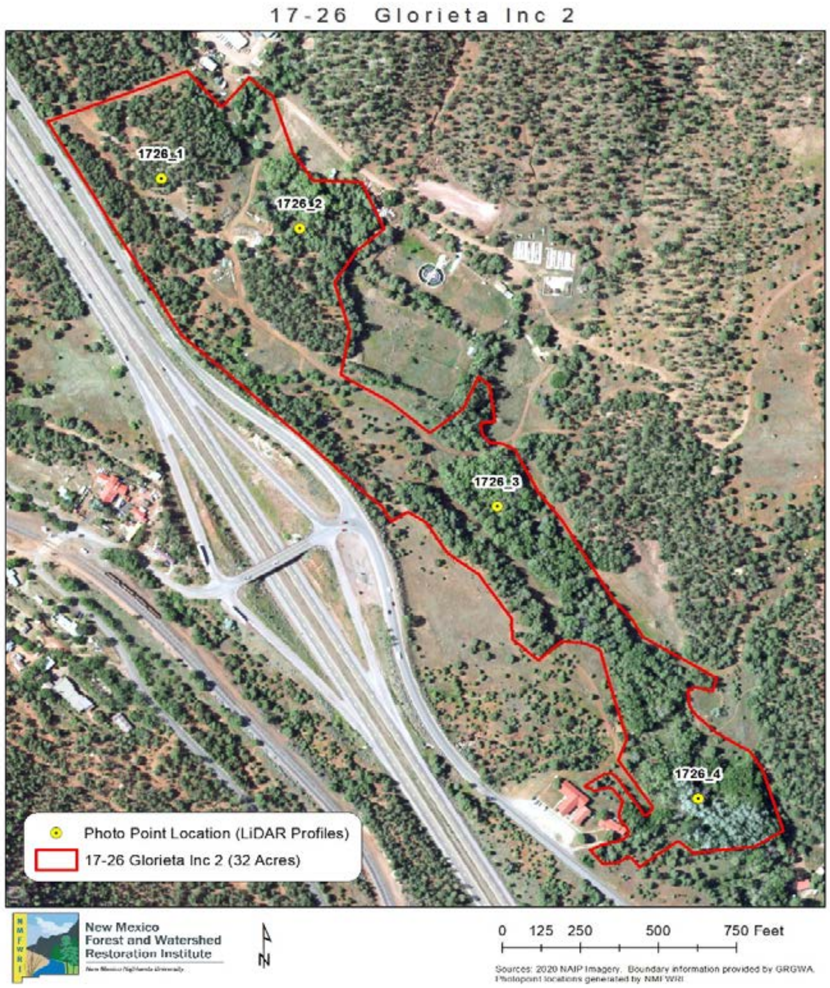
Glorieta 17-26

Pre-treatment Monitoring Report

2020/2021



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Contents

Acronyms and Abbreviations

Acronym, Abbreviation, or Term	Explanation or Definition as used by NMFWRI
FSA	Farm Service Agency, a department of the USDA
GIS	Geographic Information Systems
GRGWA	Greater Rio Grande Watershed Alliance
LIDAR	Light detecting and ranging, a remote sensing technique using light to gather elevation data
NAIP	National Agriculture Imagery Program (aerial imagery)
NDVI	Normalized Difference Vegetation Index; GIS term for a band ratio of the visible red and the near infrared spectral bands and is calculated using the following formula: (NIR – Red)/(NIR+Red)
NHNM	Natural Heritage New Mexico
NMDGF	New Mexico Department of Game and Fish
NMED SWQB	New Mexico Environment Department Surface Water Quality Bureau
NMFWRI	New Mexico Forest and Watershed Restoration Institute
NMHU	New Mexico Highlands University
NMRAM	New Mexico Rapid Assessment Method, version 2.0
NRCS	Natural Resource Conservation Service
PC	Plot center
RGIS	Resource Geographic Information System
SWCD	Soil and Water Conservation District
TIFF	Tagged image file format
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQCC	Water Quality Control Commission
WSS	Web Soil Survey, a soils database of the NRCS

Purpose of Report

This report covers the remote-sensing monitoring assessment performed on a forest thinning project submitted by the Santa Fe-Pojoaque Soil and Water Conservation District for the Glorieta Inc. property project to the Greater Rio Grande Watershed Alliance, initially in 2017 and again in 2020.

Glorieta Inc. Project

The 32-acre project is located on the Glorieta, Inc property in Santa Fe County 17 miles east of Santa Fe, NM. The project is one of several forest thinning projects in the area.

The project is near Hagen Creek and includes features such as barbed wire fences, a chain link fence and construction debris. It is adjacent to a water treatment facility, church building, maintenance building, and hiking trails.

This project has two forest types. There are 13 acres of cottonwood (riparian) and 19 acres of piñon-juniper (woodland). Within the riparian forest, the project will remove junipers to reduce ladder fuels and fire risk, although junipers with a diameter at root collar (DRC) of 16 inches or more will not be removed. Cottonwoods will be protected.

In the woodland, treatment goals include creating a more open stand, producing firewood, promoting understory grass cover to reduce erosion and complementing similar efforts occurring on adjacent lands. Woodland treatment will leave ponderosa and Douglas-fir trees while removing piñon and juniper. Treatment will establish defensible space around the church building, and restore a historically open meadow area.

Initial cruises in September 2020 used a 10 basal area factor (BAF). In the riparian forest, the Rocky Mountain juniper in the understory was estimated at 50 square feet per acre, with an average diameter of 5.5 inches. The juniper trees represented over 80% of the trees per acre recorded during this cruise. In the woodland, piñon and juniper (both Oneseed and Rocky Mountain) species were estimated to have a basal area of 94 square feet per acre.

No re-treatment is planned at this time. Land managers will monitor for invasive species (weeds and insects) following thinning, and may spread native seed on up to 10 acres. Land managers will also remove fuelwood following completion of treatment.

Due to the COVID-19 Pandemic during the window available for pre-treatment monitoring, NMFWRI was unable to collect traditional photo points as travel restrictions and safety issues limited our traditional field season. Remote Sensing methods were used to try to assess the pre-treatment characteristics of the riparian site using LiDAR (Light Detection and Ranging) and Aerial Imagery. These methods and protocols are outlined in Appendix III. Plot coordinates and other project geospatial data can be found in Appendix I.

Site Description

Project 17-26 is located on the Glorieta Inc. property in Santa Fe County, NM.

The nearby city of Santa Fe receives an average annual precipitation of 14.18 inches. The average high temperature is 86 degrees Fahrenheit in July. The average low is 17 degrees Fahrenheit in January. (U.S. Climate Data, 2021)

According to the NRCS Web Soil Survey, the project area is comprised of 1.0% Arents-Urban land-Orthents complex, 1 to 60 percent slopes, 41.8% Morenda, Fiesta, and Espanola soils, 1 to 85 percent slopes, flooded, 6.2% Estrada-Chacuaco complex, 2 to 8 percent slopes, 0.0% Lomapedro gravelly sandy clay loam, 25 to 50 percent slopes, 32.2% Glorieta-Ribera complex, 1 to 15 percent slopes, and 18.8% Bernal-Cueva complex, 10 to 50 percent slopes. Ecological sites within this project include F070AY021NM Pinus edulus-Juniperusmonosperma/Quercusgambleii/Bouteloua curtipendula, F070AY020NM Juniperus monospermaPinus edulus/Bouteloua gracilis-Bouteloua curtipendula F070AY022NM Pinus ponderosa-Juniperus scopulorum/Quercusgamblei, F048AY011NM Mountain Shallow Loam, F048AY012NM Wet Streambank, F048AY010NM High Mountain Loam, and R070AY001NM Loamy Upland. (USDA NRCS, n.d.)

The Pinus ponderosa-Juniperus scopulorum/Quercus gambleii site is dominated by *Pinus Ponderosa* and J*uniperus scopulorum* trees. Dominant shrubs are typically Gambel oak and mountain mahogany. Grasses include *Poa fendleriana* and *Muhlenbergia montana*. The surface texture of the site is Cobbly sandy loam, and Stony fine sandy loam. It is well-drained and moderately permeable. Site degradation may occur from overgrazing. (USDA NRCS, n.d.)

The Loamy Upland site occurs on nearly level to undulating upland plains, alluvial fans and some depressions. Soils are moderately deep to deep, with textures such as loams, silt loams and clay loam. The soils have the ability to store moisture from winter snowfall and early spring rains for use by cool-season forbs and grasses. Vegetation is dominated by shrubs such as winterfat and prairie sagewort, and grasses like blue grama and Western wheatgrass. (USDA NRCS, n.d.)

The Pinus ponderosa-Juniperus scopulorum/Quercus gamblei Juniperus monosperma Pinus edulus/Bouteloua gracilis-Bouteloua curtipendula site occurs on valley sides, hills, and mesas. Slopes tend to be steep. Woody vegetation is dominated by piñon, Oneseed juniper, and Gambel oak, while sideoats grama and Fernald's blue grass are common herbaceous species. (USDA NRCS, n.d.)

The Mountain Shallow Loam, Wet Streambank, and High Mountain Loam are all obsolete ecological sites. This means labels indicated in the soil map are no longer tied to Ecological Site Descriptions. We will update the report when updates are available from NRCS. (USDA NRCS, n.d.)

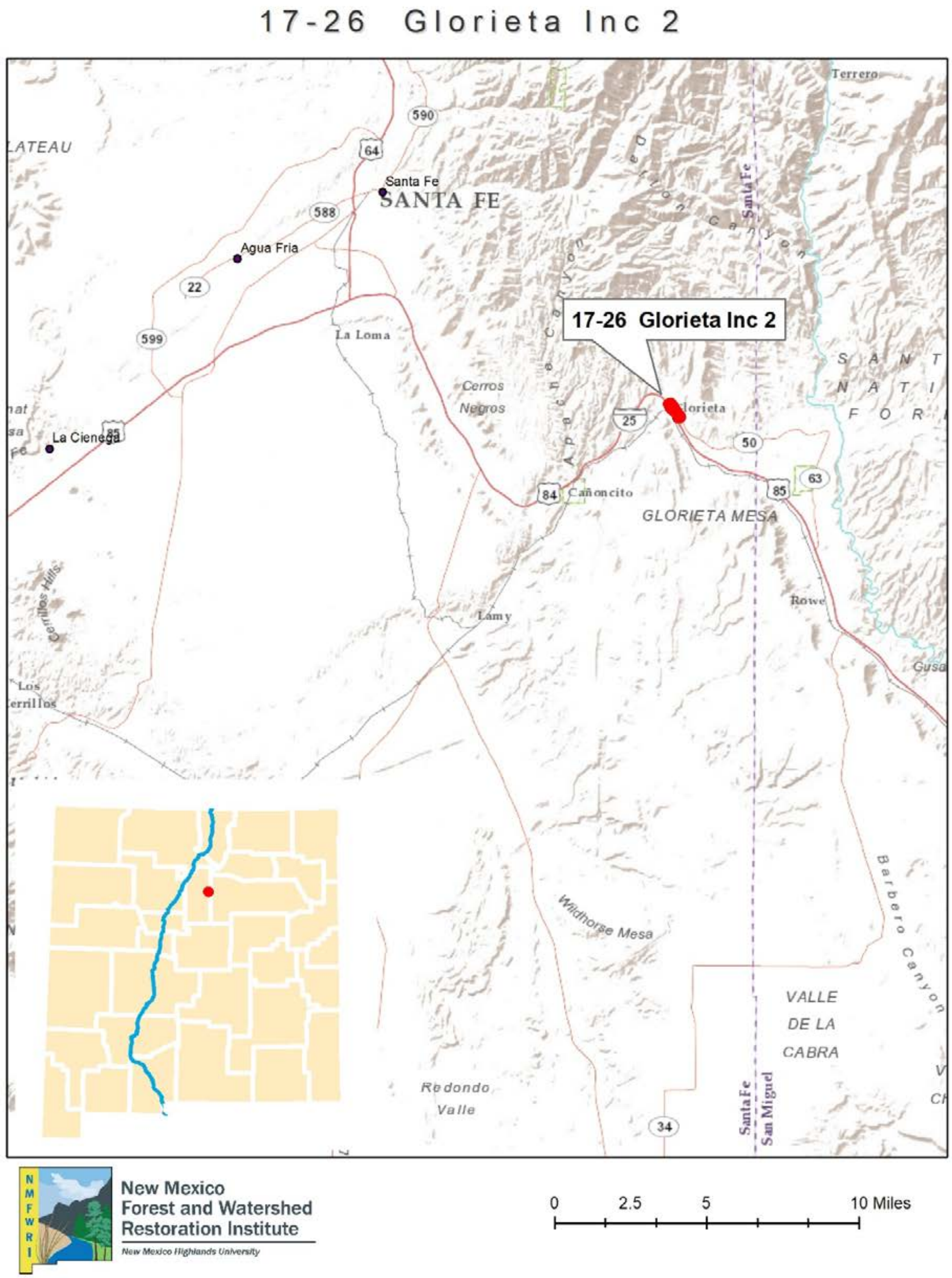


Figure 1. Project 17-26 in geographic context.

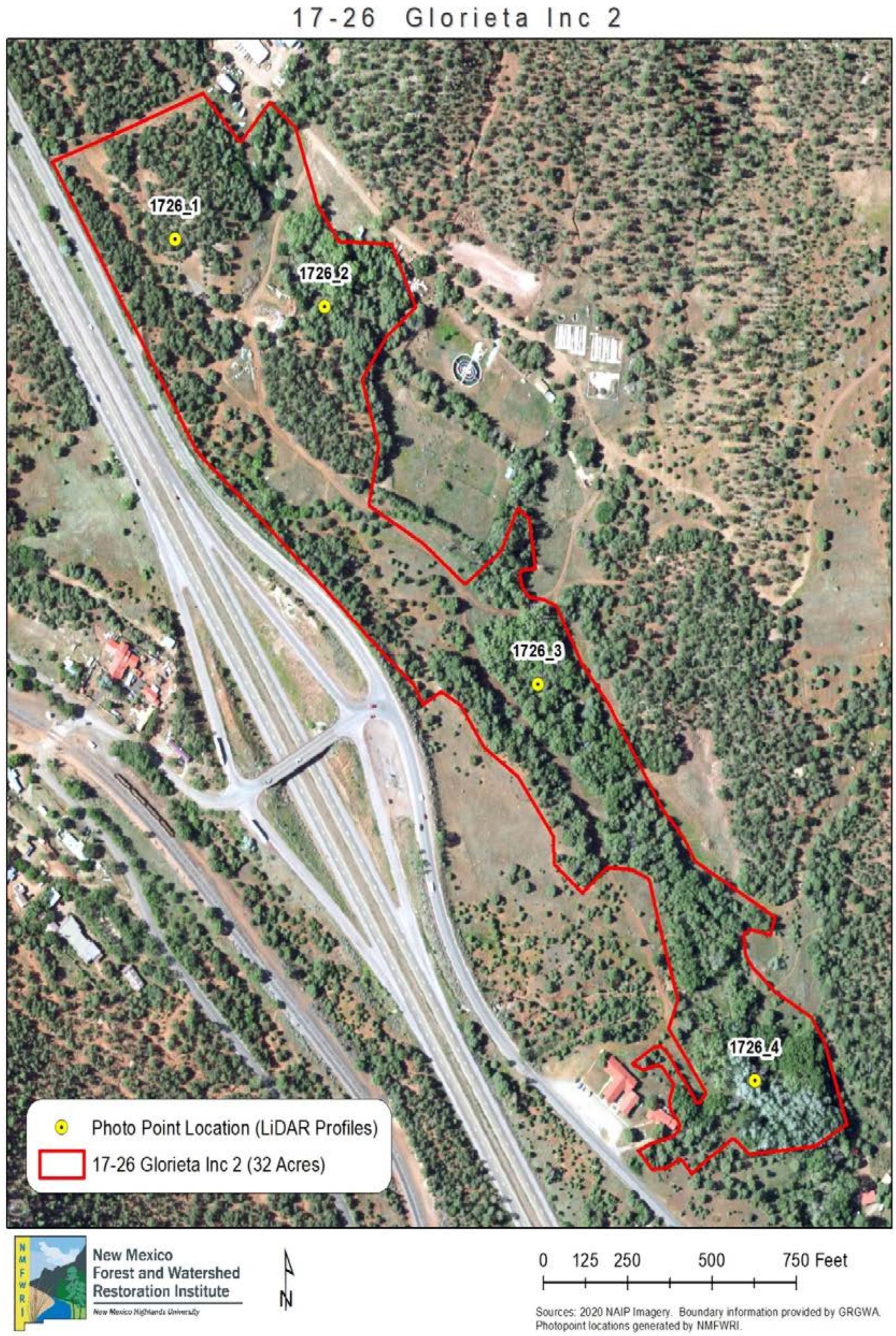


Figure 2. 17-26 Glorieta project outline.

Pre-Treatment Monitoring

Vegetation Vertical Structure Type Classification

To develop a vegetation height classification, LiDAR and NAIP imagery were analyzed using eCognition software. An object oriented classification systems was used so that spectral characteristics as well as height above ground values of the vegetation could be incorporated into a robust classification system. (See Appendix III for details.)

17-26 Glorieta Inc. was classified according to modified Hink and Ohmart defined classes. The acreage for each cover type are provided below keeping in mind that the total acreage for the treatment acres was 32 acres.

Type 2-Low Structure Forest with little or no understory (11.67 Acres). This represents tall mature to intermediate-aged trees {>5 m [>15 feet]) with canopy covering >25% of the area of the community and understory layer {1-5 m [3-15 feet]) covering <25% of the area of the community. Majority of foliage is over 5m (15 feet).

Type 5 -Tall Shrub Stands (8.29 Acres). Young tree and shrub layer only {1.5-5 m [4.5-15 feet]) covering >25% of the area of the community. Stands dominated by tall shrubs and young trees, may include herbaceous vegetation underneath the woody vegetation.

Type 65- Short Shrub Stands (1.49 Acres). Short stature shrubs or very young shrubs and trees (up to 1.5 m [up to 4.5 feet]) covering >10% of the area of the community (polygon). Stands dominated by short woody vegetation, may include herbaceous vegetation underneath the woody vegetation.

Type 6H- Herbaceous (2.06 Acres). Herbaceous vegetation covering >10% of the area of the community. Stands dominated by herbaceous vegetation of any type except obligate wetland species. Woody species absent or <10% cover.

Bare Ground (8.46 Acres). Areas of bare soil or bare rock with no vegetative cover.

See the Figures on the following page for maps showing the distribution of these structure types.

Vegetation Structure Type	Acres	Percent of Total Area
Forest Type 2	11.67	36.52%
Type 5 Tall Shrubs	8.29	25.93%
Type 6S Short shrubs	1.49	4.65%
Bare Ground	8.46	26.47%
Type 6H Heraceous	2.06	6.44%

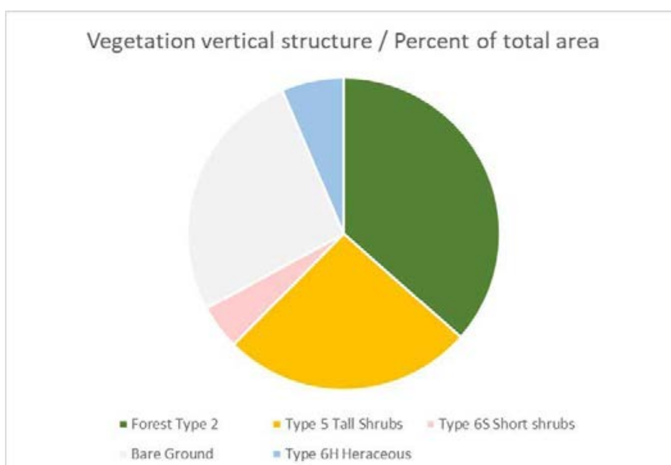


Figure 3. Vegetation Structure Type percents for 17-26.

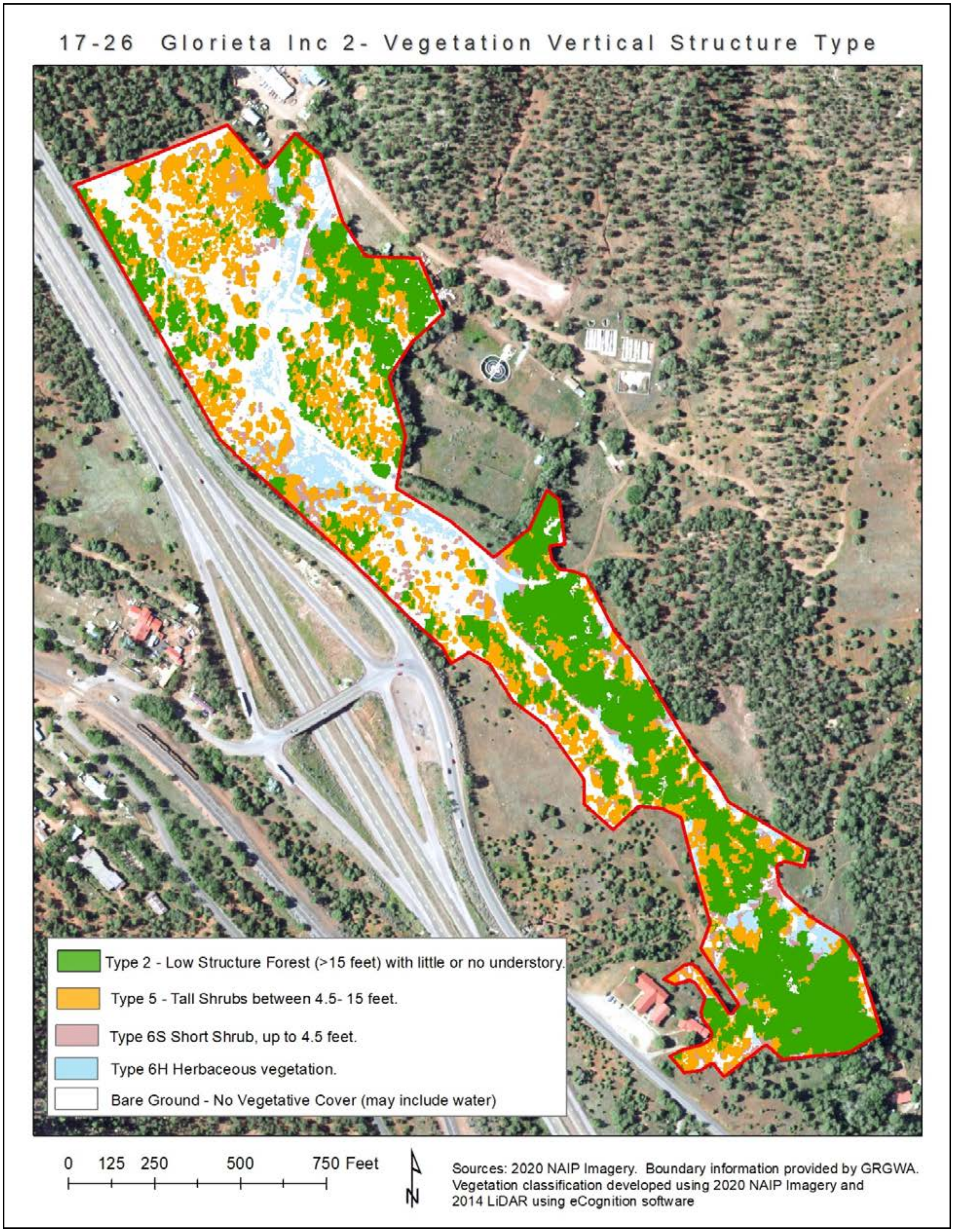


Figure 4. Vegetation structure classification for 17-26.

LiDAR Profiles

In order to visualize the pre-treatment area without photographs, LiDAR profiles were created at each photopoint locations. Again, due to the COVID-19 Pandemic, traditional photo points were not collected as travel restrictions and safety issues limited our traditional field season. Four profiles were created at each photo point location. The transects were drawn using the photo point in the center of a 20 x 130 meter window or 65 x 426 feet.

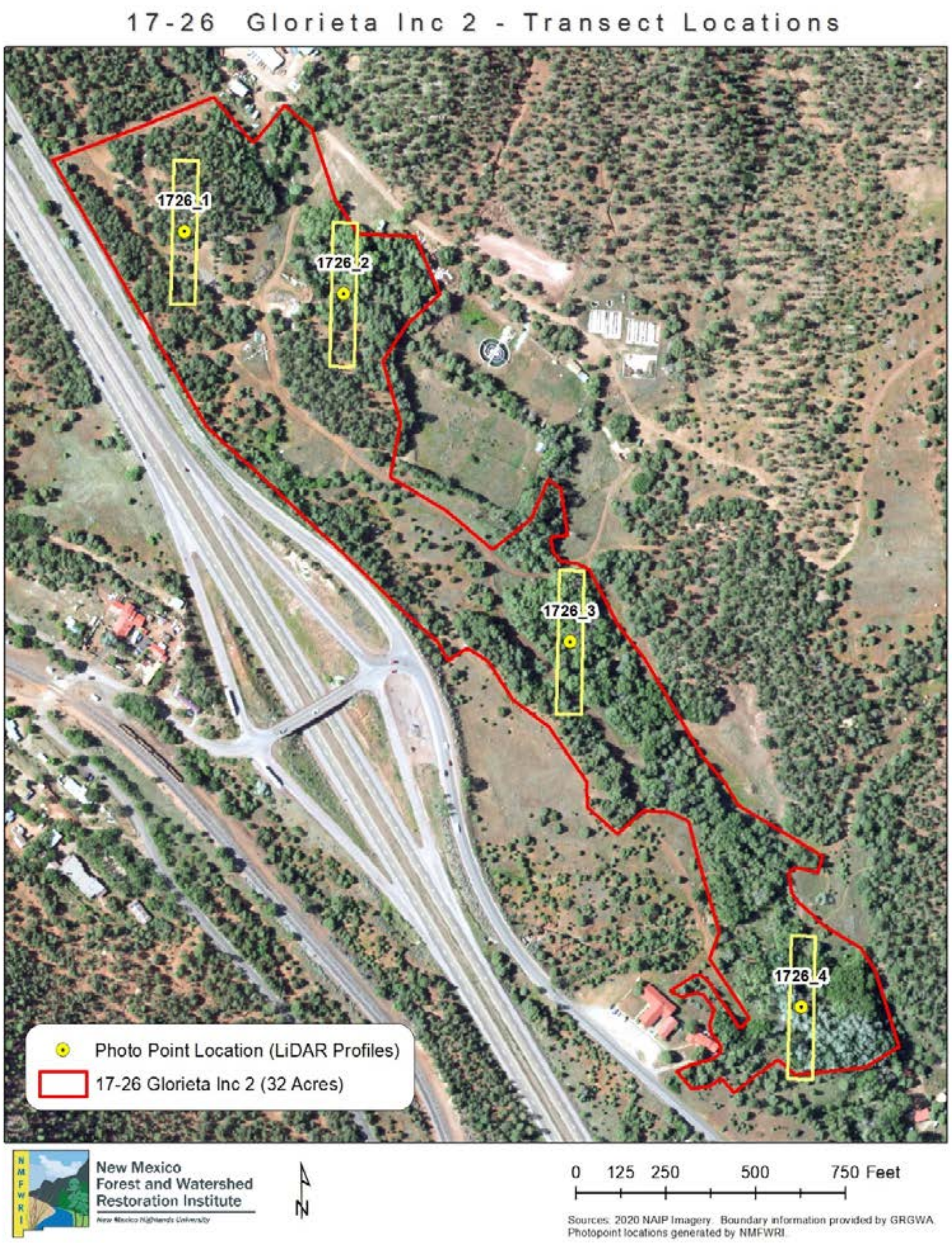
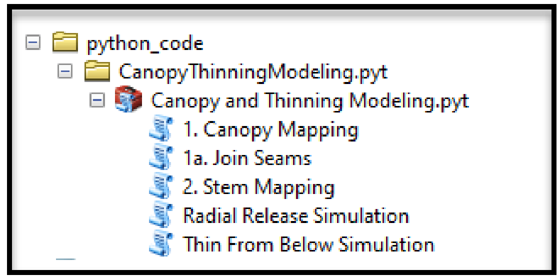


Figure 6. LiDAR Transect Locations for 17-26.

Deriving Tree Canopy Footprints and Number of Trees using LiDAR

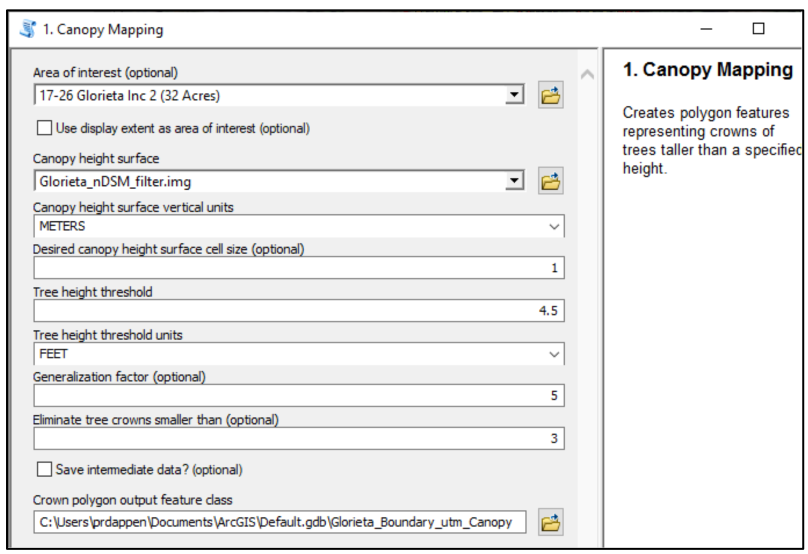
Since the 17-26 Glorieta Inc. 2 project area is located in an upland forest dominated stand, it was important to try to measure other forest metrics of the stand in addition to tree height. The US Forest Service, Pacific Northwest Region, Data Resources Management department has developed a Python tool using ArcMap 10.7.1 that identifies tree canopies and then estimates the number of tree stems.

The input for this tool it a nDSM or a normalized digital surface model that represents height above ground. For the 17-26 Glorieta Inc. 2 project area, the nDSM was calculated and a low pass filter was performed to smooth the elevation values to remove 'spikes' in the elevation values. Once the nDSM was smoothed, it was used as an input into the canopy model.

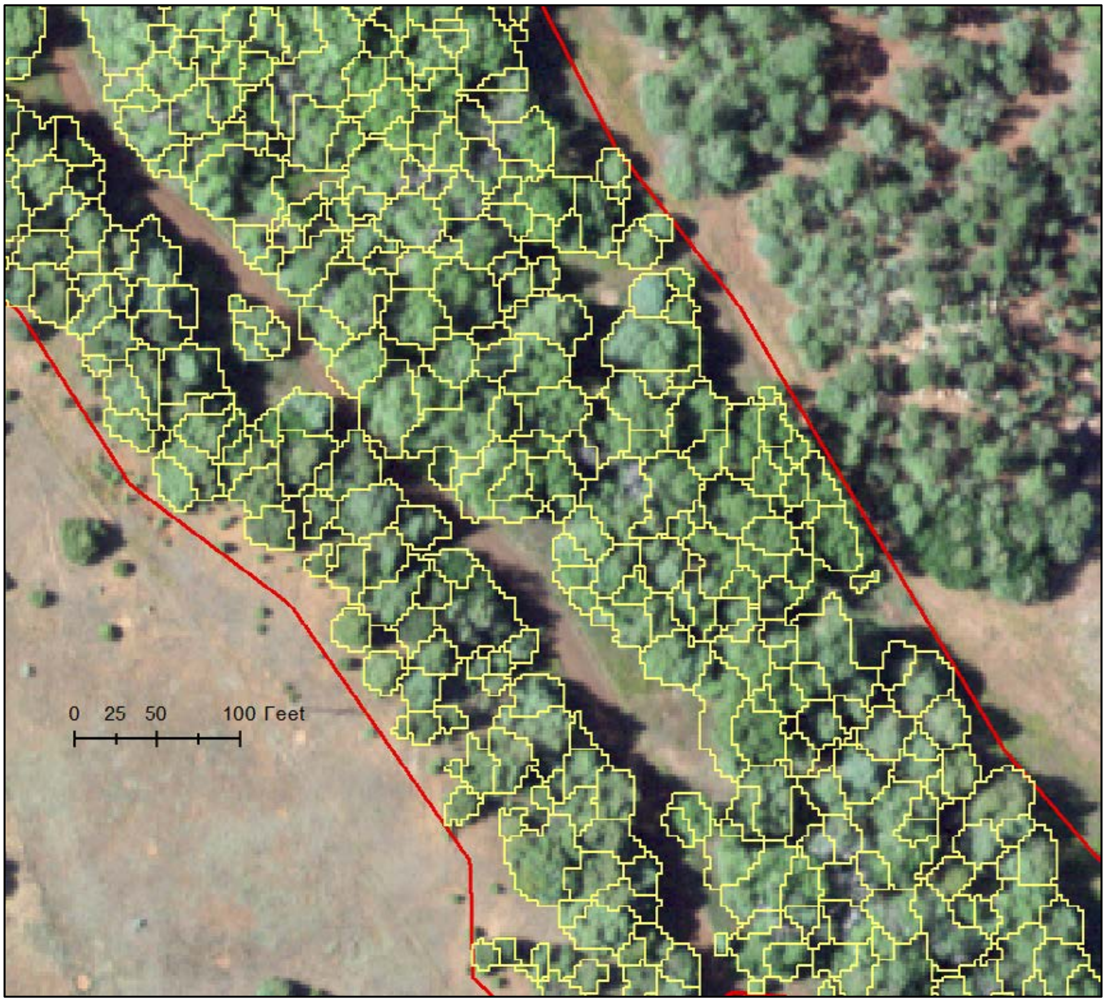


Tree Canopy Mapping

For this section of the project we were interested in identifying tree canopy for trees greater than 4.5 feet. The desired outcome was to estimate the number of matures trees to derive the number of Trees Per Acre (TPA). Within the modeling program, you can specify the threshold height, above which crowns will be identified. This value was set to 4.5 feet. Other factors can be modified to better represent canopy features such as a generalizing factor and minimum tree threshold sizes.

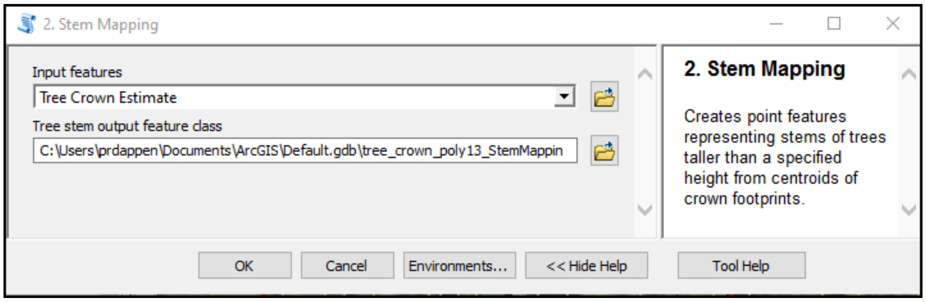


Because the LiDAR for the study area was flown in 2014, there were some trees that were no longer present in 2020. To solve for this, the 2020 imagery was used to visually inspect and remove non trees. Canopy polygons were deleted if there were no evidence of trees in the 2020 imagery. This edited canopy polygon layer was used as the input for the next step in determining number of mature trees (stems).



Tree Crown Polygons Mapped using LiDAR – 17-26 Glorieta Inc 2

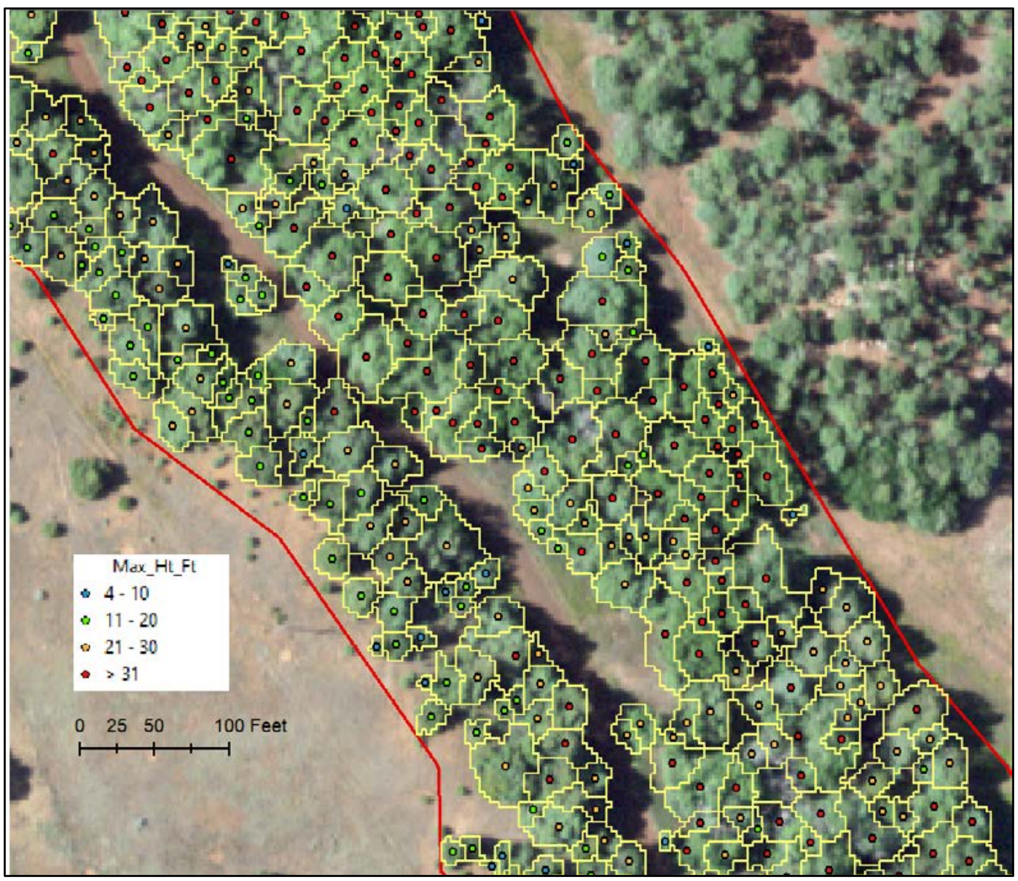
Estimating Number of Trees (Stems)



Using the tree crown polygon layer edited from step 1, centroids were created in the centers of the tree crown footprints. 1784 mature live trees were calculated for the 17-26 Glorieta Inc. 2 study area. Within the tree stem and canopy footprints, the attributes include maximum canopy height and mean height.

For the 17-26 Glorieta Inc. 2 study area an estimated 1,784 mature live trees were identified. For this 32 acre project area, Trees per acre was an estimated at 55.75.

Tree Height Class	Number of Trees
4 -10 feet	178
11-20 feet	700
21-30 feet	427
Greater than 31 feet	479



Tree Stems Identified using Tree Crown Footprints

Conclusions & Plans going forward

This project will be re-measured five years post-treatment to monitor the success of treatment in effecting long-term change. The re-measurement plans will include both field measurements on the plots and remote sensing analysis. It is our intention and expectation that the data collected in these intervals will reflect any significant changes in disturbance and ecological function of the site. The water on site will likely support heavy re-sprouts, and treatment maintenance will be key.

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Appendix I – Photopoint and Plot Coordinate Table

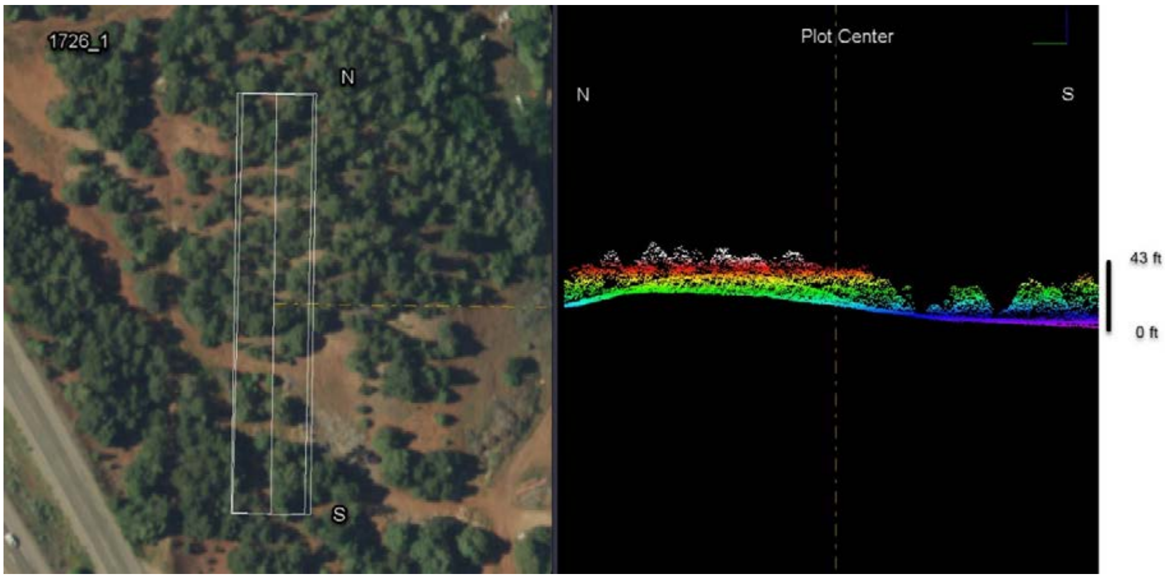
Photo_ID	PROJNAME	SWCDTXT	IDproject	Latitude	Longitude
1726_1	Glorieta Inc	Santa Fe-Pojoaque	17-26	35.58557214470	-105.76760460800
1726_2	Glorieta Inc	Santa Fe-Pojoaque	17-26	35.58646875310	-105.76731248200
1726_3	Glorieta Inc	Santa Fe-Pojoaque	17-26	35.58355244530	-105.76522888100
1726_4	Glorieta Inc	Santa Fe-Pojoaque	17-26	35.58077651360	-105.76303817100

Appendix II – LiDAR Transect Images

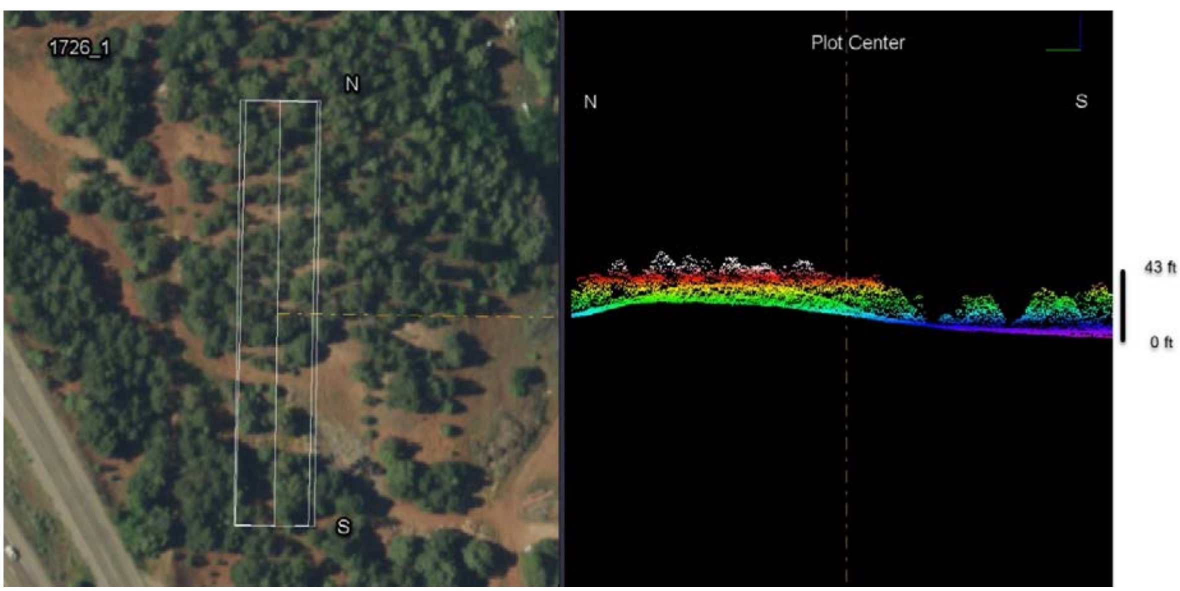
These LiDAR transects were drawn using the photo point in the center of a 20 x 130 meter window (65 x 426 feet). The transects were drawn north to south, and the aerial view of the areas is on the left in the images below. On the right is the LiDAR profile. The scale on the far right of each image represents the vertical height, and is marked from 0 feet (ground level) to the highest object height recorded in each transect.

These transects provide a visual representation of the canopy cover and vegetation structure present on site.

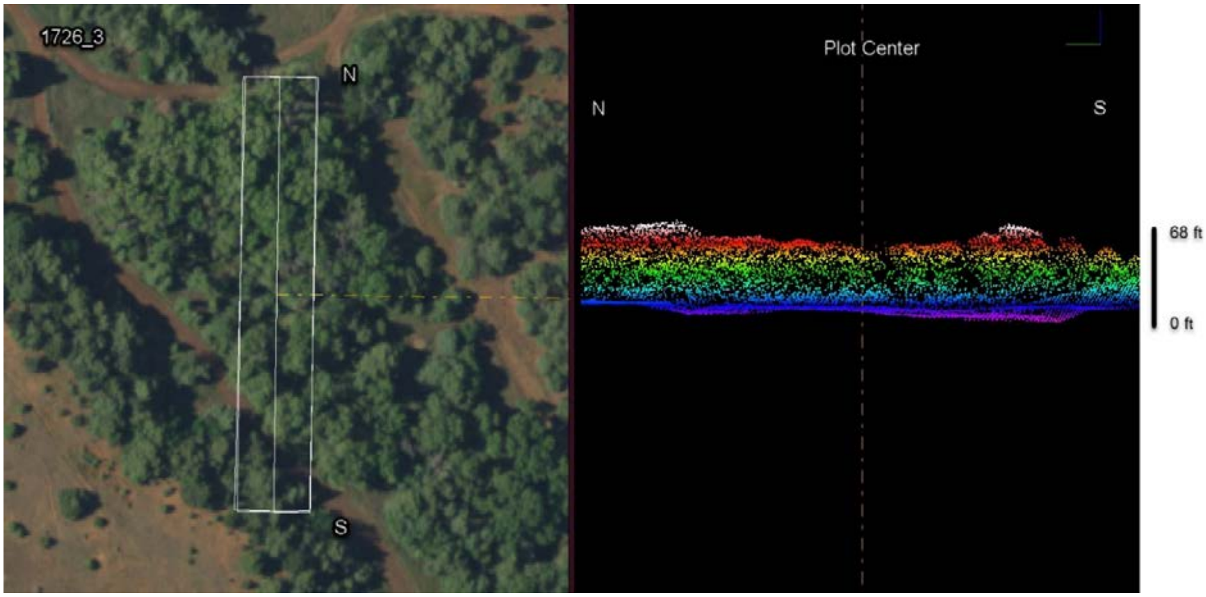
1726_1 LiDAR Profile



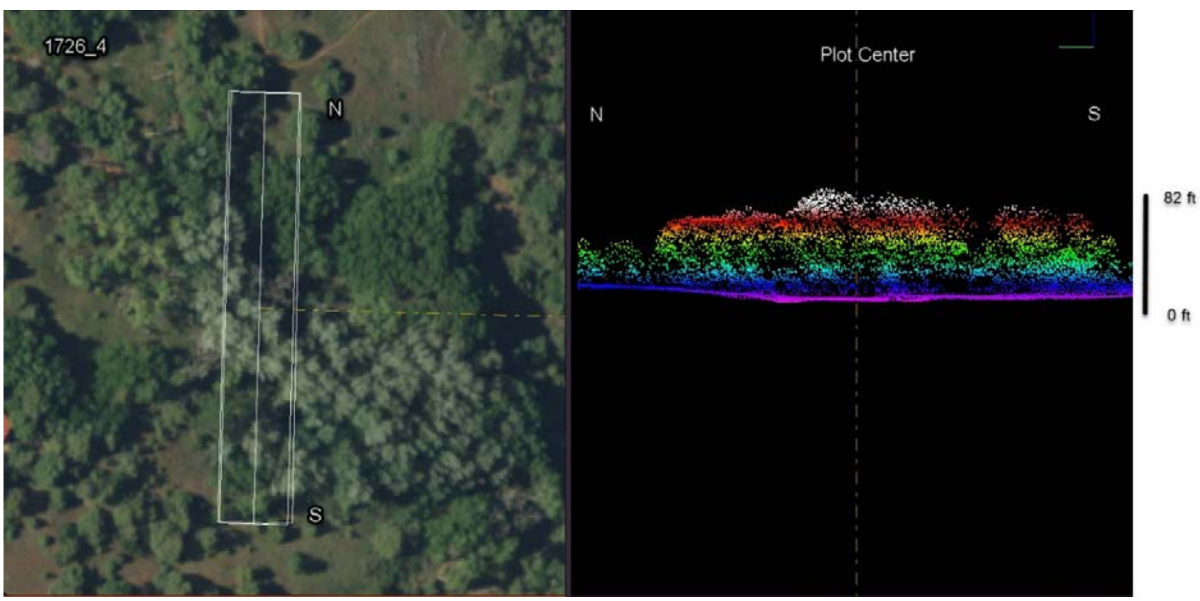
1726_2 LiDAR Profile



1726_ 3 LiDAR Profile



1726_ 4 LiDAR Profile



Appendix III – Remote Sensing Monitoring and Analysis Methods

Due to the COVID-19 Pandemic, traditional photo points were not collected as travel restrictions and safety issues limited our traditional field season. Remote Sensing methods were used to try to assess the pre-treatment characteristics of the riparian site using LiDAR (Light Detection and Ranging) and Aerial Imagery.

Using LiDAR, one is able to develop a very accurate elevation model as well as estimating surface feature heights and characteristics by using a multiple return, high density, LiDAR data set. Airborne laser sensors provide information to analyze forests in a 3-D format over large areas. Current LiDAR systems provide georeferenced information of the vertical structure of land cover features. Laser pulses from a sensor carried aboard an aircraft are directed toward the ground to collect ranging data to the top of the canopy, and in some instances, to sub canopy layers of vegetation and to the ground (Popescu, 2002).

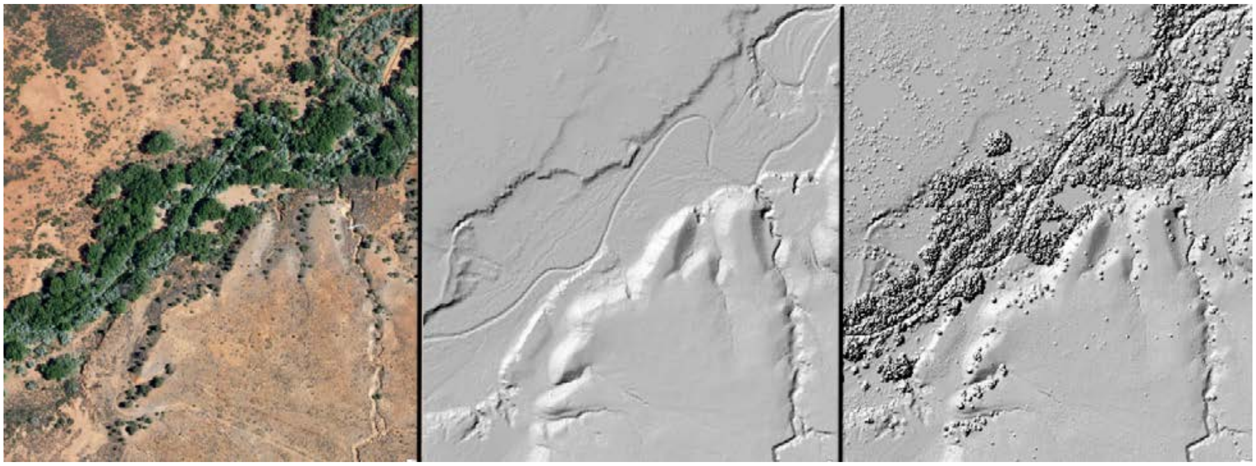
To develop a vegetation height classification, LiDAR and NAIP imagery were analyzed using eCognition software. An object oriented classification systems was used so that spectral characteristics as well as height above ground values of the vegetation could be incorporated into a robust classification system. LiDAR was also used to develop Vegetation Height Profiles for areas around the photo point locations.

LiDAR (Light Detection and Ranging) point clouds for this county were collected in 2014 and 4-Band 2020 Aerial Imagery with the Near Infra-Red band was incorporated to develop a classification stratifying vegetation within height classes. LiDAR was also used to develop Vegetation Height Profiles for areas around the photo point locations.

2014 LiDAR Processing

2014 LiDAR for the Glorieta site was downloaded from The USGS 3DEP LiDAR Explorer (https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/) in LAS file format.

Using the 2014 LiDAR, A Digital Terrain Model (DTM) was created by filtering only the point clouds classified as ground and then only those ground point clouds were converted to a raster DTM. Next, LiDAR first returns were filtered and selected to represent surface features. Only those first returns were converted to a raster Digital Surface Model (DSM). Bird and other noise that were not surface features were removed before creating the raster DSM. In order to get true heights above ground the Digital Surface Model was subtracted from the Digital Terrain model creating a Normalize Digital Surface Model (nDSM). The values of the nDSM were heights above ground in meters.



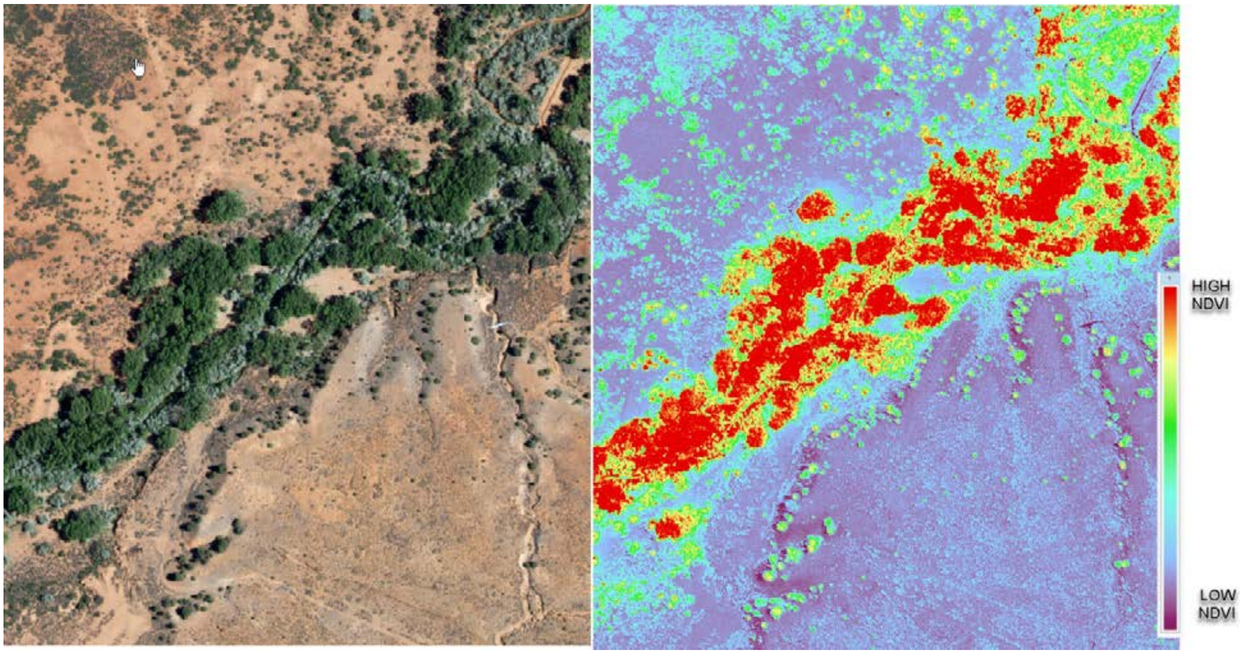
2020 NAIP *LiDAR Derived Digital Terrain Model* *LiDAR Derived Digital Surface Model*

2020 National Agriculture Imagery Program (NAIP) Imagery

The other input to this classification was the 2020 National Agriculture Imagery Program (NAIP) digital ortho photography. The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to make digital ortho photography available to governmental agencies and the public within a year of acquisition.

The 4-Band 2020 NAIP for the Glorieta Inc. 2 project was downloaded from Earth Explorer (https://earthexplorer.usgs.gov/)

The 2020 NAIP ortho photography are 4-Band images. Band 1 is Visible Red, Band 2 is Visible Green, Band 3 is Visible Blue, and Band 4 is Near-InfraRed. Having the Near-InfraRed band is very important for vegetation assessments and necessary to calculate the Normalized Difference Vegetation Index (NDVI). This index is widely used to assess vegetation health and leaf structure. NDVI takes into account the amount of red energy that is absorbed by chlorophyll and the amount of near-infrared energy that is reflected by the cellular structure of the leaf (because the red and near infrared measurements are normalized in an indirect measure of vegetation health). The formula is (NIR – Red)/ (NIR + Red), where NIR is the Near Infrared Band, and Red is the Red Band (Carlson & Ripley, 1997).



Normalized Difference Vegetation Index NDVI Calculation

Vegetation Vertical Structure Classification using eCognition (modified Hink and Ohmart)

eCognition software is an object based image classification system that allows for a semi-automated analysis of high resolution images. This approach divides the image into meaningful homogenous regions, known as image objects. These image objects are groups of pixels that are adjacent to each other and are spectrally similar. Once image objects are created, they provide a great deal of information from which an image classification can be developed.

Having height information with LiDAR greatly increases the accuracy of the classification. Though the use of traditional remote sensing is an effective means of mapping and monitoring land cover, the mapping of small shrubs and trees based only on spectral information is challenged by the fact that shrubs and trees often spectrally resemble grassland and thus cannot be safely distinguished and classified. With the aid of LiDAR-derived information, such as height, the classification of spectrally similar objects can be improved (Hellesen & Matikainen, 2013).

Image segmentation within eCognition was based on elevation surface models. The 4-Band NAIP imagery was used to calculate image brightness values and NDVI values were calculated and both were used as inputs to identify vegetated and non-vegetated areas. The image was classified to identify vegetation vertical structure types representative of the modified Hink and Ohmart system developed by NMED (Muldavin, 2014). LiDAR profiles were used to identify understory vegetation to determine if forested area were Types 1 or Type 2. A digital surface model for all heights above ground was used to classify single-story Communities (Types 5, 6S, 6H, and 7). This classification incorporated height classes as well as NDVI to identify active vegetation. Once the vegetation was classified by height the resulting classification was exported from eCognition as a Raster image and acreages were calculated.

Appendix IV – Ecological Context of Bosque Restoration

Neither the challenges nor the importance of working in the bosque and other riparian areas in New Mexico today should be underestimated. According to the New Mexico Department of Game and Fish Conservation Division, wetlands and riparian areas comprise approximately 0.6 percent of all land in New Mexico (2012). Despite this small percentage, estimates of New Mexican vertebrate species depending on wetland and riparian habitat for their survival ranges from 55% (New Mexico Department of Game and Fish Conservation Services Division, 2012) to 80% (Audubon New Mexico, 2013). These areas also provide flood mitigation, filtration of sediment and pollutants, and water for a variety of purposes including groundwater recharge (Audubon New Mexico, 2013). In addition, native vegetation such as cottonwoods have cultural significance to many communities.

As much as these areas are disproportionately important to ecosystems and human communities, they are equally disproportionately impacted by disturbance. Anthropogenic impacts with major consequences for our riparian areas include dams, reservoirs, levees, channelization, acequias and ditches, jetty jacks, riprap and Gabion baskets, urbanization, removal of native phreatophytes, grazing by domestic livestock, excessive grazing pressure by native ungulate populations absent natural predation cycles, beaver removal, logging, mining, recreation, transportation, introduction and spread of invasive exotic species, groundwater extraction, altered fire and flood regimes drought and climate change (Committee on Riparian Zone Functioning and Strategies for Management, et al., 2002). Statewide, it is estimated that as much as 90% of New Mexico's historical riparian areas have been lost (Audubon New Mexico, 2013), and approximately 39% of our remaining perennial stream miles are impaired (New Mexico Department of Game and Fish Conservation Services Division, 2012).

New Mexico *is* fortunate enough to have the Middle Rio Grande Bosque, the largest remaining bosque in the Southwest (USDA USFS, 1996). However, over the past two decades, the number of fires in the bosque has been increasing. Historically, the primary disturbance regime in the bosque has been flooding, not fire, which means the system is not fire-adapted. In fact, native species like cottonwood resprout from their roots after floods and need wet soils to germinate from seed. Flooding also promotes decomposition of organic material and keeps the soil moist which reduces the likelihood of fire. Today, overbank flow is uncommon in many areas of the Rio Grande due to the heavy alteration of the channel and flow regimes (two obvious examples are the structures defining the upper and lower extent of the Middle Rio Grande: Cochiti Dam and Elephant Butte Reservoir). This has led to low fuel moisture content and high fuel loads, as well as increased human presence in the riparian area. As a result, bosque fires are more common and more severe: they kill cottonwoods and other native species, creating spaces which are filled by non-native species such as salt cedar, Russian olive, Siberian elm, and Tree-of-Heaven. We are constantly learning more about how these species can exploit and encourage a riparian fire regime, in addition to many other changes they bring to ecosystems.

Efforts geared toward the removal of these nonnative species can help to reduce fire risk, preserve native vegetation, and be part of a larger effort to restore the bosque and the watershed as a whole to a more natural and functional ecosystem. The Greater Rio Grande Watershed Alliance (GRGWA) has been working on these issues with a variety of collaborating organizations and agencies within the Rio Grande basin for several years. Since 2013, the New Mexico Forest and Watershed Restoration Institute (NMFWRI) has been working with GRGWA and the Claunch-Pinto Soil and Water

Conservation District (SWCD) to begin construction of a geodatabase for all of GRGWA's non-native phreatophyte removal projects as well as to perform the formal pre- and post-treatment monitoring, utilizing the field methods explained below as well as LIDAR analysis where appropriate and available.

Appendix V - Modified Hink and Ohmart categories, from NMRAM

The following is pages 39-41 in Muldavin et al.'s 2014 NMRAM for Montane Riverine Wetlands v 2.0 Manual (draft, not yet published)

Vegetation Vertical Structure Type Definitions for NMRAM

Multiple-Story Communities (Woodlands/Forests)

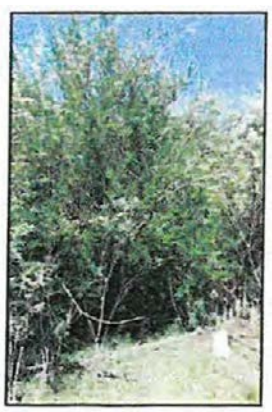
Type 1- High Structure Forest with a well-developed understory.

Tall mature to intermediate-aged trees (>5 m [>15 feet]) with canopy covering >25% of the area of the community (polygon)and understory layer (0-5 m [0-15 feet]) covering >25% of the area of the community (polygon). Substantial foliage is in all height layers. (This type incorporates Hink and Ohmart structure types 1 and 3.) Photograph on Gila River by Y. Chauvin, 2012.

Type 2 -Low Structure Forest with little or no understory.

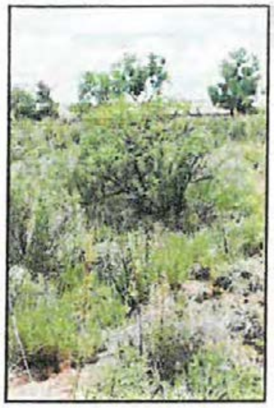
Tall mature to intermediate-aged trees (>5 m [>15 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (1-5 m [3-15 feet]) covering <25% of the area of the community (polygon). Majority of foliage is over 5 m (15 feet) above the ground. (This type incorporates Hink and Ohmart structure types 2 and 4.) Photograph on Diamond Creek by Y. Chauvin, 2012.

Single-story Communities (Shrublands, Herbaceous and Bare Ground)



Type 5 -Tall Shrub Stands.

Young tree and shrub layer only (1.5-5 m [4.5-15 feet]) covering >25% of the area of the community (polygon). Stands dominated by tall shrubs and young trees, may include herbaceous vegetation underneath the woody vegetation. Photograph on San Francisco River by Y. Chauvin, 2012.

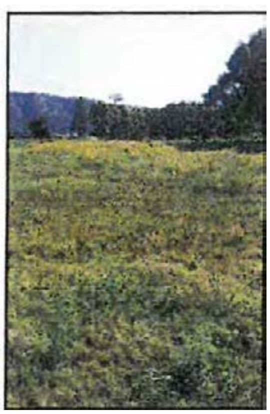


Type 6S-Short Shrub Stands.

Short stature shrubs or very young shrubs and trees (up to 1.5 m [up to 4.5 feet]) covering >10% of the area of the community (polygon). Stands dominated by short woody vegetation, may include herbaceous vegetation underneath the woody vegetation. Photograph on Lower Pecos River by E. Lindahl, 2008.

Type 6W-Herbaceous Wetland.

Herbaceous wetland vegetation covering >10% of the area of the community (polygon). Stands dominated by obligate wetland herbaceous species. Woody species absent, or <10% cover. Photograph of *Carex nebrascensis* meadow on upper Rio Santa Barbara by Y. Chauvin, 2009.



Type 6H-Herbaceous.

Herbaceous vegetation covering >10% of the area of the community (polygon). Stands dominated by herbaceous vegetation of any type except obligate wetland species. Woody species absent or <10% cover. Photograph on Diamond Creek by Y. Chauvin, 2012.

Type 7–Sparse Vegetation/Bare Ground.

Bare ground, may include sparse woody or herbaceous vegetation, but total vegetation cover <10%. May be natural in origin (cobble bars) or anthropogenic in origin (graded or plowed earth) Photograph on Lower Gila River by Y. Chauvin, 2012.