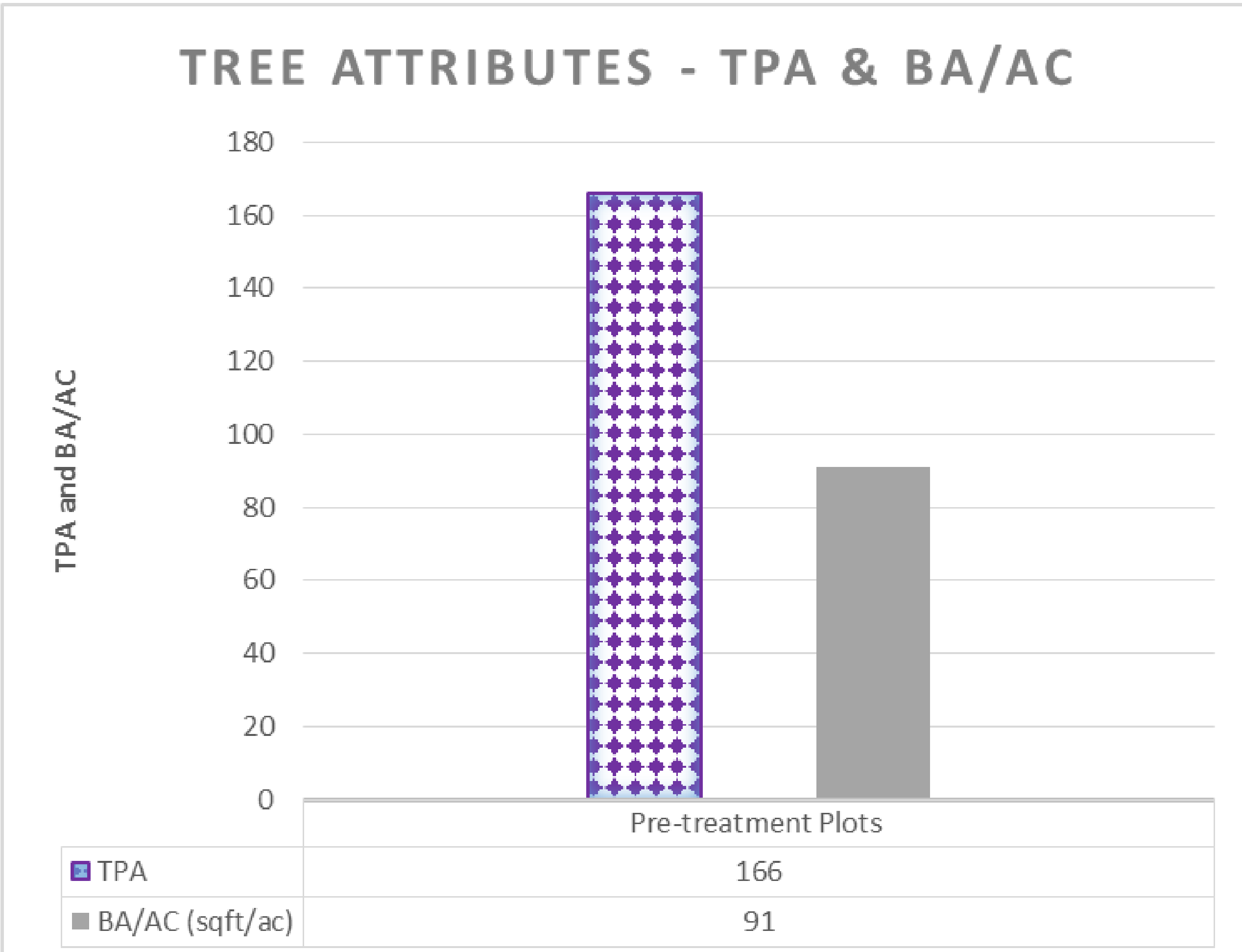


Figure 14. Basal area (square feet/ acre) and trees per acre for Cerro de la Olla 2016 study area.

The quadratic mean diameter (QMD) was 10.1 inches. The average tree height was 13 feet, and the average live crown base height (LiCrBHt) was 2 feet. Among live and sick trees, the numerically dominant species was two-needle piñon (PIED) at 110 trees per acre, followed by Rocky Mountain juniper (JUSC2) at 40 TPA, ponderosa pine (PIPO) at 7.2 TPA, Douglas-fir (PSME) at 2.8 TPA, and oneseed juniper (JUMO) and Gambel oak (QUGA) at 2.4 TPA. See Figure 15 and Figure 16.

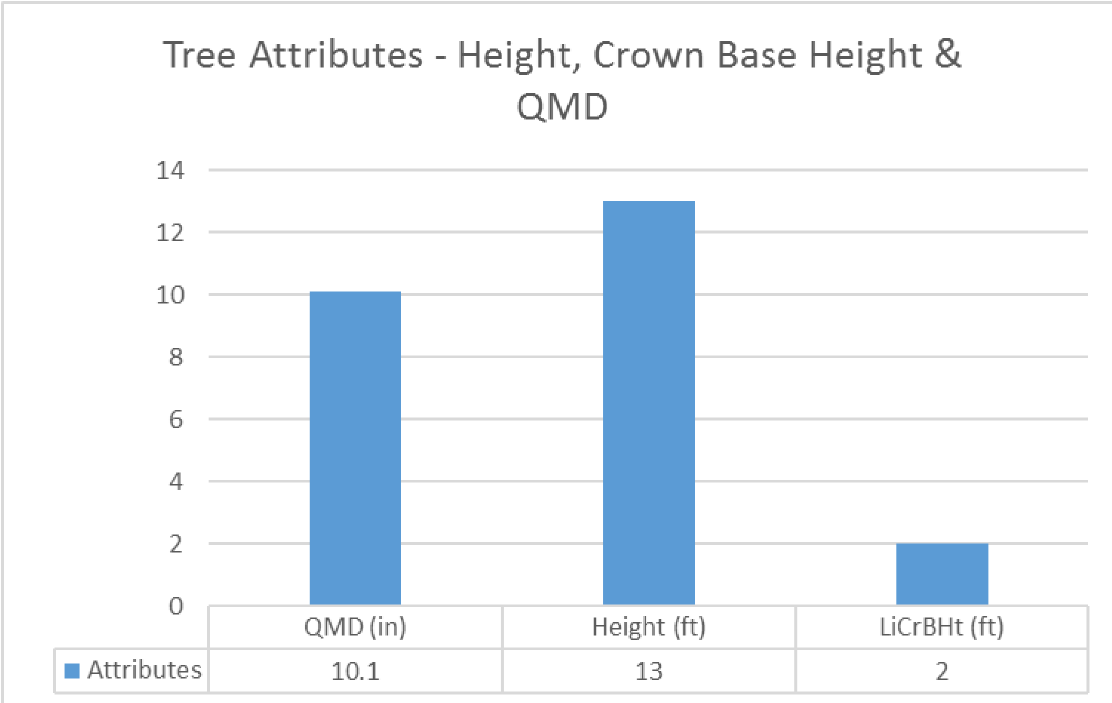
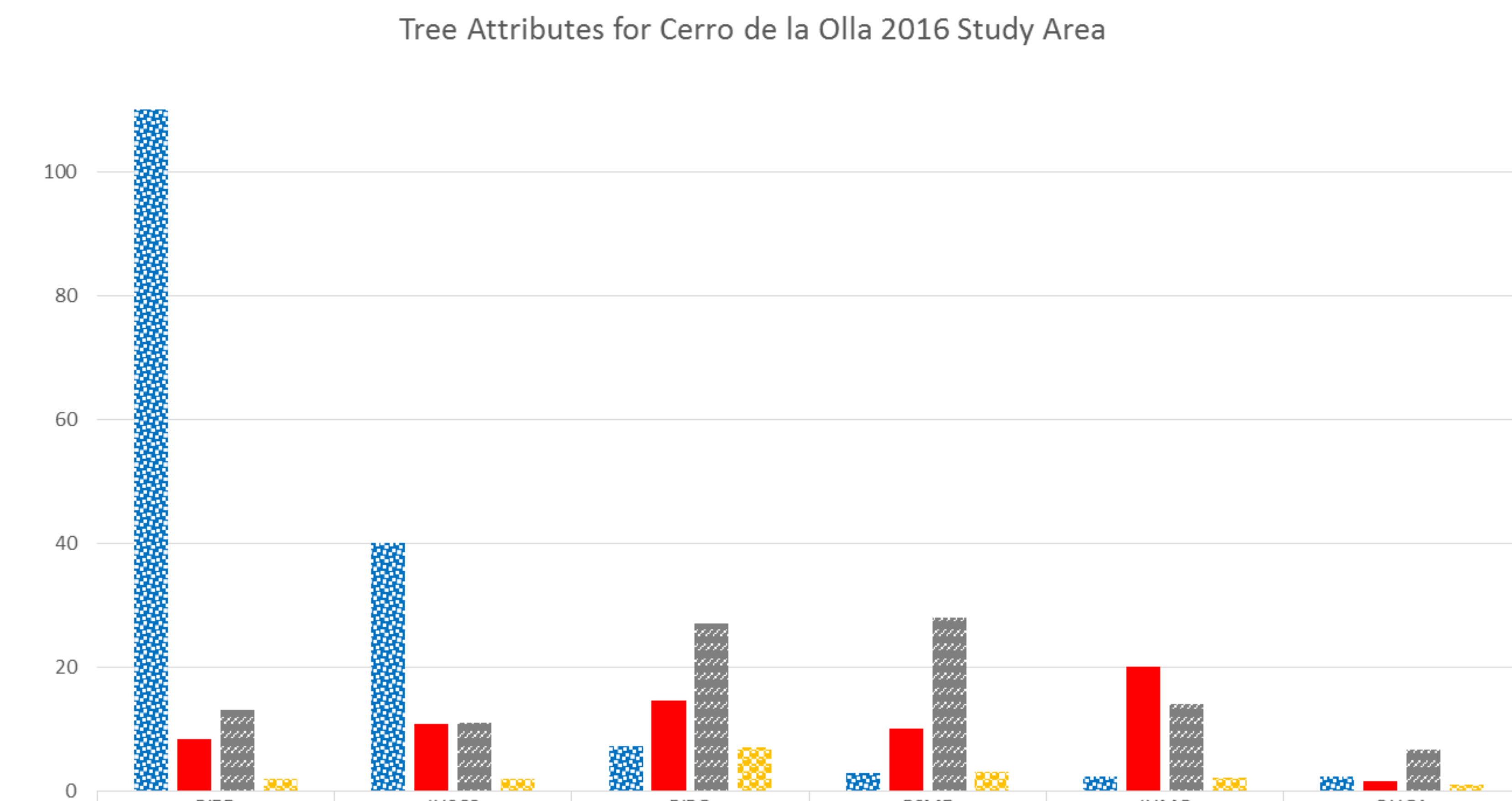


Figure 15. Quadratic Mean Diameter, Live Crown Base Height, and Tree Height averages for trees in the Cerro de la Olla 2016 study area.



	PIED	JUSC2	PIPO	PSME	JUMO	QUGA
TPA	110	40	7.2	2.8	2.4	2.4
QMD	8.4	10.9	14.5	10.1	20.0	1.5
Ht	13	11	27	28	14	6.7
LiCrBHt	1.9	1.9	7.1	3	2.2	1

Figure 16. TPA, QMD, Height, and LiCrBHt by species for Cerro de la Olla 2016 study area.

The total seedlings (tree regeneration) per acre was 380. The numerically dominant species was Gambel oak (QUGA) at 200 individuals per acre, followed by piñon (PIED) at 150 individuals per acre, and Rocky Mountain juniper (JUSC2) at 24 individuals. No Ponderosa pine, Douglas-fir, or oneseed juniper seedlings were recorded.

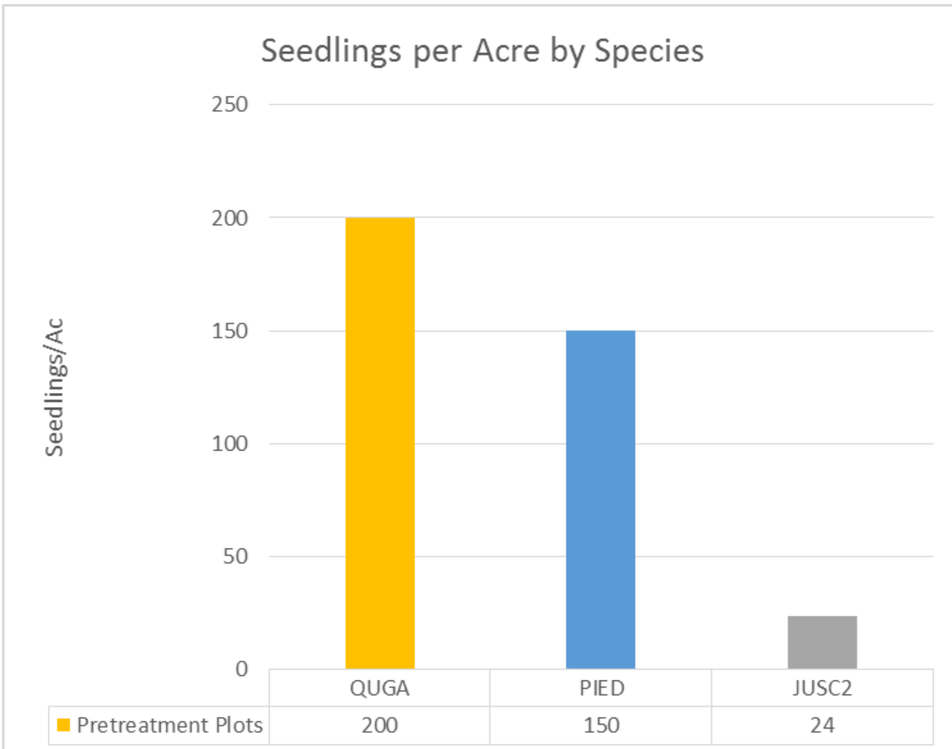


Figure 17. Seedlings per acre by species for Cerro de la Olla 2016 study area.

Shrub species under 4.5 feet were also recorded separately from other woody species at the request of the BLM. The total number of shrub individuals per acre was 1100. The most common shrub recorded was Broom snakeweed (GUSA2) at 800 individuals per acre, followed by 2 species of yucca (YUCCA) at 260 individuals per acre, gooseberry (RIIN2) at 35 per acre, pricklypear (OPUNT) at 17 per acre, and roundleaf snowberry (SYRO) at 3.4 individuals per acre. See Figure 18. It is also worth noting that gooseberry (RIIN2) was recorded over 4.5 feet at an incidence of an additional 35 individuals per acre (not shown on graph).

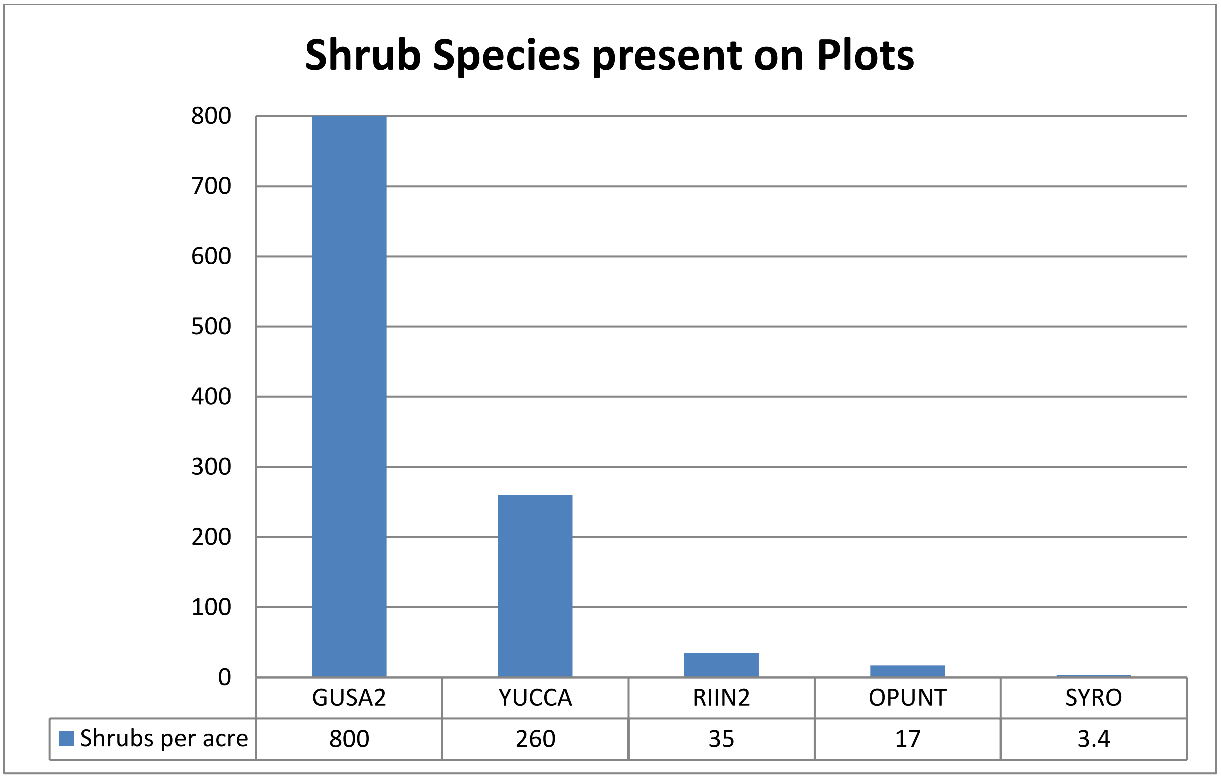


Figure 18. Shrubs (under 4.5 feet) per acre by species for Cerro de la Olla 2016 study area.

In 2016, the survey area was found to have 41 snags per acre and 21 logs (1000-hour fuels) per acre. Of the snags, 53% were piñon, followed by 38% Rocky Mountain juniper, 3.3% Gambel oak, and 1.7% each quaking aspen, Douglas-fir, ponderosa pine, and oneseed juniper. Of the logs, 50% of them were decay class 4, 25% were in decay class 5, 23% were in decay class 3, and 2% were decay class 2; average diameter was 7.3 inches where they intersected the fuels transect. See Figure 19.

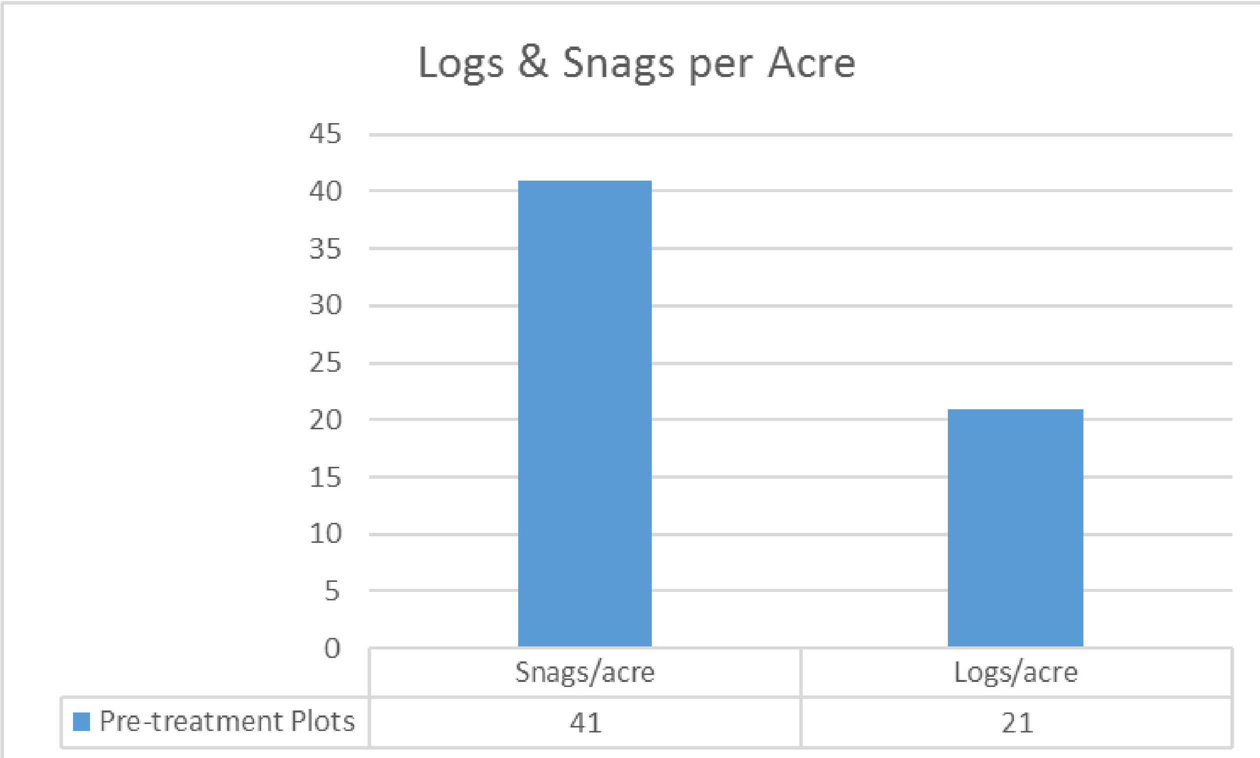
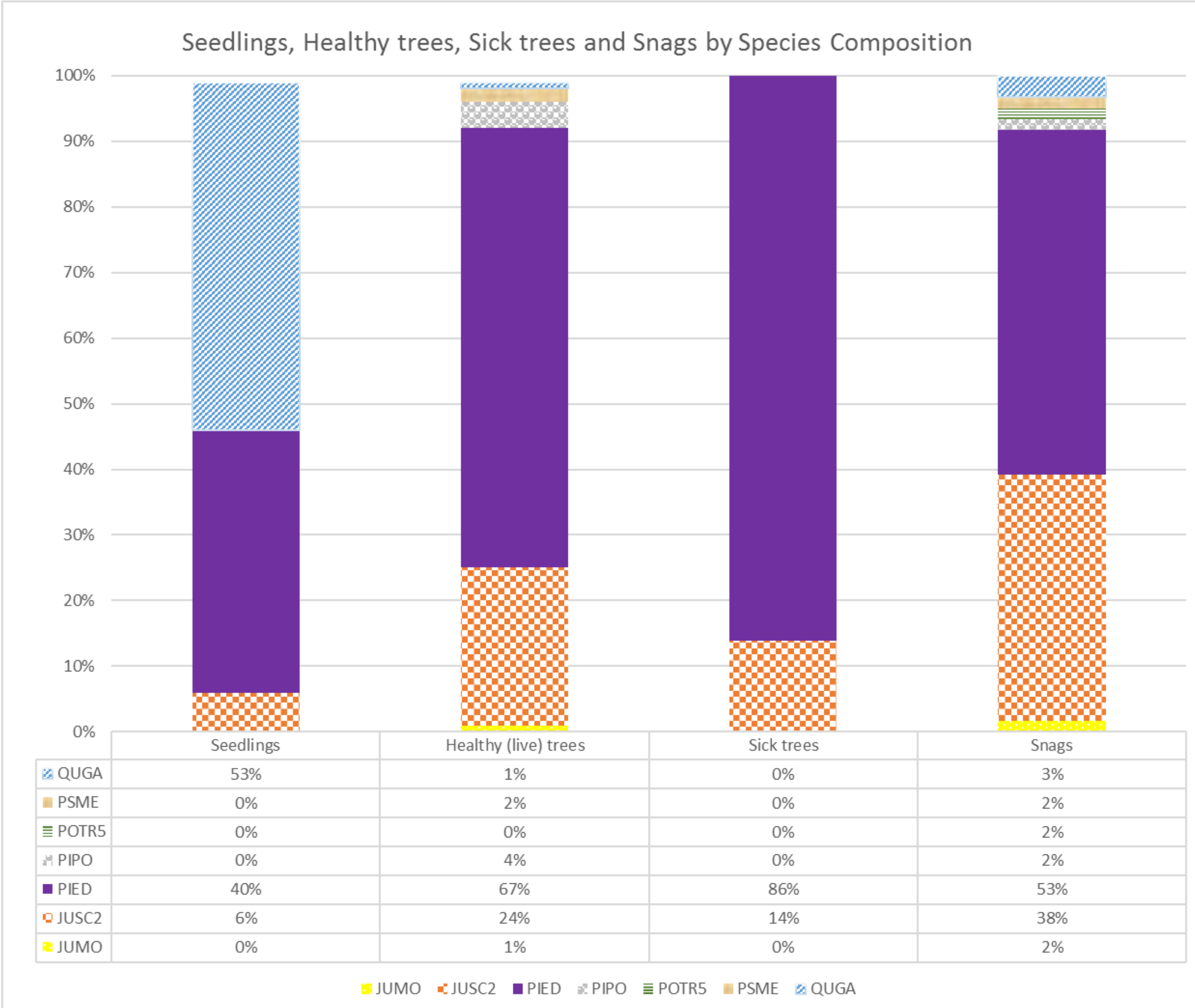


Figure 19. Logs and snags per acre for Cerro de la Olla 2016.

Figure 20 offers a comparison of species composition within the seedling, healthy (live) tree, sick tree, and snag categories. The large proportion of Gambel oak (QUGA) seedlings can be attributed in part to the tree's smaller stature, but is nevertheless interesting. Similarly, piñon (PIED) was a higher proportion of the sick trees than it was of live trees. This is in keeping with field crew observations of several piñon sick trees covered with ants.



	Seedlings	Healthy (live) trees	Sick trees	Snags
QUGA	53%	1%	0%	3%
PSME	0%	2%	0%	2%
POTR5	0%	0%	0%	2%
PIPO	0%	4%	0%	2%
PIED	40%	67%	86%	53%
JUSC2	6%	24%	14%	38%
JUMO	0%	1%	0%	2%

Figure 20. Seedlings, healthy trees, sick trees and snags by species percent composition for Cerro de la Olla 2016.

Table 3. Monitoring Summary of Tree Component for Cerro de la Olla 2016

Stand Total		Saplings			Pole			Tree or Sawlog											*Total by Class,Growing Stock & Dead*	*% by Class, Growing Stock vs Dead*
Diameter Class		*0*	*2*	*4*	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*	*24*	*26*	*28*	*30*	*32*		
Growing Stock	**COUNT**	2	57	74	78	81	56	43	25	23	15	14	4	3	2	2	0	0	***479***	
(All living trees	**TPA**	0.69	19.66	25.52	26.90	27.93	19.31	14.83	8.62	7.93	5.17	4.83	1.38	1.03	0.69	0.69	0.00	0.00	***165***	***80%***
in woodland &	**BA/AC**	0.00	0.44	2.01	5.18	9.48	10.53	11.34	8.91	10.74	9.00	10.53	3.51	3.35	2.65	3.14	0.00	0.00	***91***	***78%***
forestland)	**AVE HT, HL**	6	7	9	11	13	15	14	16	16	20	19	18	21	30	17	0.00	0.00		
Summary by	**TPA**	45.86			74.14			45.17											***165***	
Size Class (All	**TPA %**	27.77%			44.89%			27.35%											***100%***	
living trees in	**BA/AC**	2.46			25.19			63.17											***91***	
woodland &	**BA/AC %**	2.71%			27.73%			69.56%											***100%***	
forestland)	**QMD MEAN DIA.**	3.13			7.89			16.01											***10***	
	AVE HT, HL	9			14			18											***16***	
Dead (All dead	**COUNT**	0	7	6	22	29	23	12	6	2	7	2	1	2	0	1	0	0	***120***	
trees in	**TPA**	0.00	2.41	2.07	7.59	10.00	7.93	4.14	2.07	0.69	2.41	0.69	0.34	0.69	0.00	0.34	0.00	0.00	***41***	***20%***
woodland &	**BA/AC**	0.00	0.04	0.21	1.43	3.22	4.10	3.28	2.13	0.94	4.14	1.50	0.88	2.20	0.00	1.50	0.00	0.00	***26***	***22%***
forestland)	**AVE HT, HL**	0.00	10	7	10	11	11	12	12	14	10	12	20	13	0.00	18	0.00	0.00	***12***	
Total for all	**COUNT**	2	64	80	100	110	79	55	31	25	22	16	5	5	2	3	0	0	***599***	
sample trees	**TPA**	0.69	22.07	27.59	34.48	37.93	27.24	18.97	10.69	8.62	7.59	5.52	1.72	1.72	0.69	1.03	0.00	0.00	***207***	***100%***
including	**BA/AC**	0.00	0.48	2.22	6.61	12.70	14.63	14.62	11.04	11.68	13.14	12.03	4.39	5.55	2.65	4.64	0.00	0.00	***116***	***100%***

*NOTE1: Average Diameter calculated using the Quadratic Mean Diameter (QDM), equvalent equation: (SQRT((BA/AC)/TPA) /.005454)) ; NOTE2: Average Height (HL), calculated using Lorey's height equation for a weighted mean, HL=SUM(bi * hi)/SUM(bi) , where bi is basal area of individual tree & hi is height of an individual tree.*

Table 4. Woodland Species by Diameter Class for Cerro de la Olla 2016

Stand Table		Cerro de la Olla 2016	September 2016																	
Woodland Species		Saplings			Pole			Mature Trees											Total by Species	%Species for all G-Stock
Diameter Class		0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32+		
PIED	COUNT	2	25	59	65	58	43	24	15	12	7	6	3	0	1	0	0	0	*320.00*	
Pinon pine	TPA	0.69	8.62	20.34	22.41	20.00	14.83	8.28	5.17	4.14	2.41	2.07	1.03	0.00	0.34	0.00	0.00	0.00	*110.34*	*66.81%*
	BA/AC	0.00	0.24	1.65	4.34	6.79	8.12	6.24	5.22	5.68	4.14	4.28	2.66	0.00	1.36	0.00	0.00	0.00	*50.71*	*55.84%*
	AVE HT. (HL)	6	7	9	12	14	16	15	17	16	19	18	19	0.00	15	0.00	0.00	0.00		
JUMO	COUNT	0	1	0	0	0	1	0	1	0	0	1	1	0	0	2	0	0	*7.00*	
One-seed juniper	TPA	0.00	0.34	0.00	0.00	0.00	0.34	0.00	0.34	0.00	0.00	0.34	0.34	0.00	0.00	0.69	0.00	0.00	*2.41*	*1.46%*
	BA/AC	0.00	0.01	0.00	0.00	0.00	0.23	0.00	0.40	0.00	0.00	0.77	0.85	0.00	0.00	3.14	0.00	0.00	*5.40*	*5.95%*
	AVE HT. (HL)	0.00	7	0.00	0.00	0.00	11	0.00	15	0.00	0.00	13	16	0.00	0.00	17	0.00	0.00		
JUSC2	COUNT	0	11	9	12	22	11	19	7	10	7	5	0	3	0	0	0	0	*116.00*	
Rocky Mnt juniper	TPA	0.00	3.79	3.10	4.14	7.59	3.79	6.55	2.41	3.45	2.41	1.72	0.00	1.03	0.00	0.00	0.00	0.00	*40.00*	*24.22%*
	BA/AC	0.00	0.10	0.23	0.77	2.59	2.02	5.10	2.57	4.55	4.23	3.94	0.00	3.35	0.00	0.00	0.00	0.00	*29.46*	*32.44%*
	AVE HT. (HL)	0.00	7	7	8	11	10	12	12	13	17	14	0.00	21	0.00	0.00	0.00	0.00		
QUGA	COUNT	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*7.00*	
Gambel oak	TPA	0.00	2.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.41*	*1.46%*
	BA/AC	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.03*	*0.03%*
	AVE HT. (HL)	0.00	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Woodland Species	***COUNT***	***2***	***44***	***68***	***77***	***80***	***55***	***43***	***23***	***22***	***14***	***12***	***4***	***3***	***1***	***2***	***0***	***0***	*450.00*	
Sub-total	***TPA***	***0.69***	***15.17***	***23.45***	***26.55***	***27.59***	***18.97***	***14.83***	***7.93***	***7.59***	***4.83***	***4.14***	***1.38***	***1.03***	***0.34***	***0.69***	***0.00***	***0.00***	*155.17*	*93.95%*
	BA/AC	***0.00***	***0.38***	***1.88***	***5.11***	***9.38***	***10.36***	***11.34***	***8.19***	***10.23***	***8.37***	***8.99***	***3.51***	***3.35***	***1.36***	***3.14***	***0.00***	***0.00***	*85.59*	*94.26%*
	AVE HT. (HL)	***6***	***7***	***9***	***11***	***13***	***15***	***14***	***15***	***15***	***18***	***16***	***18***	***21***	***15***	***17***	***0.00***	***0.00***		
Summary by Size	***TPA***	***39.31***			***73.10***			***42.76***											***155.17***	
Class for	***TPA %***	***25.33%***			***47.11%***			***27.56%***											***100.00%***	
Woodland Species	***BA/AC***	***2.27***			***24.85***			***58.48***											***85.59***	
	BA/AC %	***2.65%***			***29.03%***			***68.32%***											***100.00%***	
	QUADRATIC MEAN DIA.	***3.25***			***7.89***			***15.84***											***10.06***	
	AVE HT. (HL)	***9***			***13***			***16***											***15***	

Table 5. Forestland Species by Diameter Class for Cerro de la Olla 2016

Forestland Species		Saplings			Pole			Mature Trees											***Total by Species & Covertype***	***%Species for all G-Stock***
Diameter Class		***0***	***2***	***4***	***6***	***8***	***10***	***12***	***14***	***16***	***18***	***20***	***22***	***24***	***26***	***28***	***30***	***32***		
PIPO Ponderosa pine	COUNT	0	13	3	0	0	0	0	2	0	1	1	0	0	1	0	0	0	***21.00***	
	TPA	0.00	4.48	1.03	0.00	0.00	0.00	0.00	0.69	0.00	0.34	0.34	0.00	0.00	0.34	0.00	0.00	0.00	***7.24***	***4.38%***
	BA/AC	0.00	0.06	0.07	0.00	0.00	0.00	0.00	0.71	0.00	0.63	0.78	0.00	0.00	1.29	0.00	0.00	0.00	***3.54***	***3.90%***
	AVE HT. (HL)	0.00	7.74	10.98	0.00	0.00	0.00	0.00	27.88	0.00	40.00	31.00	0.00	0.00	46.00	0.00	0.00	0.00		
PSME Douglas-fir	COUNT	0	0	3	1	1	1	0	0	1	0	1	0	0	0	0	0	0	***8.00***	
	TPA	0.00	0.00	1.03	0.34	0.34	0.34	0.00	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	***2.76***	***1.67%***
	BA/AC	0.00	0.00	0.07	0.07	0.10	0.16	0.00	0.00	0.51	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	***1.68***	***1.84%***
	AVE HT. (HL)	0.00	0.00	10.07	16.50	22.00	34.00	0.00	0.00	51.00	0.00	42.00	0.00	0.00	0.00	0.00	0.00	0.00		
Forestland Species Sub-total	***COUNT***	***0***	***13***	***6***	***1***	***1***	***1***	***0***	***2***	***1***	***1***	***2***	***0***	***0***	***1***	***0***	***0***	***0***	***29.00***	
	TPA	***0.00***	***4.48***	***2.07***	***0.34***	***0.34***	***0.34***	***0.00***	***0.69***	***0.34***	***0.34***	***0.69***	***0.00***	***0.00***	***0.34***	***0.00***	***0.00***	***0.00***	***10.00***	***6.05%***
	BA/AC	***0.00***	***0.06***	***0.13***	***0.07***	***0.10***	***0.16***	***0.00***	***0.71***	***0.51***	***0.63***	***1.54***	***0.00***	***0.00***	***1.29***	***0.00***	***0.00***	***0.00***	***5.22***	***5.74%***
	AVE HT. (HL)	***0.00***	***8***	***11***	***17***	***22***	***34***	***0.00***	***28***	***51***	***40***	***36***	***0.00***	***0.00***	***46***	***0.00***	***0.00***	***0.00***		
Summary by Size Class for Forestland Species	***TPA***	***6.55***			***1.03***			***2.41***											***10.00***	
	TPA %	***65.52%***			***10.34%***			***24.14%***											***100.00%***	
	BA/AC	***0.19***			***0.34***			***4.69***											***5.22***	
	BA/AC %	***3.66%***			***6.44%***			***89.91%***											***100.00%***	
	QUADRATIC MEAN DIA.	***2.31***			***7.71***			***18.87***											***9.78***	
	AVE HT. (HL)	***10***			***27***			***40***											***38***	

Table 6. Individual Plot Summary for Cerro de la Olla 2016

Cerro de la Olla 2016				Sept 16
Individual Plot Summary Table				
		Growing Stock		
Macro Plot Name	Total number of sample trees on plot	Number of growing stock sample trees on plot	Trees per Acre	Basal Area per Acre
CO_1	19	12	120	62
CO_2	24	18	180	131
CO_3	25	24	240	38
CO_4	8	4	40	38
CO_5	18	14	140	125
CO_6	21	16	160	100
CO_7	32	29	290	111
CO_8	21	21	210	185
CO_9	45	43	430	199
CO_10	24	22	220	87
CO_11	25	19	190	109
CO_12	11	11	110	62
CO_13	6	4	40	9.2
CO_14	21	18	180	147
CO_15	17	16	160	96
CO_16	7	5	50	17
CO_17	13	10	100	119
CO_18	29	16	160	110
CO_19	7	6	60	29
CO_20	32	25	250	151
CO_21	18	16	160	84
CO_22	17	7	70	63
CO_23	22	14	140	62
CO_24	21	15	150	56
CO_25	20	17	170	73
CO_26	30	26	260	102
CO_27	25	21	210	140
CO_28	18	12	120	54
CO_29	24	19	190	83
Total	**Total number of sample trees on plot**	**Number of growing stock sample trees on plot**	**Average for all Plots**	
			TPA	**BA/AC**
	600	**480**	**166**	**91**

Understory and Forest Floor Component

Understory and ground cover data were collected on a 1/100th acre nest subplot. Tree canopy was measured with a spherical densiometer and the other cover types were estimated. Note that the total percent cover may be over 100%, usually due to the presence of litter beneath other vegetation. Canopy cover ranged from 0% to 65% and averaged 40%. For more details, see Table 7.

Table 7. Average percent tree canopy, understory and ground cover for Cerro de la Olla 2016.

Cerro de la Olla 2016	**Aerial cover**			
Tree Canopy	**Seedlings/Saplings**	**Shrub cover**	**Graminoid Cover**	**Forb Cover**
40%	2.7%	6.5%	11%	0.48%

Ground cover					
Plant Basal	**Bole**	**Litter**	**Bare Soil**	**Rock**	**Gravel**
12%	5.2%	22%	7.7%	34%	18%

Additional cover data was collected using the planar intercept method as revised by Brown (1974) for the sampling of down woody debris (DWD) and ladder fuels. This method uses cylinders which have 6 foot diameters and are 6 feet high from the horizontal plane. This means canopy of mature trees typically is not included. This data is broken down into four categories: herbaceous dead (HD), herbaceous live (HL), woody standing dead (SD), and woody standing live (SL). The average total percent cover for Cerro de la Olla was 4%. Average HD cover was 7.6%, average HL cover was 3.3%, SD cover was 1.3%, and SL was 4.3%. See Table 8, below.

Table 8. Planar intercept cover and fuels for Cerro de la Olla 2016.

Fuel	**Avg Cover %**	**Avg Ht (ft)**	**Avg Biomass (tons/ac)**	**Total biomass (tons)**
HD	7.6	0.1	0	1.0
HL	3.3	0.2	0	0.67
SD	1.3	0.5	0.1	4.0
SL	4.3	1.3	0.4	10
TOTAL (AVG)	4	0.53	0.13	*SUM = 16*

Surface fuels were also measured using Brown's transects. The average tons/acre for all fuels (1, 10, 100, and 1000-hour wood fuels as well as litter and duff) was 17. Total wood fuels were measured at 12 tons/acre with fine wood fuels (1 to 100 hour fuels) measured at an average of 5.2 tons/acre and coarse wood fuels (1000 hour fuels) at 6.8 tons/acre. Duff was measured at 2.2 tons/acre and an average depth of 0.22 inches; litter was measured at 2.3 tons/acre and an average depth of 0.47 inches. See Table 9.

Table 9. Surface fuels for Cerro de la Olla 2016.

2016	
Fuel	**Avg Tons/Ac**
1-Hour	0.21
10-Hour	2.5
100-Hour	2.6
1000-Hour	6.8
Duff	2.2
Litter	2.3
TOTAL FINE WOOD FUELS	5.2
TOTAL WOOD	12
TOTAL SURFACE FUELS	17
Fuel	**Depth (inches)**
Duff	0.22
Litter	0.47
TOTAL DEPTH	0.69

Summary

One interesting observation made by the field crew was the presence of several spot fires throughout and in particular above the study area which seemed to be started by lightning strikes on ponderosa pine, Douglas-fir or white fir which had a consistently taller growth form than the piñon and juniper. These spot fires seemed to occur across a wide area and serve a maintenance function within the forest.

Another frequent comment in the field crew notes was the unusually high number of sick piñon trees covered with ants, which were likely an indicator of illness rather than the cause. NMFWRI staff contacted Tom Coleman of the Forest Service's Forest Health Protection staff for more information. Based on photographs provided by NMFWRI, Mr Coleman stated that most of the mortality looked as though it had originated in the early 2000s drought and subsequent piñon ips (bark/engraver beetle) outbreaks. He noted that piñon mortality across the state was around 22%, but some of Forest Health Protection's plots near Cerro de la Olla recorded mortality near 80-90%, and added that bark beetle outbreask are common after 2-3 years of consecutive drought due to the higher levels of stress in pines. He also offered to visit the site should the BLM prefer (T. Coleman, personal communication, Dec 16, 2016).

The Cerro Montoso EA mentions the use of wildland fire on mountain tops "primarily because of the success observed in such cases. For example, in 2000 a natural wildfire occurred on Pot Mountain and since then, the area has seen tremendous recovery and a diversity of native plant species. The area has also served as an effective natural fuel-break in containing potential wildfire starts and could be used a fuel-break for project burns."[41]The NMFWRI field crew saw signs of several small spot fires between the study area and the mountaintop and agrees that the area looked healthy.

The following table represents the summarized data.

[41] (United States Department of the Interior, BLM, 2008), p 10-11

Table 10. Data summary for all plots for Cerro de la Olla 2016.

Metric	Average (if applicable)	Range of values on individual plots (if applicable)
Trees per acre	170	40 - 430
Dominant tree (numerically)	piñon	---
Basal area (ft^2/acre)	92	9.2 - 200
QMD (inches)	10.1	0.18 - 28.9 (DBH)
Average tree height (ft)	13	4.5 - 51
Average LiCrBHt (ft)	2	0 - 19
Seedlings per acre	207	0 - 4800
Dominant seedling (numerically)	Gambel oak	----
Shrubs per acre	1100	0 - 6400
Dominant shrub (numerically)	Broom snakeweed	----
Sick trees per acre	13	0 - 60
Dominant sick tree (numerically)	piñon	----
Snags per acre	41	0.7 - 22
Dominant snag (numerically)	piñon	----
Average slope (%)	33%	3 – 69%
Dominant aspect	South (72%)	East, South, West
Canopy cover (%)	40%	0 – 68%
Grass and forb cover (%)	11%	0.5 - 30
Logs per acre (1000-hour fuels)	21	0 - 60
Average total tons of surface fuel per acre	17	1.6 - 34

Sample Point CO_1, looking east from plot center

Sample Point CO_4, looking west from plot center

Sample Point CO_10, looking north from plot center

Sample Point CO_13, looking east from plot center

Sample Point CO_23, looking south from plot center

Sample Point CO_28, looking south toward plot center

Figure 21. Sample photopoints from Cerro de la Olla in 2016.

References

Dick-Peddie, W. A. (1993). *New Mexico Vegetation: Past, Present and Future.* Albuquerque: University of New Mexico Press.

Lambert, W. (1966). Notes on the Late Cenozoic Geology of the Taos-Questa Area, New Mexico. (N. M. Society, Ed.) Albuquerque, United States of America. Retrieved from https://nmgs.nmt.edu/publications/guidebooks/downloads/17/17_p0043_p0050.pdf

National Cooperative Soil Survey. (2007, November). *Ration Series*. Retrieved from Official Soil Series Description: https://soilseries.sc.egov.usda.gov/OSD_Docs/R/RATON.html

National Cooperative Soil Survey. (2009, April). *Stunner Series*. Retrieved from Official Soil Series Description: https://soilseries.sc.egov.usda.gov/OSD_Docs/S/STUNNER.html

National Park Service. (2015). *Pinyon-Juniper Woodlands: Introduction and Distribution*. Retrieved from NPS Articles: http://www.nps.gov/articles/pinyon-juniper-woodlands-distribution.htm

New Mexico Bureau of Geology & Mineral Resources. (2014, July 17). *Cerro de la Olla*. Retrieved from New Mexico Tech Geo Info: https://geoinfo.nmt.edu/banner/home.cfml?id=116

New Mexico Game and Fish. (n.d.). Chapter 5, "Assessments and Stategies for Key Habitats Within Ecological Frameworks": Southern Rocky Mountains Ecoregion. In *Comprehensive Wildlife Conservation Stategy (CWCS/NM) for New Mexico: Conserving New Mexico's Biodiversity* (p. 174). Retrieved from http://fws-case-12.nmsu.edu/cwcs/pdfdocs/ch5_southern_rockies.pdf

New Mexico Rare Plant Technical Council. (2005). *Rare Plant List: Taos County*. Retrieved from New Mexico Rare Plants: http://nmrareplants.unm.edu/county_result.php?output=html

NRCS: Web Soil Survey. (2015). *All Ecological Sites - Rangeland - Taos County and Parts of Rio Arriba and Mora Counties, New Mexico (Guadalupe Mtn Soils).* Retrieved from Web Soil Survey: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

The Society of American Foresters. (1998). *The Dictionary of Forestry.* Bethesda, MD: The Scoiety of American Foresters.

United States Department of the Interior, BLM. (2008). *Cerro Montoso Vegetation Treatment Project, EA #NM-220-08-053.*

US Climate Data. (2015). *Climate Cerro - New Mexico; Weather history Cerro*. Retrieved from U.S. Climate data: Temperature - Precipitation - Sunshine - Snowfall: http://www.usclimatedata.com/climate/cerro/new-mexico/united-states/usnm0056

US Climate Data. (2016). *Climat Cerro - New Mexico*. Retrieved from Weather history Cerro (2016): http://www.usclimatedata.com/climate/cerro/new-mexico/united-states/usnm0056/2016/7

US Fish and Wildlife Service in collaboration with flyway and state waterfowl managers. (n.d.). *The Central Flyway*. Retrieved from Flyways.us Central Flyway: http://central.flyways.us/

USDA Forest Service. (n.d.). *2013-2027 National Insect and Disease Risk Map Viewer*. Retrieved from Forest Health Protection Mapping and Reporting: http://foresthealth.fs.usda.gov/nidrm/

USDA Forest Service, Forest Health Protection and its partners. (2014). *Douglas fir Beetle in Taos County.* Retrieved from Forest Health Protection Insect and Disease Detection Survey Data Explorer.

USDA Forest Service, Forest Health Protection and its partners. (2014). *Subalpine Fir Mortality Summary for Taos County.* Retrieved from Forest Health Protection Insect and Disease Detection Survey Data Explorer: http://foresthealth.fs.usda.gov/portal/Flex/IDS

USDA NRCS Geospatial Data Gateway. (n.d.). 12 Digit Watershed Boundary Dataset in HUC8 NRCS Version. (FracTrackerAlliance, Compiler) doi:http://datagateway.nrcs.usda.gov/GDGOrder.aspx; http://www.arcgis.com/home/item.html?id=d685c29732864aa38960aec5d5c7fac6

USDA NRCS Geospatial Data Gateway. (n.d.). Basins of the Colorado Plateaus, Arizona/New Mexico Plateau, and Sonoran Desert eco-regions (Data Basin Dataset). (consbio, Compiler) Retrieved from http://www.arcgis.com/home/item.html?id=89bf414297ef4591b1c3d3bf07869110; https://gdg.sc.egov.usda.gov/GDGOrder.aspx?order=QuickState

USFWS, Esri, et al. (2016, November 30). *Critical Habitat for Threatened & Endangered Species [USFWS]*. Retrieved from ECOS: Environmental Conservation Online System USFWS Threatened & Endangered Species Active Critical Habitat Report: http://fws.maps.arcgis.com/home/webmap/viewer.html?webmap=9d8de5e265ad4fe09893cf75b8dbfb77

Western Regional Climate Center. (2005). *Monthly Climate Summary for Cerro, New Mexico (291630)*. Retrieved from Western Regional Climate Center Coop Sites: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nmcerr

Appendix I: Coordinates of Sample Points

Plot Name	Latitude	Longitude	Elevation (feet)
CO_1	36.7425	-105.791	8969.67
CO_2	36.7398	-105.791	8739.5
CO_3	36.7394	-105.79	8662.14
CO_4	36.7407	-105.788	8716.05
CO_5	36.7388	-105.787	8535.17
CO_6	36.7418	-105.786	8825.97
CO_7	36.7391	-105.785	8562.97
CO_8	36.738	-105.785	8498.89
CO_9	36.7381	-105.783	8423.98
CO_10	36.7401	-105.784	8657.84
CO_11	36.7425	-105.783	8865.06
CO_12	36.742	-105.781	8659.57
CO_13	36.7424	-105.779	8566.66
CO_14	36.7398	-105.779	8394.22
CO_15	36.7387	-105.779	8329.12
CO_16	36.7406	-105.777	8383.86
CO_17	36.7423	-105.777	8534.44
CO_18	36.7436	-105.775	8620.26
CO_19	36.7416	-105.775	8386.83
CO_20	36.7401	-105.774	8235.73
CO_21	36.7402	-105.77	8180.22
CO_22	36.742	-105.769	8237.87
CO_23	36.7424	-105.771	8345.98
CO_24	36.744	-105.772	8479.33
CO_25	36.7448	-105.768	8282.85
CO_26	36.744	-105.766	8179.01
CO_27	36.7432	-105.765	8122.89
CO_28	36.742	-105.765	8032.74
CO_29	36.7408	-105.765	8020.38

Appendix II: New Mexico State Forestry Working Group PJ Key

Key for the Five Piñon-Juniper types (for further information, contact Kent Reid at NMFWRI)

These five P-J types have been identified by a working group, convened by NM State Forestry, whose job is to develop a Piñon-Juniper Management Framework consistent with NM Ecological Restoration Principles. Their draft documentation includes the dichotomous key from Romme et al. 2007, which does not match the working group's five PJ types. The NRCS in New Mexico has its own key to PJ types, which is less concerned with naming the PJ type than with deciding how to manage it. The key presented here draws from both the Romme and NRCS keys, but its primary concern is differentiating the types identified by the working group. It does that by using information on soil factors, rainfall patterns, and the existing plant community from the draft descriptions of the five types.

Any type as elastic and as diverse as "P-J" defies easy categorization, which is what this key attempts to do. In particular, the differences between Savanna and Grassland, and among Persistent, Shrub, and Open Woodlands, are subject to nuance and gradations that are not easily captured in a dichotomous key. Note that tree height and canopy cover are so variable that they are not used here as diagnostic factors. Despite these difficulties, a land manager should be able to use this key in conjunction with the five descriptions to make informed decisions about actions toward restoration, desired conditions, and land health.

1a. Deep soils (>14 inches deep), surface generally free of large rock fragments or large amounts of gravel, and capable of producing continuous fine fuels under normal precipitation - **2**

1b. Shallow or transitional soils, surface may be eroded and often is rocky or droughty, and usually not capable of producing continuous fine fuels under normal precipitation – **3**

2a. Most precipitation falls during summer. The oldest trees (possibly >150 years) are older and usually taller than those found in Grasslands – **PJ Savanna or Juniper Savanna**

2b. Season of greatest precipitation can vary. Old trees are very rare and found on microsites that historically would have allowed escape from fire – **Grassland**

3a. Generally on shallow, coarse-textured soils. Most precipitation falls during winter. Piñon and juniper are the dominant species – **PJ Persistent Woodland**

3b. Soil transitional between deep Savanna soils and shallow Persistent Woodland soils – **4**

4a. Bi-modal precipitation pattern. Uneven-aged stands on rolling uplands with persistent, taller trees. Probably common historically, but rare under current conditions – **PJ Open Woodland**

4b. Most precipitation falls during winter. Sagebrush or oak co-dominate with the P-J, but the shrub species may be crowded out under current conditions. This type often found in small patches that can be difficult to map on a statewide scale – **PJ Shrub Woodland**