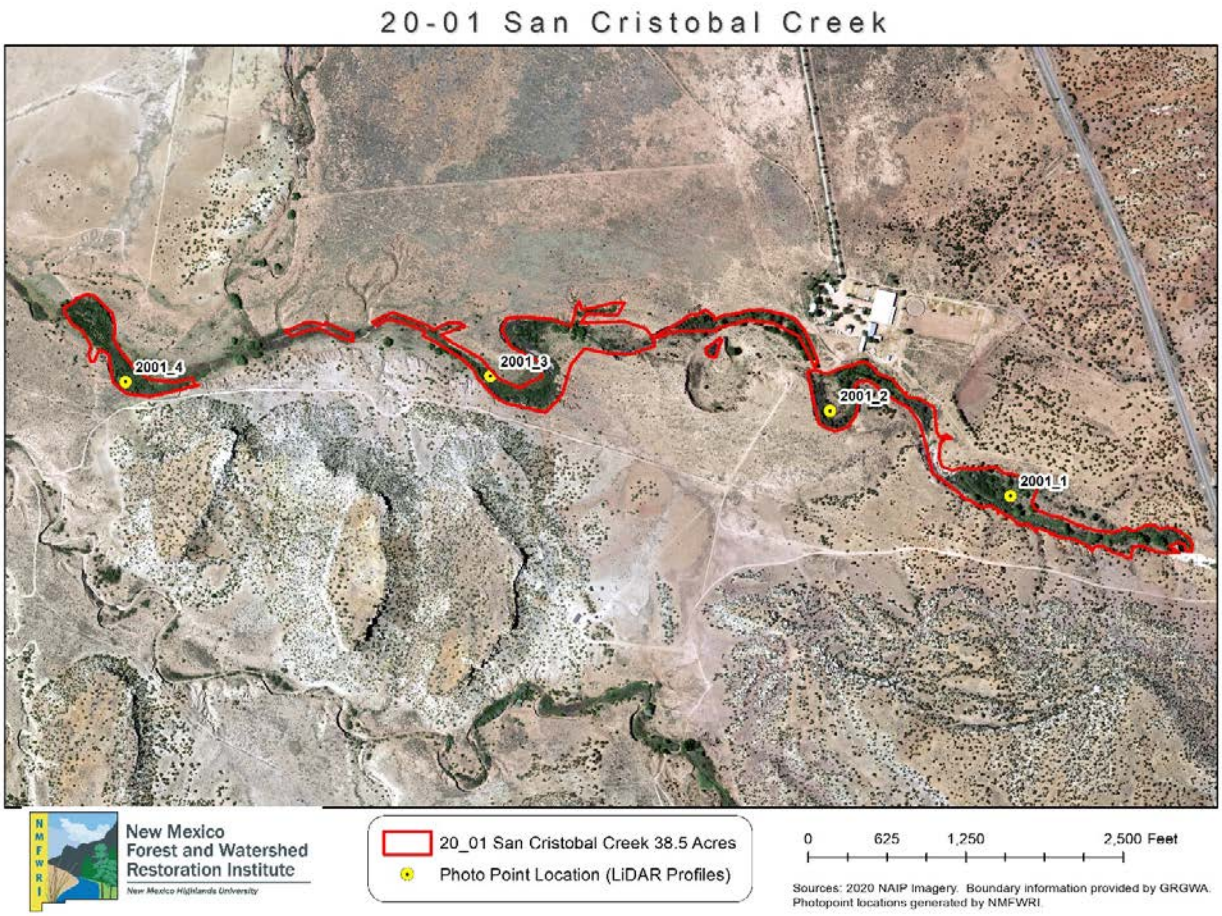
San Cristobal Project 20-01

Pre-treatment Monitoring Report

2020/2021



Prepared by
Patti R Dappen, GIS Program Manager
Kathryn R Mahan, Ecological Monitoring Specialist
Gerardo Montijo, Monitoring and Data Technician
New Mexico Forest and Watershed Restoration Institute
for the Greater Rio Grande Watershed Alliance

Santa Fe - Pojoaque Soil & Water Conservation District

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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 non-native phreatophyte removal project submitted by the Santa Fe – Pojoaque Soil and Water Conservation District for the San Cristobal project to the Greater Rio Grande Watershed Alliance in 2020.

San Cristobal Project

The project is located on the San Cristobal Ranch, Galisteo Basin, San Cristobal Drainage, Galisteo, in Santa Fe County, NM. This is an initial treatment of isolated patchy to heavy density nonnative phreatophytes in a perennial stream riparian zone. The proposed project is 38.4 acres and represents the highest priority project area for the ranch. The area consists of six separate polygons that have not been previously treated, but are surrounded by treated areas. There are several patches of scattered, low-density salt cedar and Russian olive, as well as small areas of heavy-density salt cedar. The Tamarisk leaf beetle has impacted some salt cedar trees in the drainage; although dead/dying branches may be present, all salt cedar will be treated as live. Siberian elm will not be treated except for a designated 1.4-acre area that will treat pole sized Siberian elm that are 8 inches or less at diameter at breast height (DBH). There are various age groups of willow and cottonwoods, including snags and fallen cottonwood logs; these will be excluded from treatment.

The treatment will reduce frequency and height of non-native phreatophytes, increase forage for wildlife and grazing, reduce channelization and soil erosion in the drainage, promote natural hydraulic processes, increase overland water flow and increase ecosystem function and health. Natural vegetation such as the cottonwoods and willows should become more established, and it is likely there will be increased flow of water near two springs that feed open water pools in the drainage bottom.

Steep sides and wet conditions may provide challenges to operability and access. A second re-treatment should take place three years after the initial treatment. Monitoring for the desired condition should take place five years after the initial project.

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. 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 20-01 is located on the San Cristobal Ranch, Galisteo Basin, San Cristobal Drainage, Galisteo, NM Santa Fe County. 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 with 23.6 Devargas-Riovista-Riverwash complex, 0 to 5 percentslopes, flooded, 18.1% Jocity-Gilco complex, 1 to 3 percent slopes.1.6% Wenota silty clay loam, 1 to 6percent slopes, 1.8% Penistaja family fine sandy loam, 1 to 3 percent slopes, 3.7% Zia-Gullied land complex, 2 to10 percent slopes, 2.9% Penistaja family loam, 3 to 8 percent slopes, 59.7% Jaralosa-Chupe-Riverwash complex, 0 to 1 percent slopes, flooded, 8.2% Sena very fine sandy loam, 0 o to 2 percent slopes, and 0.1% Oelop-Charalito complex, 1 to 3 percent slopes.

Ecological sites contained within the project area include R035XA112NM Loamy, R035XG114NM Gravelly, R035XA113NM Sandy, R035XA126NM Salt Flats, and R035XA005NM Riverine Riparian. (NRCS USDA, 2020)

The Gravelly ecological site type typically supports grassland with minor shrub and piñon-juniper components. Common dominant grass species include blue, black and sideoats grama, little bluestem, spike muhly, Western wheatgrass, New Mexico feathergrass, Indian ricegrass, and squirreltail. Common shrubs include fourwing saltbush, winterfat, Apache plume, rabbitbrush, soapweed yucca, sagebrush and broom snakeweed. The site can also be found in a shrub-encroached state dominated by rabbitbrush and blue grama; erosion is more common in this state. (USDA NRCS n.d.)

The Loamy ecological site typically supports a grassland state dominated by blue grama, western wheatgrass, galleta, ring muhly, dropseeds, and/or threeawns. It can also be found in a piñon-juniper invaded state (dominated by piñon, juniper, and blue grama), a grass/succulent-mix state (dominated by blue grama, cholla and prickly pear), a shrub-dominated state (dominated by rabbitbrush or horsebrush and blue grama), as well as a bare state with sparse grass. (USDA NRCS n.d.)

The Sandy ecological site typically supports plant communities composed of fourwing saltbush, winterfat, and sagebrush at the shrub layer, and at the herbaceous layer, Rocky Mountain bee plant, blue grama, western wheatgrass, threeawns, galleta, dropseed, Indian ricegrass, needle-and-thread, squirreltail, and New Mexico feathergrass. This may also support a shrub-dominated state (dominated by sagebrush, rabbitbrush with a blue-grama/threeawn/dropseed/muhly understory), as well as a juniper-dominated state (with a patchy grass understory of blue grama, dropseeds, galleta, Indian ricegrass and threeawn). (USDA NRCS n.d.)

The Salt Flats ecological site type is typically dominated by alkali sacaton along with western wheatgrass, blue grama, vinemesquite grass, galleta, inland saltgrass, and spike muhly. Dominance of grass species is determined by salt; salty sites are dominated by alkali sacaton while areas with less salt tend to have more blue grama and galleta. Shrubs include fourwing saltbush, shadscale, and greasewood and are typically scattered when grass is dominant. However, a shrub-dominated state is possible with overgrazing and/or drought. A gullied state is also possible as a site deteriorates and changes in cover lead to changes in hydrology resulting in increasing surfaces salts and downcutting. In this state, shrubs and salt-tolerant forbs are dominant while grasses are absent. (USDA NRCS n.d.)

The Riverine Riparian ecological site is made up of sediments adjacent to perennial streams and vegetation is determined largely by local hydrology. Examples of typical species at different strata include Fremont cottonwood, sandbar willow, Western wheatgrass, and Nebraska sedge (USDA NRCS n.d.).

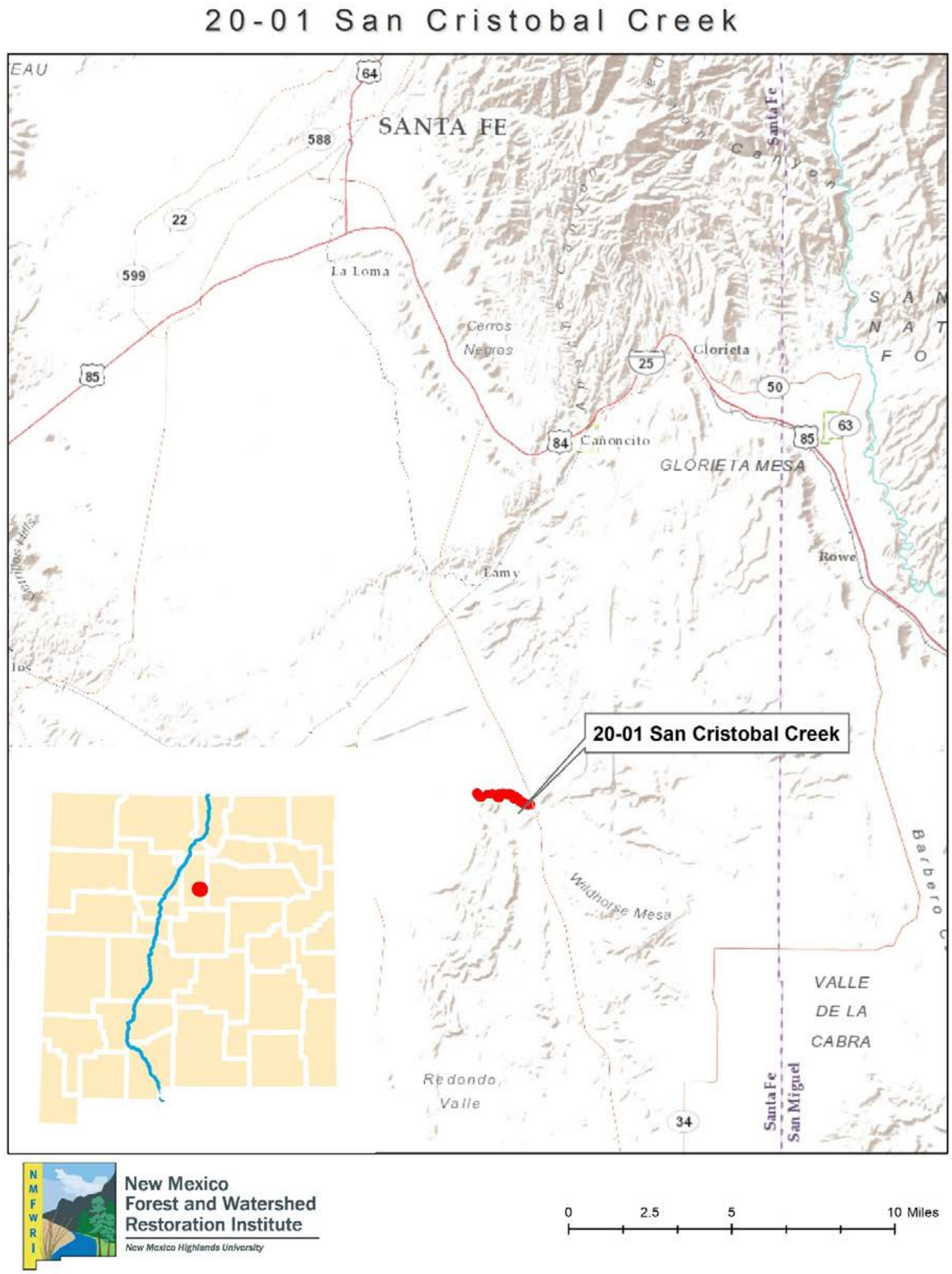

Figure 1. Project 20-01 in geographic context.

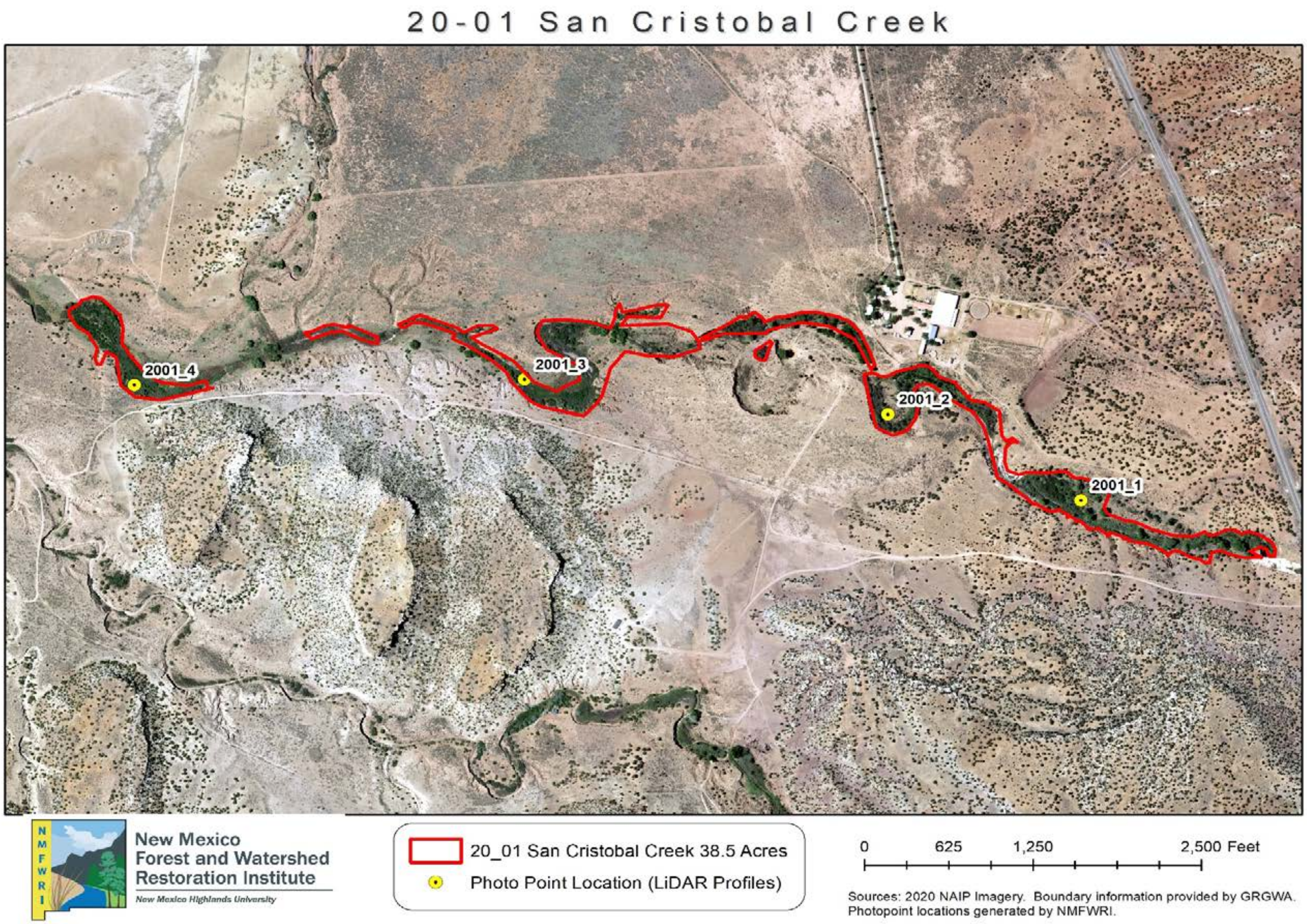

Figure 2. 20-01 San Cristobal project outline.

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.)

20-01 San Cristobal Creek 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 38.5 acres.

Type 1-High Structure Forest with a well-developed understory (6.8 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 {0-5 m [0-15 feet]) covering >25% of the area of the community. Substantial foliage is in all height layers.

Type 5 -Tall Shrub Stands (12.1 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 (11.5 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 (1.5 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 (6.5 Acres). Areas of bare soil or bare rock with no vegetative cover.

See Figure 4 on the following page for a map showing the distribution of these structure types.

Vegetation Structure Type	Percent of Total Area
Forest Type 1	17.87%
Type 5 Tall Shrubs	31.43%
Type 6S Short shrubs	30.01%
Bare Ground	16.85%
Type 6H Heraceous	3.84%

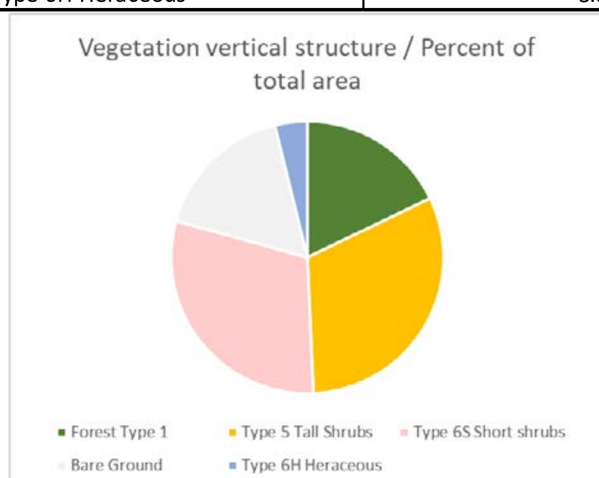

Figure 3. Vegetation Structure Type percents for 20-01.

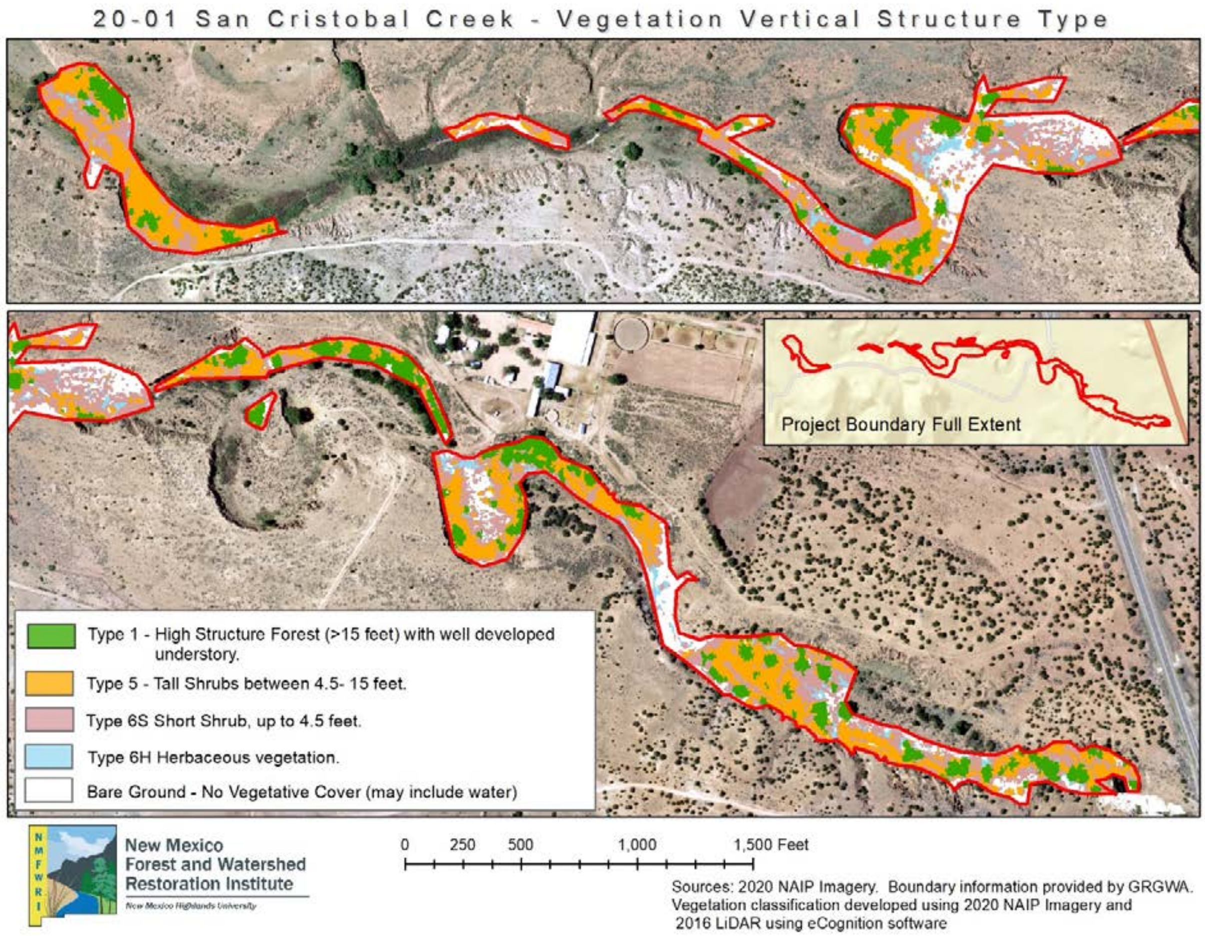

Figure 4. Vegetation structure classification for 20-01.

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.

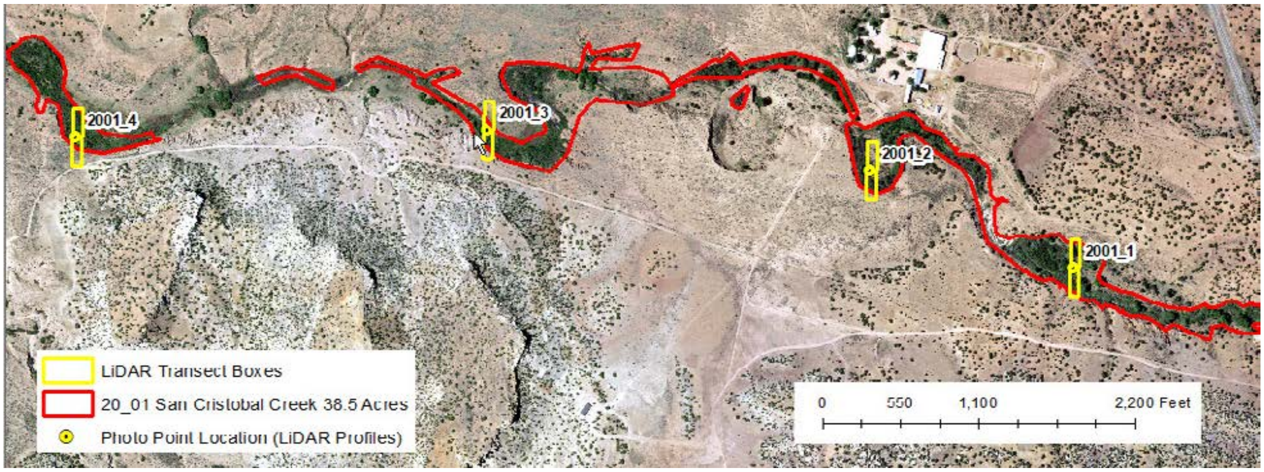

Figure 5. LiDAR Transect Locations for 20-01.

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

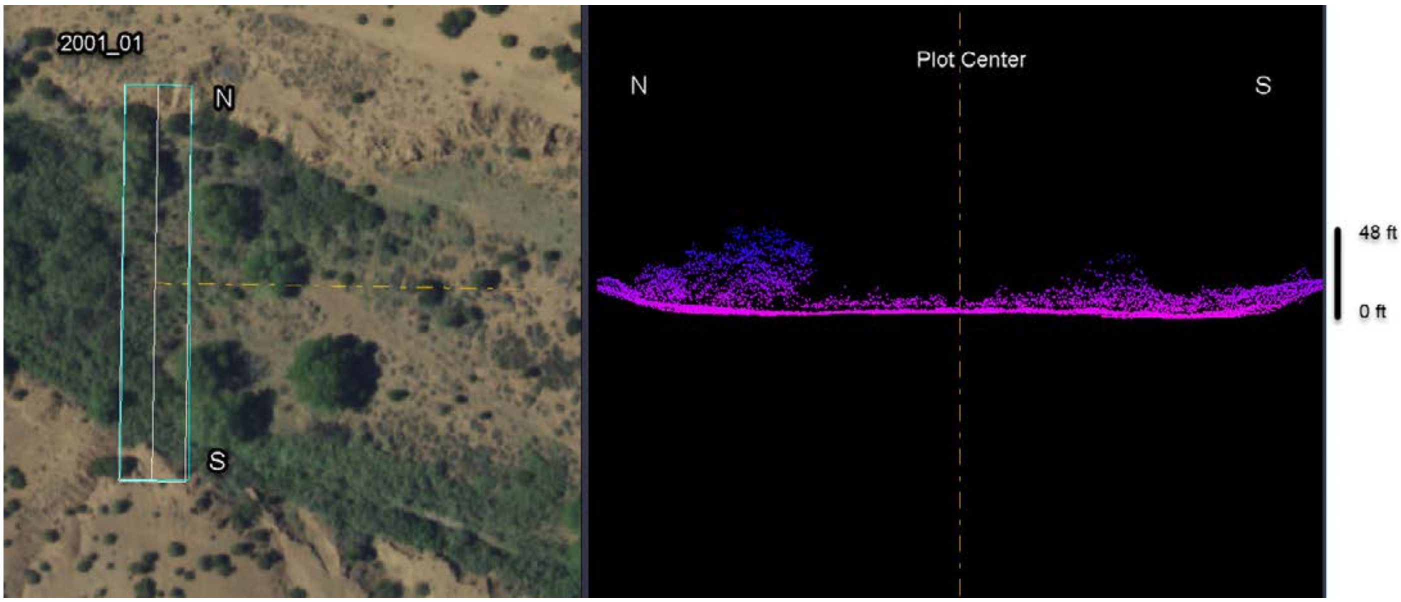
Photo_ID	PROJNAME	IDproject	Longitude	Latitude
2001_1	San Cristobal Creek	20-01	-105.85750469700	35.38320454000
2001_2	San Cristobal Creek	20-01	-105.86232573200	35.38506516100
2001_3	San Cristobal Creek	20-01	-105.87137347900	35.38576887660
2001_4	San Cristobal Creek	20-01	-105.88108422100	35.38557238290

Appendix II – LiDAR Transect Images

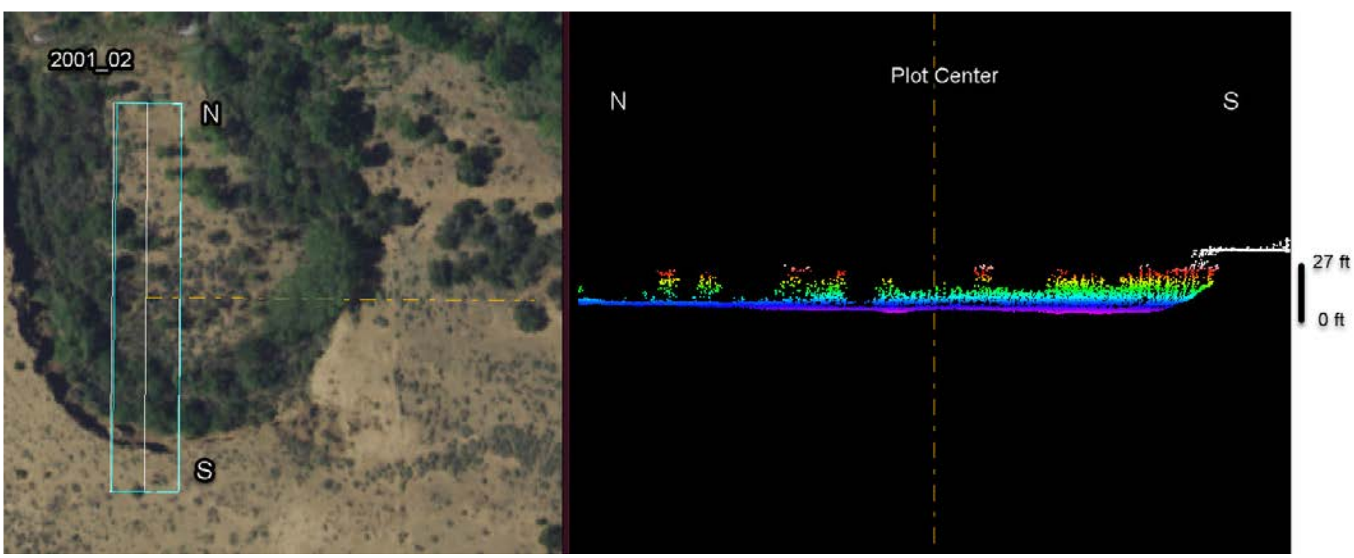
These LiDAR transects were drawn using the photo point in the center of a 20 x 130 meter window (65 x 426 feet). The transects were drawn north to south, and the aerial view of the areas is on the left in the images below. On the right is the LiDAR profile. The scale on the far right of each image represents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

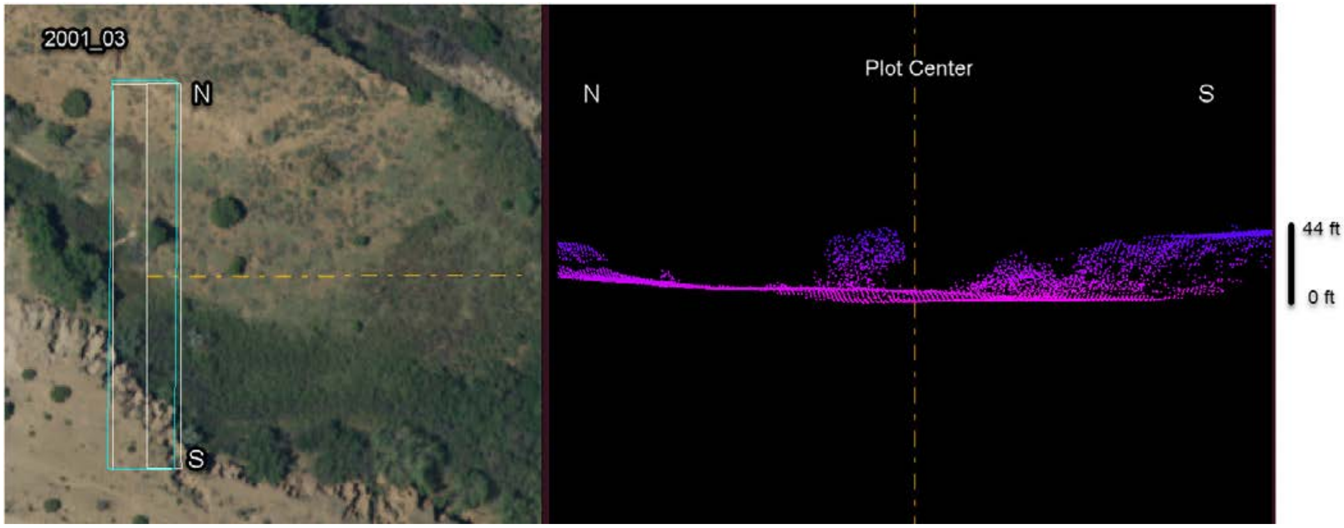
2001 – 1 LiDAR Profile



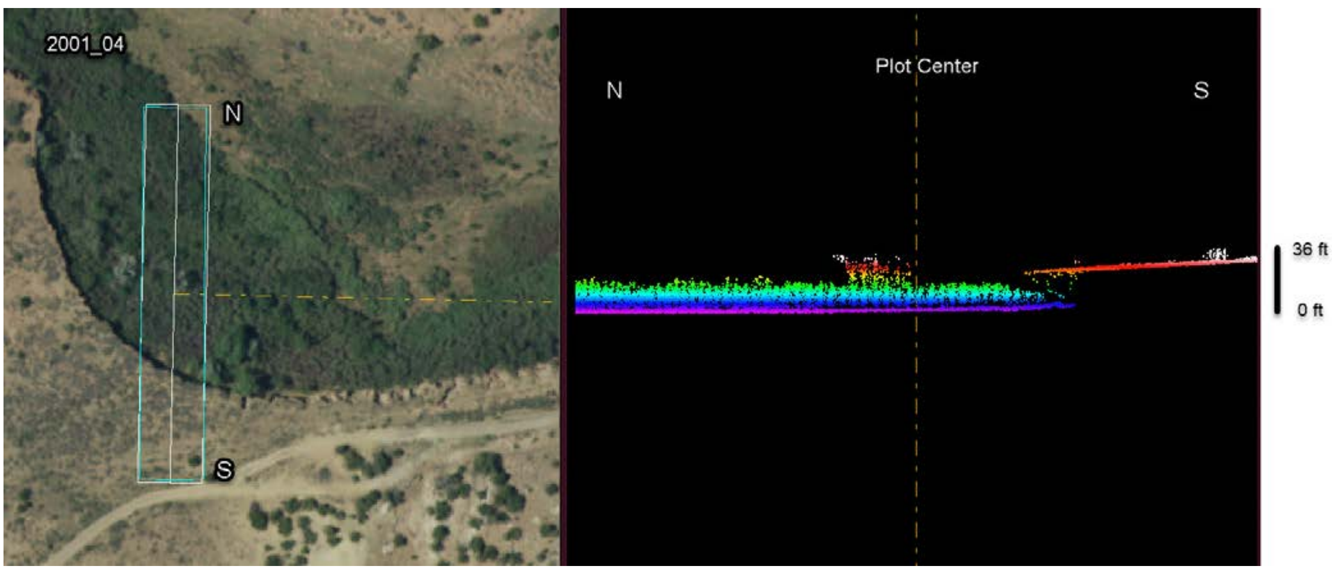
2001 – 2 LiDAR Profile



2001 – 3 LiDAR Profile



2001 – 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).

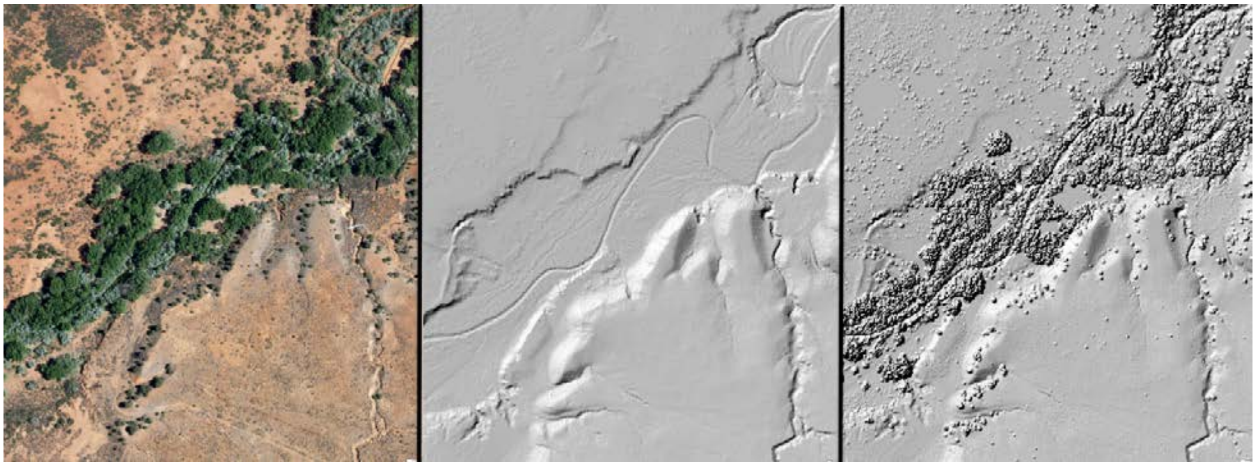
To develop a vegetation height classification, LiDAR and NAIP imagery were analyzed using eCognition software. An object oriented classification systems was used so that spectral characteristics as well as height above ground values of the vegetation could be incorporated into a robust classification 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 2016 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.

2016 LiDAR Processing

2016 LiDAR for the San Cristobal Creek site was downloaded from The USGS 3DEP LiDAR Explorer (https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/) in LAS file format.

Using the 2016 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.



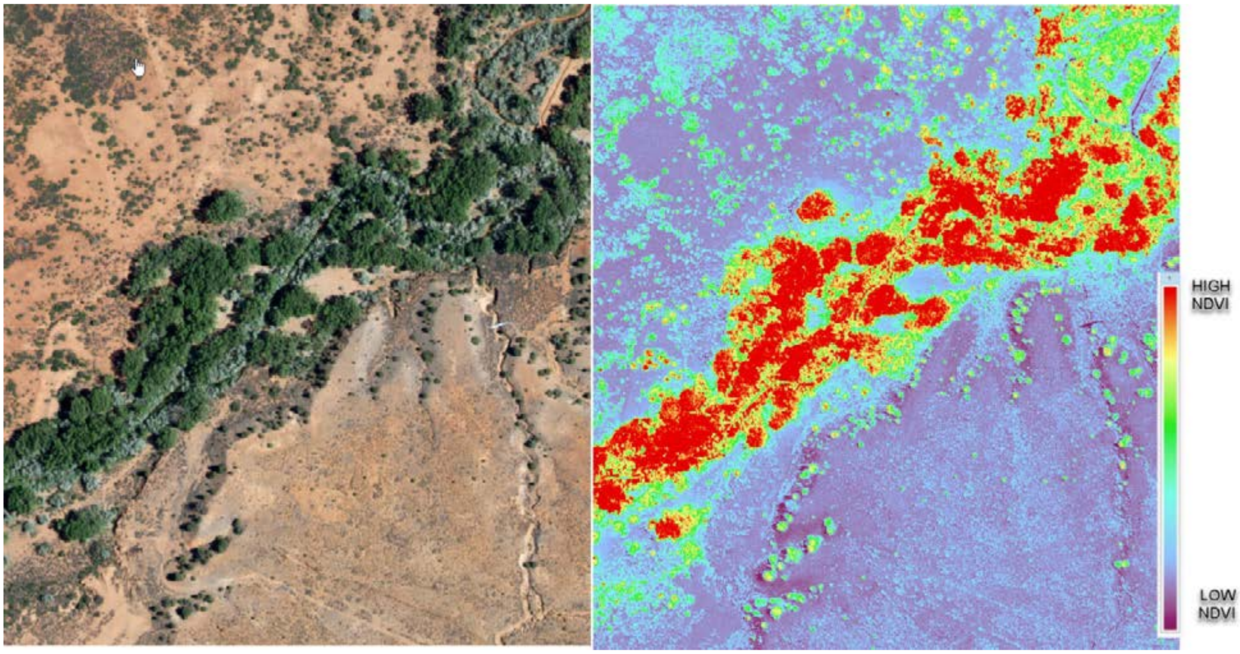
2020 NAIP *LiDAR Derived Digital Terrain Model* *LiDAR Derived Digital Surface Model*

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 San Cristobal Creek 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)

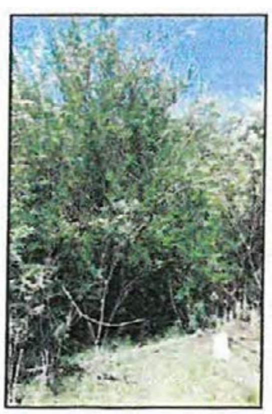
Type 1 - High Structure Forest with a well-developed understory.

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.

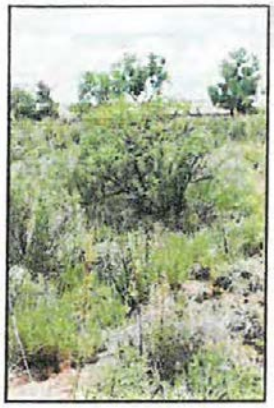
Tall mature to intermediate-aged trees (>5 m [>15 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (1-5 m [3-15 feet]) covering <25% of the area of the community (polygon). Majority of foliage is over 5 m (15 feet) above the ground. (This type incorporates 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.

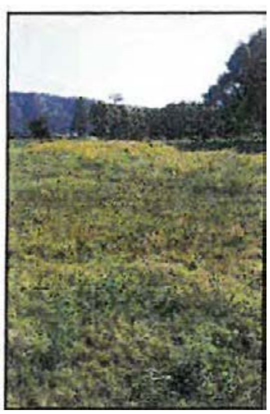


Type 6S- Short Shrub Stands.

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.