Monitoring Protocols for the Greater Rio Grande Watershed Alliance

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Executive Summary

The purpose of this document is to outline the process that the NMFWRI monitoring program uses in house and teaches to our partners. Historical context about the NMFWRI and its partners is given to provide rationale behind some processes, as well as a workflow for organizations to use for their own monitoring needs. Included are resources from the NMFWRI, where our own monitoring results and other information about our work can be found. Amongst those resources is a section on Key Considerations for Successful Monitoring where we expand on the logistical aspects of monitoring (mostly considerations outside of protocol and fieldwork) that we have found are important parts of making a monitoring plan as useful as possible. Also included are examples of the forms we use to collect data in the field, and explanations around the different sections of the protocol.

About the Partners

Greater Rio Grande Watershed Alliance

In the early 2000s, five Soil and Watershed Conservation Districts (SWCDs) whose boundaries include the Rio Grande formed the Upper Rio Grande Non-Native Phreatophyte Control Steering Committee with the goal of managing state funding to remove non-native invasive trees from the bosque. The original funding targeted salt cedar, but they also treated Russian olive, Siberian elm, and Tree-of-Heaven.

Around 2010, the five SWCDs invited other partners to join them, and the collaboration evolved into the Greater Rio Grande Watershed Alliance. GRGWA's partners and collaborators include or have included: Claunch-Pinto, Ciudad, Coronado, Cuba, East Rio Arriba, Estancia, Lava, McKinley, Santa Fe-Pojoaque, Socorro and Valencia SWCDs; Pueblos of Kewa, Santa Ana, and Sandia; EMNRD Forestry Division (NMSFD); New Mexico Department of Game and Fish (NMDGF); New Mexico Department of Agriculture (NMDA); New Mexico Environment Department (NMED); the State Land Office (NMSLO); Middle Rio Grande Conservancy District (MRGCD); Natural Resources Conservation Service (NRCS); U.S. Army Corps of Engineers (USACE) and the New Mexico Forest and Watershed Restoration Institute (NMFWRI) as well as businesses and non-profits working in bosque ecology and watershed restoration.

GRGWA's objective is to strategically deploy a landscape-scale bosque restoration project that enhances and connects previous efforts. This most commonly means collaborating across jurisdictions to conduct invasive removal treatments in the upper and middle Rio Grande Watershed, with funding from the New Mexico Water Trust Board. GRGWA partners submit project proposals that are evaluated by a Technical Committee; the Alliance meets to collectively decide where and how to apply their funds to maximize results.

New Mexico Forest and Watershed Restoration Institute

The New Mexico Forest and Watershed Restoration Program is one of three Southwest Ecological Restoration Institutes created by Congress in 2004[1]. The Southwest Ecological Restoration Institutes (SWERI) includes the New Mexico Forest and Watershed Restoration Institute (NMFWRI) at New Mexico Highlands University, the Colorado Forest Restoration Institute (CFRI) at Colorado State University, and the Ecological Restoration

Institute (ERI) at Northern Arizona University. These institutes co-develop, translate, and apply actionable knowledge in collaboration with forest land managers and partners to foster fire-resilient forests for the benefit of communities and nature, now and in the future[2].

NMFWRI's mission is to work to reduce catastrophic wildfires and restore resilient, fire- and climate-adapted ecosystems. We collaborate with partners and engage communities to bridge scientific and local knowledge and build capacity in landscape-scale adaptive management.

The NMFWRI's Ecological Monitoring Program maintains a professionally managed field crew to collect data on short and long-term ecosystem responses to restoration treatments. This data provides a critical scientific basis for adaptive management decisions and improved forest treatment effectiveness. The program also collects data on, and responds to, partner needs related to monitoring and adaptive management through a variety of projects to help build state- wide capacity for ecological monitoring and restoration.

Partnership History

The New Mexico Forest and Watershed Restoration Institute (NMFWRI) became involved with the GRGWA project in 2011, when we took over the formal monitoring and began constructing a geodatabase for GRGWA's non-native phreatophyte removal projects. Since our initial involvement, a few different monitoring methods have been used to capture pre- and post-treatment data on GRGWA projects. The protocols that follow are intended to capture the current best practices and recommendations for moving forward. These protocols have been in use in our partnership since 2018.

General Monitoring and Treatment Workflow

According to NMFWRI records, as of March 2024, GRGWA has completed 119 projects across 3,863 acres, from Abo to Ojo Caliente.

Most projects focus on the removal of non-native species such as Salt Cedar, Russian Olive, Siberian Elm, and Tree-of-Heaven. Work done to remove these species can help to reduce fire risk, preserve native vegetation, and is an addition to other efforts to restore the bosque and the watershed as a whole to a more natural and functional ecosystem.

Individual SWCDs submit project proposals to the GRWGA. Tribal partners and private land owners are sponsored by SWCDs. Once with GRWGA, the Technical Committee visits all sites and completes an evaluation of the opportunities and challenges present with each proposed project. If GRGWA receives Water Trust Board funding, the Alliance meets and prioritizes the project proposals that could be accomplished within their budget. Next, they put out a request for proposals (RFP) and host site visits for treatment contractors. Treatment contractors submit their bids, and GRGWA selects projects and contractors to proceed. At this point, NMFWRI needs to collect pre-treatment monitoring data on that site before the treatment contractors begin work.

Treatment plans are created with each individual collaborator to decide on the most effective treatment method for invasive removal. GRGWA projects employ a variety of techniques including extraction, mastication, aerial, basal, foliar and cut-stump herbicide applications and planting grass, shrubs and trees. Contractors follow community, state, and national conservation management plans, and also seek to monitor the effectiveness of their restoration efforts. In addition, GRGWA has funded NMFWRI to develop literature reviews on topics such as invasive species control methods, and the impacts of bosque treatments on wildlife, to better understand the impacts of their efforts.

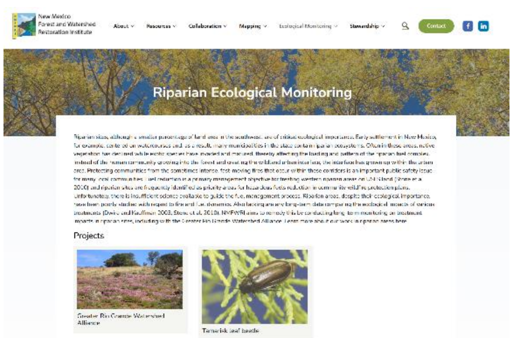
GRGWA is committed to monitoring their treatments to make their limited funds go as far as possible. NMFWRI has been contracted to do this monitoring since 2011, and we have established over 280 monitoring points (plots and/or photopoints). Monitoring efforts allow us to see changes in the landscape over time. It allows us to see which treatments of invasive species are proving most effective in which ecological site types, and aids in the creation of future land management plans.

Monitoring is ideally conducted before and after treatment occurs. There are also timelines on continuing projects where monitoring is conducted every 5-years. By conducting long-term monitoring, we learn about the efficacy of treatments so that maintenance efforts can be optimized.

The plans for monitoring begin long before the crew heads out to the field, to accommodate the needs of GRGWA, NMFWRI, and each individual partner involved in the work. This requires frequent communication and coordination between multiple parties such as land owners, contractors and the GRGWA technical committee.

Monitoring Results

All of the NMFWRI's reports, web maps, story maps, and other results are available online at the NMFWRI website at https://nmfwri.org/monitoring/riparian-ecological-monitoring/.



GRGWA Story Map
https://storymaps.arcgis.com/stories/5bc9a325830040468a49127c40adb1a6

GRGWA Web Map
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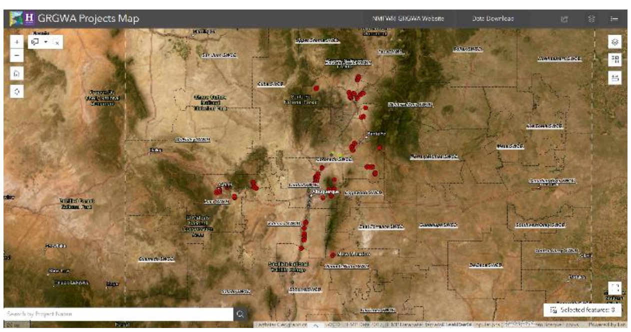
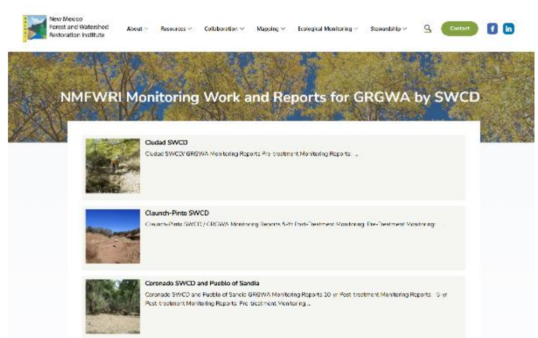


Reports
https://nmfwri.org/resources/monitoring-reports/



Key Considerations for Successful Monitoring

Long-term monitoring sites are a valuable source of data on the continuing effects of treatments, filling gaps in the knowledge left by short-term monitoring for short-term goals, and helps managers understand landscape level effects in the process. In order to have long-term datasets on a given site for many years, there are challenges to overcome and a strong partnership is critical.

Communication and Coordination

To make the monitoring and adaptive management process most efficient, both NMFWRI and GRGWA must focus resources on projects that will allow long-term access for repeated monitoring and ensure that we have as complete as possible information on all projects. Coordination among partners is important so that we have the best chance to schedule **pre-treatment, treatment, treatment inspection,** and **post-treatment** visits to ensure that the most useful and relevant information is collected and stored for long-term handling and processing.

Monitoring Schedule

The efficacy and efficiency of monitoring a project relies in large part on timing. Ecosystems move with or without eyes looking at them, and there is often a small window available to capture the information most vital to understanding our actions. For this reason, it is important that pre and post treatment visits and inspections are done in a timely manner. Pre-treatment visits should be scheduled close to the treatment, and inspection reports should be finished soon after the treatment to confirm proper treatment application. These inspection reports should be available for the monitoring crew's post-treatment visit. Projects that meet the criteria laid out below should be considered for long-term monitoring (at 5-year intervals in most cases). Post-treatment revisits (5-year, 10-year, 15-year etc.) should take place within a two-week window of the original post-treatment visit date, to ensure the seasonal differences are minimal. To make those long-term monitoring sites more viable, it is an excellent practice to get land managers and owners involved and invested in the monitoring process so that they can coordinate access to the site and provide additional support. New projects will use the plot-based protocols outlined in this document, but existing projects will use plot-based protocols in addition to the previous protocols used in the pre-treatment visit (i.e. NMRAM, BEMP protocols).

Additionally, remote sensing should be mentioned as a work around for some access issues. There is a lot of data available online through ESRI or other sources and can help fill gaps when access isn't possible. Remote sensing isn't a replacement for much of the data we collect, but it should not be forgotten as a useful tool when limitations begin to arise.

Prioritize Projects

For long-term projects, it isn't always possible to re-measure all sites. Instead we will prioritize projects that:

- have **good access**, (and to the best of our knowledge will remain accessible, which includes matters of safety)
- projects that have certain **land history/management goals** or other similar factors relevant to the treatment under observation
- and consider the **technical factors complicating data collection** (like weather, equipment needs).

Other factors include:

- Landowner/manager cooperation and interest
- landowner/manager documentation of management and land tenure
- previous data of high quality or ecological importance
- sites within ecological groups/landforms that can be compared
- sites that will have enough time to re-measure effectively
- projects that can be reasonably sampled in the season they need to be; and represent a diversity of ecological settings.

Data Management, Standardized Forms and Data-Sharing

One of the key components of a successful monitoring program is good data management. It is important to have standardized methods of data collection, sharing, processing, QC, analysis, and reporting.

For all partners involved, a **thorough** and **standardized** set of forms should be used for all data collection and quickly processed and stored to ensure data quality and funding effectiveness.

To this end, NMFWRI has utilized various methods of file-sharing with GRGWA, including email, ftp sites, DropBox, SharePoint, and Box. The key components have been:

- A simple file-sharing platform that does not restrict file name lengths
- Accessible by all partners
- Commitment by all parties to share information in a consistent and timely format.

The NMFWRI Ecological Monitoring Program primarily uses custom databases and protocols within Excel, FFI, Microsoft Access to manage GRGWA data, as well as custom R Scripts for data QC and analysis.

Complete Information

For the purposes of improving our understanding of treatment effectiveness, we need detailed records on the treatment applied, which should include method of treatment, broadly categorized such as **mechanical (mastication)**, **mechanical (extraction)**, **mechanical (hand crew)**, **chemical (foliar)**, **chemical (stump spray/paint)** and **how many projects of each type**, **the project acreage**, **month and year treated**, **who performed the treatment**, and any **retreatments** including when and who did it to see if there are any broad trends.

Whenever possible, we also request that data on land use be collected for projects, such as **known fire impacts on site, current land use, history of land use, primary land use after treatment, any impacts on non-target vegetation due to treatment, livestock use after treatment and intensity, and native plant**

response. This has been made into a Landowner and Contractor Survey (found in our **Forms** sections), easy to fill out for many different landownership situations. It is also advised to ask landowners/managers for permission to monument plot locations with rebar whenever possible for ease of repetition in remeasurement and photopoint accuracy.

Adaptive Management

The ultimate goal of monitoring work is adaptive management, or learning from experience so that future decisions incorporate the monitoring results of previous efforts. This applies not just to the work of the GRGWA but the work of other organizations or individuals that could benefit from the lessons learned by GRGWA's history of restoration efforts.

To help facilitate this learning, NMFWRI shares all data collected (with the exception of confidential Tribal data) with partners and the public. For instance, the GRGWA project reports are made available on our website. GRGWA can use these summary reports to obtain a better understanding of treatment effectiveness and provide oversight of restoration projects in the future. Other organizations can also access the data and summary reports, as well as reach out to the NMFWRI Ecological Monitoring Program for further consultation.

We also hope to facilitate adaptive management by collecting information on projects beyond just the on-the-ground data. This information (such as that included in the Landowner and Contractor survey) can be used for cross-project queries such as understanding more about the importance of retreatments and the interval within which projects escape; which treatments may be most effective in which ecosystem types; etc. The NMFWRI Ecological Restoration Data System (or NERDS) was developed to be able to store our datasets in a publicly accessible space and provide query services within the database for exploration of the data by our staff, partners and other public.

NMFWRI regularly updates the processes and the technologies that we utilize to provide these services. Moving forward, NMFWRI looks forward to supporting GRGWA's adaptive management decision-making, so that the "lessons learned" from previous seasons inform the management actions planned for future projects. We are also working on using the NERDS to help look at landscape-level questions around treatment effectiveness and longevity, as well as sharing the results with partners across the Southwest.

Conclusion

Successful monitoring with GRGWA requires communication, collaboration and coordination between land managers, field technicians, data manager, and all partners engaged in this work and a commitment to ensure all workflows provide consistent, high-quality data.

Monitoring Methods and Protocols

The sections that follow outline the monitoring methods currently in use on GRGWA projects.
Please note that these protocols are applied to all new and existing projects, but when re-measuring older projects, if other protocols were initially used (e.g. NMRAM, or different rules for establishing placement of photopoints) those protocols will also be re-measured for allow for comparison across time. Those legacy protocols are not documented here but documentation can be provided upon request.

NMFWRI Riparian CSE-Based Plot Sample Protocols Used on GRGWA Projects

Based on the 2011 Guidelines and Protocols for Monitoring Riparian Forest Restoration Projects (Bonfantine, et al.) and the Common Stand Exam-based protocols used by NMFWRI for CFRP projects

Crews, Navigation & Plot Setup

Plots are most efficiently accomplished with a **3-person crew** but can also be taken with 2 people. More detailed plots, presented here as options, are most efficient with a 4- to 5-person crew. All crews need basic knowledge of monitoring methods and rationale, equipment, plant species and common tree pests and diseases.

Plots are established using a random point location with project-specific boundaries e.g. stand boundaries, treatment areas, vegetation types, etc. In our office, maps and plot locations are generated with **ArcGIS** utilities and are loaded onto a **Tablet/Geode pair** and **Garmin GPS units**. **The sampling density scheme** for GRGWA projects is as follows:

Projects under 21 acres – 2 plots 21-50 – 1 plot per 10 acres
For projects 51+ acres:
51-70 ac --- 5 plots
71-90 ac --- 6 plots
91-110 ac --- 7 plots
111-200 ac --- 8-9 plots
201-400 ac---- 10 plots
400+ ac – discuss alternate sampling methods (e.g. LiDAR)

The plot minimum spacing is 300 ft on most projects, or 200 or 100 ft on projects where a 300 ft spacing will not allow the prescribed number of plots to fit within boundaries. Plots must be a minimum of min 50 ft from project boundary. Plots will be moved in a random direction towards the inside of project if plot lands less than 50 ft of boundary using "Create Random Points" in ArcMap. Note that within this framework, flexibility exists to add plots as needed to capture site diversity.

Unit maps, driving maps and driving directions are created and sent with the field crew. Once in the project area, **navigation** to a plot is typically accomplished through paper maps and the Garmin GPS units. Paper maps can be easily marked with Sharpies to indicate sequence of plot collection, dates, and teams at work; this information can be stored with the datasheets and may help answer questions that arise later. We use Garmin GPS units because they are user-friendly and can run on AA batteries which are easily replaced in the field. We use the Tablet and Geode to more accurately determine plot location and collect updated plot location coordinates which can later be post-processed for greater location accuracy with a handheld GPS unit. Plots must be moved one chain (66 ft) at a random azimuth from their original, intended location if they are within 75 feet of a road.

A marker (we typically use a 1-foot piece of ½ inch rebar with a mushroom cap) is installed at plot center if the landowner/manager gives permission. Markers should be low to the ground and well flagged so that they are obvious to managers and treatment contractors. Where plots are being re-visited, a good metal detector may be of use to locate the center stake (marker). Copies of the previous plot photos can also be useful.

Plots are set up using 8 pin flags in addition to the center stake. 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, Witness Trees & Other Plot data

Eight photographs are taken per plot. If more than the two standard Brown's transect is collected, additional photographs are taken in the same format. 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. It is helpful if the camera used can record GPS coordinates.
Additional photos include:

- "C," taken from 75 feet along the North azimuth looking at a crew member holding the white board at plot center
- Brown's transect photo, "B_*degrees*" taken from the 75-foot mark of each fuels azimuth looking towards a crew member holding the white board at plot center
- "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 azimuth flags. Additional photographs may be taken, but we recommend these be taken after the mandatory eight plot photos, and noted on the data sheets, so that there is no confusion for the data technicians.

All plot photos except "PC" need to be documented in the **Photopoint Log**. The Photopoint Log provides places to document landmarks and other information about each photograph to make re-takes simpler.
A **witness tree** or trees should be near plot center to assist with finding plot center and ideally should be expected to survive any future thinning, fire, or other disturbance. For example, mature yellow-bark pines near plot center are easy to find and not likely to be thinned. Any healthy tree will work. The tree should be flagged, noted in the overstory data, and described on the Plot Description datasheet.

Photo order, hill slope, dominant 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

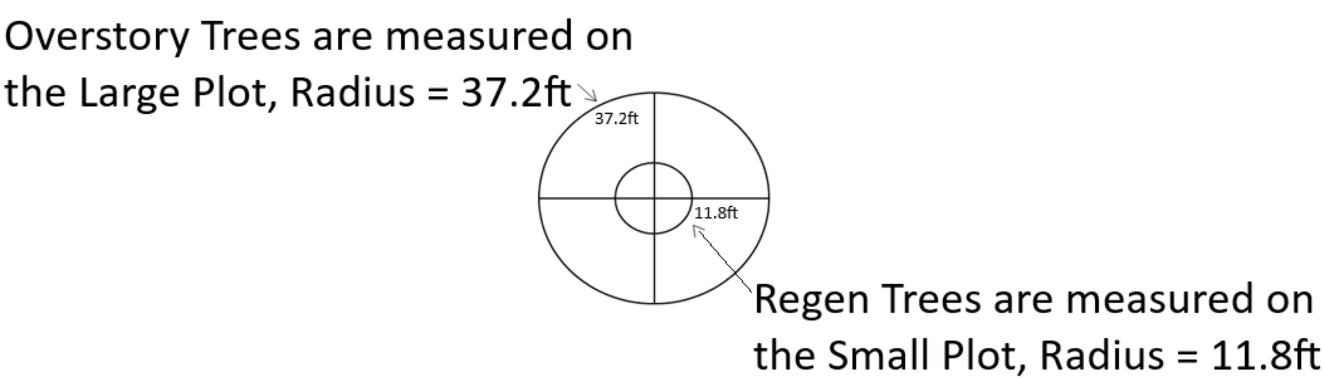
All **trees and snags** are measured within the 1/10th acre plot (37.24 ft. radius) circular, fixed area sample plot. We typically define a tree as ≥ 4.5 ft. and > 5 in dbh or drc, although other cutoffs may be used depending on objectives. Species, condition, dbh or drc, number of stems, total height, and live crown base height are recorded for each tree located within the plot. Most trees are measured at dbh with exception of *Quercus* spp., *Juniperus* spp. or *Pinus edulis* species with more than two stems at dbh. Be aware that other trees/large shrubs with multiple stems, such as saltcedar, Russian olive, mountain mahogany or chokecherry, cannot be processed if they are measured at drc since their conversion formulas are unavailable. Depending upon the project, other information may be collected including damage and severity, scorch height, snag decay class, crown ratio, and crown class. 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. If appropriate, this first tree may also serve as the **witness tree**. Do not forget to flag and record your **witness tree**.

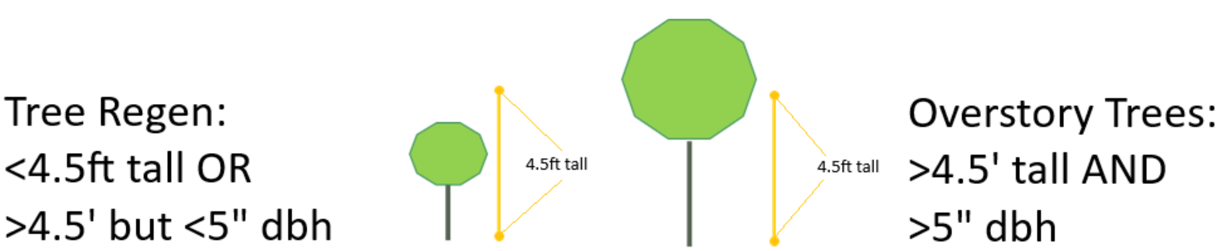
Tree regeneration is measured on the nested 1/100th acre circular plot (11.78 ft. radius) and species, condition, and height class (>0-0.5 ft; >0.5-1.5ft; >1.5-2.5ft; >2.5-3.5ft.; >3.5-4.5ft) are recorded for each **seedling** or sprout. **Saplings** (>4.5ft but <1.0in dbh/drc) are also recorded in this way. **Shrubs** are measured on the same nested subplot and species, condition and height/diameter class are recorded for each stem just as with tree species; we typically record cacti in this category as well. Other cutoffs may be used for height and diameter classes depending upon objectives.

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, QUGA, etc). Note that upon entry into a database, it is common for these codes to be followed by various numbers in order to differentiate between other species whose names would create the same code. These symbols can be found on the **USDA PLANTS website**, https://plants.usda.gov/

Canopy cover (density) is an average of four measurements from a spherical densiometer.
These four measurements are taken facing out at the four small-plot pin flags along the perimeter of the nested subplot. In this way, each reading is spaced 90 degrees apart. Each of the four measurement is recorded separately on the datasheet. The crew should be sure to count dots, not squares, and always record the area covered, not open.

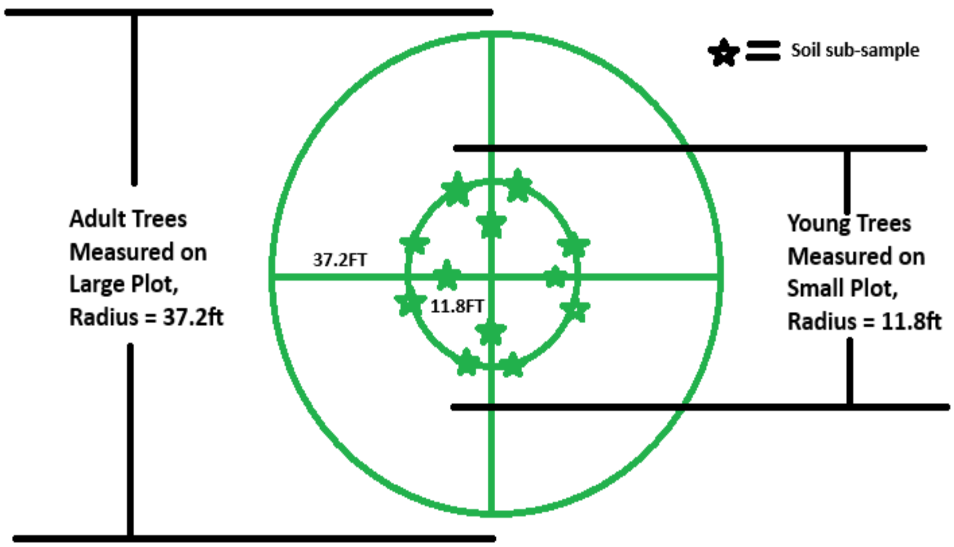
Vegetative Community Structure type is a classification system developed by Hink and Ohmart to describe patterns of vegetation specifically along the Middle Rio Grande. The **"original" Hink and Ohmart** scheme uses vegetation height and presence of understory vegetation to assign a structure type between 1 and 6. In addition, the New Mexico Environment Department developed a **"modified" Hink and Ohmart** system that assigns a value of 1, 2, 5, 6S, 6W, 6H or 7. We recommend the field crews take copies of the keys for both original and modified schemes and apply them to the entire 1/10th acre plot.





Soils

At this time, **soil texture** is collected in four locations. At each of the four 1/100th acre cardinal direction flags, collect 3 subsamples of soil using a shovel or soil corer to a depth of 6 inches. Standing over the flag as if taking canopy cover, i.e. facing away from plot center in the cardinal direction of the flag, you will collect soil subsamples 2 feet to the left, right and immediately behind you as illustrated below.

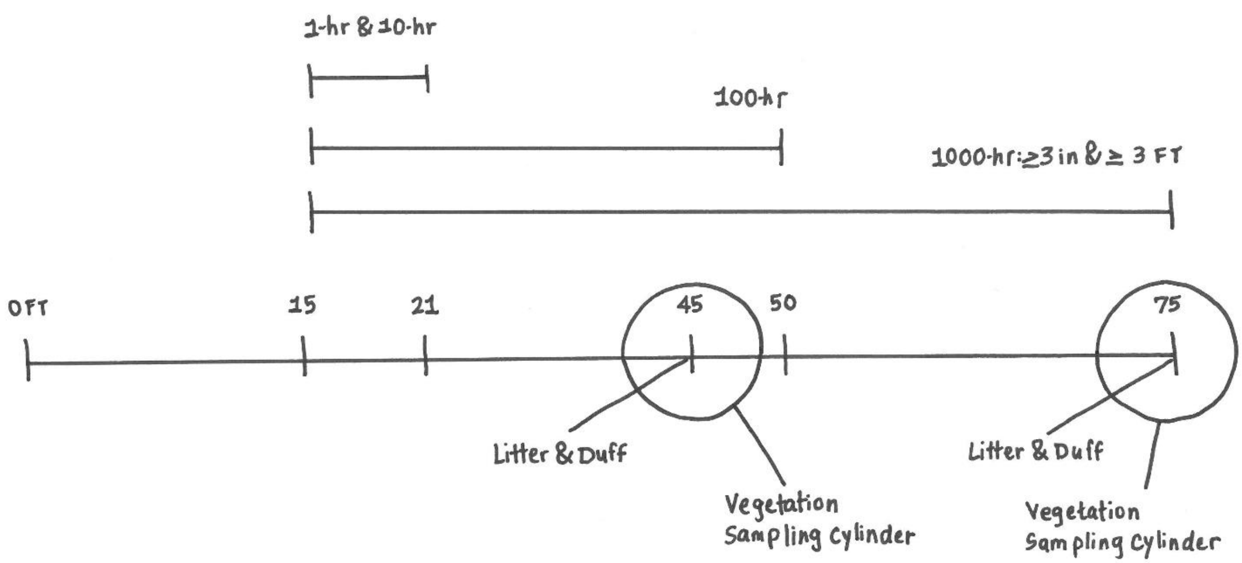


Combine each set of three subsamples into one sample by mixing thoroughly in a bag or tub. Remove any large organic debris such as plants or wood chips. Follow the soil texture flow chart to determine soil texture for each combined sample at each measurement point. Record this on the datasheet for a total of four soil textures per plot. Return soil to all holes when sampling is complete.

Fuels (Brown's)

Dead woody biomass and forest floor depth are measured using two planar Brown's transects. These are at random azimuths. To select a random azimuth, one crew member spins a compass and another decides when to stop. Typically, in our protocol, a fiberglass tape is run from the plot center stake out 75 feet and fuels are 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** ("time- lag fuels"). See diagram below for standard lengths of various transects.

For full protocol details, see Brown 1974 and subsequent guidelines or the NMFWRI training manual. Quick reminders: 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. Decay class (1 to 5) and sometimes length is collected for each 1000-hour fuel. The comment field on the datasheets is often used to record species and how the log came to be on the ground, when discernable. The sampling plane goes up to 6 ft above the transect. Rooted vegetation does not count unless it has a lean over 45 degrees. Litter and duff depth measurements are taken at 45 feet and 75 feet on each transect.



Understory Cover

Vegetation and ground cover are estimated across the entire 1/10th acre plot. Vegetation measurements include **aerial percent cover** of **seedling/saplings, shrubs (including cacti), graminoids,** and **forbs**, and may not necessarily total 100%. Aerial percent should be further stratified by individual species greater than 1% cover. **USDA PLANTS codes** are preferred. The status of each group of vegetation (**live, dead, sick**) as well as the nativity (**Native, Exotic, Both,** or **Unknown**) should be recorded. Any unknown plants should be described in comments, photographed (after plot photos!) and samples collected in a field press for subsequent identification. We strongly recommend the inclusion of sticky notes (or better yet, a filled-out herbarium voucher) with each pressed sample describing the collection location and conditions, including which plot it was collected near.

Ground cover measurements include percent cover of **plant basal area (including cacti), boles, litter, bare soil, rock, gravel,** and **water/wet soil** and must total 100%.

Data processing and reporting

At this time, we use **FFI software**, as well as **Excel** spreadsheets, and a custom Microsoft Access database **(NERDS)** to enter and analyze our data. FFI is able to export to FVS and FuelCalc. FFI software and User Guides are available for download here: https://www.frames.gov/partner-sites/ffi/software-and-manuals/

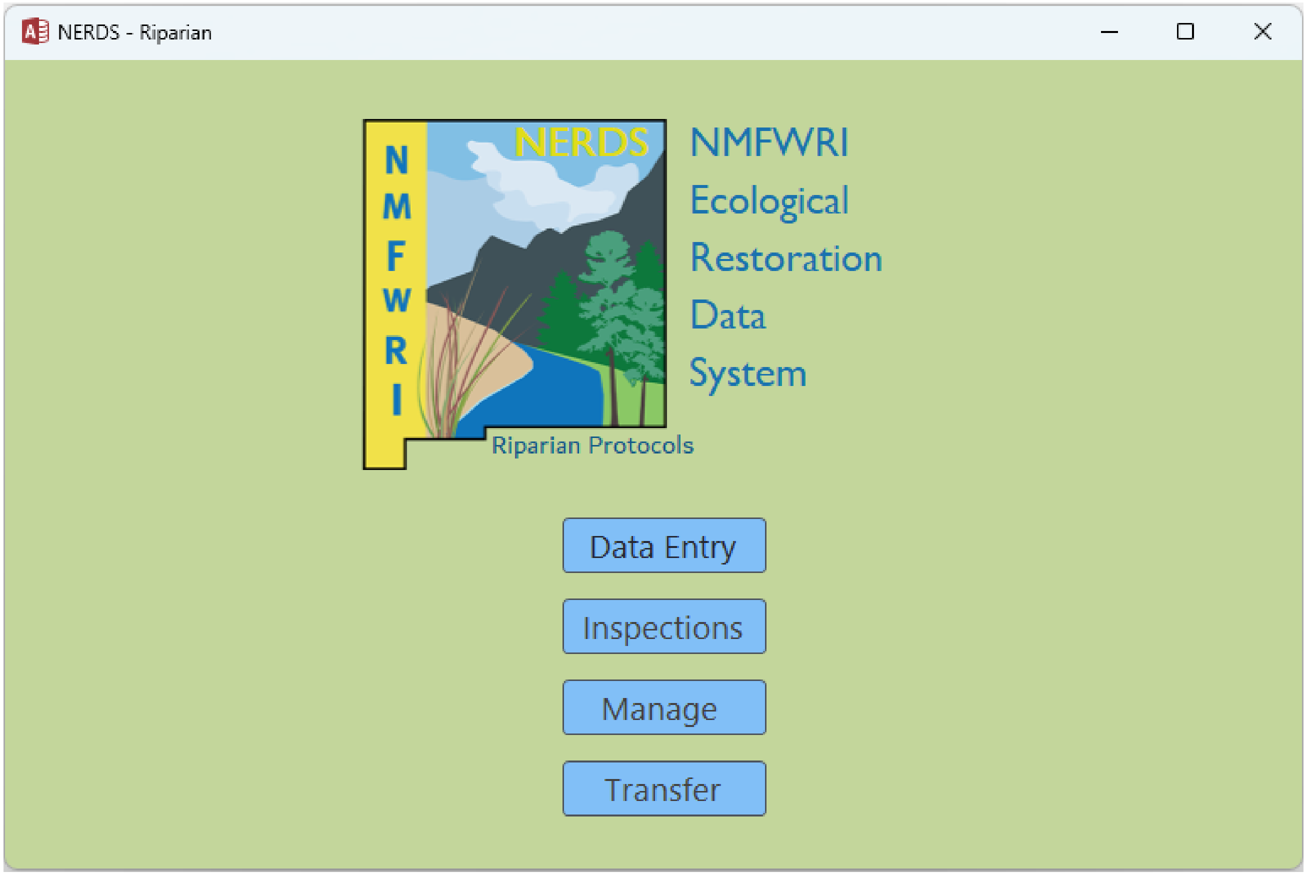
In order to process individual piñons, junipers and oaks with more than 2 stems or whose branch structure made access difficult and were therefore measured at root collar (DRC) instead of breast height (DBH), we use the **equations developed by Chojnacky and Roger** (1999).

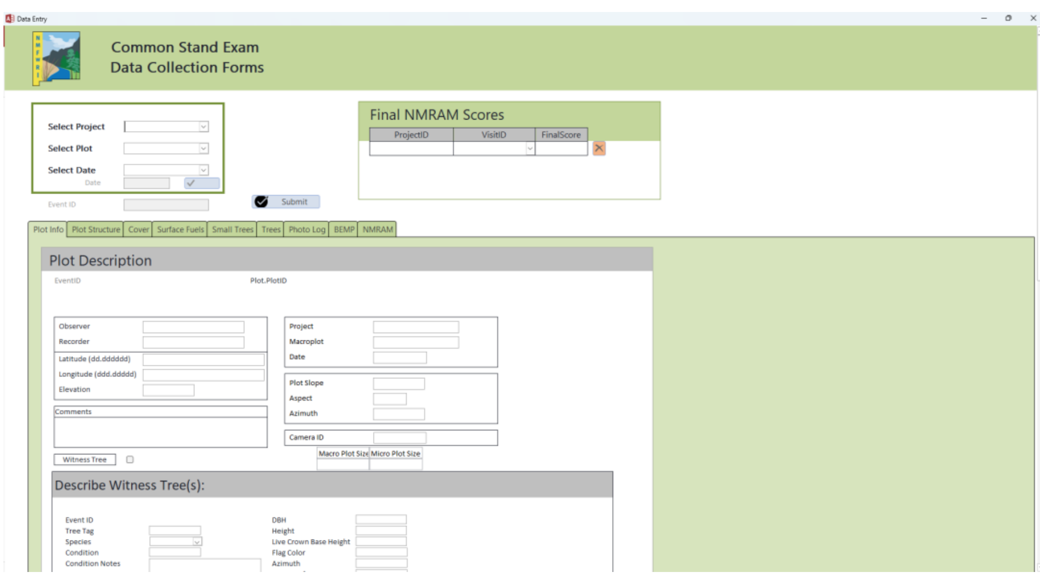
All our results are typically reported to two significant digits, with exceptions for those metrics we know were measured with either more or less precision.

Sample reports can be found on our website: http://nmfwri.org/resources/restoration-information/cfrp/cfrp-long-term-monitoring/cfrp-long-term-monitoring and https://www.nmfwri.org/collaboration/greater-rio-grande-watershed-alliance.

NMFWRI Ecological Restoration Data System (NERDS)

In addition to using FFI and Excel, the Monitoring Program has developed a database using Microsoft Access. The purpose of the **NMFWRI Ecological Restoration Data System** (or NERDS) is to store our datasets in a publicly accessible space and provide query services within the database for exploration of the data by partners and other public.





Estimating Vegetation Cover using LIDAR and eCognition Software

Using up-to-date LiDAR data, A **Digital Terrain Model** (**DTM**) is created by filtering only the point clouds classified as ground and then only those ground point clouds are converted to a raster **DTM**. Next, LiDAR first returns are filtered and selected to represent surface features. Only those first returns are converted to a raster **Digital Surface Model** (**DSM**). Birds and other noise that are not surface features are 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. Below are examples of how these products look.

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 elevation, the classification of spectrally similar objects can be improved (Hellesen T, Matikainen, L. 2013).

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

FORMS AND DATASHEETS

Riparian CSE-Based Plots

Landowner and Contractor Survey

Modified Hink & Ohmart

Original Hink & Ohmart

Project Photopoint Log

Soil Texture by Feel Flow Chart

CSE-Based Riparian Plot Description

Observer:	
Recorder:	
Latitude (dd.dddddd):	
Longitude (ddd.ddddd):	
Elevation (ft):	

Administrative Unit:	
Project Unit:	
Macroplot:	
Date (DD/MM/YYYY):	
Time:	

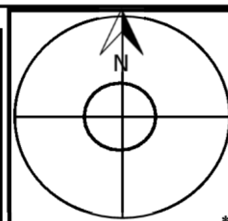
Plot Size --------------------Micro--Macro		
Size (Acres)	1/100	1/10
Radius (Feet, Decimal Feet)	11.78	37.24
Radius (Feet, Inches)	11' 9"	37' 3"

Hill Slope (where steepest): ______%

Aspect (circle one): N E S W

Aspect azimuth: ______°

Mag Declination: ______°



Describe Witness Tree(s): USE NATIVE TREES ONLY

Draw location of tree on plot

Color of Flagging Used: ____________

Photo Azimuths: (1) of whiteboard at PC. (1) from 75 feet N looking south to PC (4) from PC in all four cardinal directions; (1) from each Brown's transect looking toward PC.

ORDER TAKEN: ____________

Comments/Description of Plot:

Tree Canopy Cover (%) (densiometer)

________+________+________+________

Hink & Ohmart Dominant Structural Class

Original:

Modified:

Soil Texture (4 locations)

North: ____________

East: ____________

South: ____________

West: ____________

SMALL PLOT INCLUDES ALL SEEDLINGS OR SAPLINGS <5 INCHES DBH/DRC.

Species	Condition (Live, Dead, Sick)	Small Plot (1/100th Acre only) - Tree Regen, Shrubs & Cacti					Species	Condition (Live, Dead, Sick)	Small Plot (1/100th Acre only) - Tree Regen, Shrubs & Cacti				
		Height classes—Seedlings (feet)							Diameter classes—Saplings (inches)				
		> 0 - 0.5'	> 0.5—1.5'	> 1.5' - 2.5'	>2.5' - 3.5'	>3.5' - 4.5'			> 0 - 1"	>1-2"	>2-3"	>3-4"	>4-5"

Precisions:		
Slope:		±5 percent
Vegetation cover	:	±1 class estimation or ±10%

Aerial & Ground Cover

List by Species	Status (L, D, S)	Nativity: N, E, I, Unk?	AERIAL COVER (%) (ENTIRE 1/10th acre plot)				
			Estimate Aerial Cover % for Species by Lifeform				
			Tree	Shrub	Forb/herb	Gramanoid	Cactus
TOTALS							

GROUND COVER (%) (ENTIRE 1/10th acre plot) (must total 100 %)							
Plant basal	Bole	Litter	Bare soil	Rock (>2.5in)	Gravel (< 2.5 in)	Water, Wet Soil	Total (%)

Comments on Species Composition and/or Ground Cover:

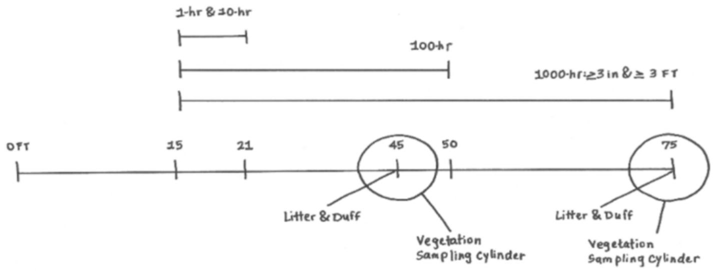
Fine Woody Debris—Coarse Woody Debris

Observer	______________
Recorder	______________

1-hour Transect Length - 6’	10-hour Transect Length - 6’
100-hour Transect Length - 35’	1000-hour Transect Length - 60’

Administrative Unit:	______________
Project Unit:	______________
Macroplot:	______________
Date (DD/MM/YYYY):	______________
Time:	______________

Class		Diameter (in)
FWD	1-hr 10-hr 100-hr	0 to 0.25 0.25 to 1.0 1.0 to 3.0
CWD	1000-hr and greater	3.0 and greater



Fine Woody Debris (1, 10, 100 hr fuels)	Transect	Azimuth	Slope	1 - Hr Count	10 - Hr Count	100 - Hr Count	Comment
	1						
	2						

Coarse Woody Debris (1000 hr fuels)	Transect	Slope	Log No.	Log Diameter	Decay Class	Comment

Litter & Duff	Transect 1	45‘	75‘	Transect 2	45‘	75’
	Litter Depth (in)			Litter Depth (in)		
	Duff Depth (in)			Duff Depth (in)		
	Comments?			Comments?		

Precisions: Diameter: ±0.5 in ; decay class ±1 class ; Slope ±5 percent

Decay Class Description

1 All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked

2 Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked

3 Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked

4. Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances

5. Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.

Overstory Trees

Observer/Recorder: ________________ Project/Site/Plot______________________ Date___________________

	1/10th acre plot (37’ 3’' radius)								
Tree #	**Species**	Tree cond.	DBH	DRC	No. stems	Total Tree Ht	LiCrBHt	Mistletoe (%)	**Comments** dam-age/disease, wit-ness tree, etc.

Landowner and Contractor Survey

*The goal of the survey is to capture information related to the most recent activity. Can be applied to initial and re-treatments

Project	Click or tap here to enter text.
Date of Visit	Click or tap to enter a date.
Visit Lead	Click or tap here to enter text.
Landowner/Manager	Click or tap here to enter text.
Community	Click or tap here to enter text.
Contractor	Click or tap here to enter text.
Current Treatment Dates (Starting and Finish)	Click or tap to enter a date. Click or tap to enter a date.

Landowner Section

1. Property Type

☐ Private
☐ Tribal
☐ Municipal
☐ Other
'Other' Please explain

2. Primary/Current Land Use

☐ Grazing
☐ Agriculture
☐ Residential
☐ Other
'Other' Please explain

3. Historical Land Use

☐ Grazing
☐ Agriculture
☐ Residential
☐ Other
'Other' Please explain

4. Observed Grazing Intensity

☐ Low ☐ Moderate ☐ High

4a Animals Grazed

☐ Cows ☐ Horses
☐ Goats ☐ Mules/Donkeys
☐ Sheep ☐ Other
☐ Alpaca
'Other' Please Explain

5. Who will provide ongoing maintenance for the site?

☐ Landowner
☐ SWCD
☐ Contractor
☐ Other
'Other' Please explain

6. Major Disturbance History in the last 15 years (Ex: flood, fire, restoration)

☐ Flood
☐ Fire
☐ Restoration
☐ Other
'Other' Please explain

7. Flowing Surface Water on the land

☐ Yes ☐ No
☐ Ephemeral or ☐ Year Round

8. Technical limitations to work?

☐ Equipment limitations
☐ Terrain
☐ Special considerations
'Special Considerations' Please explain

9. Access Concerns?

☐ Permits
☐ Locked Gates
☐ Other
'Other' Please explain

Treatment/ Contractor Section

10. Desired Condition

Click or tap here to enter text.

11. Is this Initial treatment?

☐ Yes ☐ No

***If no**

12. What Retreatment is this

☐ 1st ☐2nd ☐3rd ☐4th

13. If Retreatment, please describe re-sprout presence/absence before the retreatment occurred.

Click or tap here to enter text.

14. How many years has it been since last treatment?

Click or tap here to enter text.

15. Targeted Species

☐Russian Olive ☐Tree of Heaven
☐Tamarisk ☐Ravenna Grass
☐Siberian Elm ☐'Other'
'Other' Please specify

16. Missed Target Species? (target species observed onsite after treatment)

☐ Yes ☐ No

17. Target Species Intentionally Left

☐ Yes ☐ No

Reason :

18. Mechanical Treatment

□ Yes □ No

*If Yes please explain:

Treatment type & Equipment Used Click or tap here to enter text.

Slash Treatment ☐ Mastication ☐ Removal

Average Mastication Depth (inches) Click or tap here to enter text.

Average Percent Masticated Click or tap here to enter text.

Treatment Comments Click or tap here to enter text.

19. Chemical Treatment

□ Yes □ No

*If Yes please explain:

Application type Click or tap here to enter text.

Application rate Click or tap here to enter text.

Herbicide and Concentration Click or tap here to enter text.

Adherence to label recommendations? ☐ Yes ☐ No

Application comments Click or tap here to enter text.

20. Planted/Seeded

□ Yes □ No

Seeding mix/ Plants planted Click or tap here to enter text.

21. Acres Treated

Click or tap here to enter text.

22. Contractor Award Amount $Click or tap here to enter text.

Click or tap here to enter text.

23. Non-Targeted & Native Species Considerations/Information/Comments

Click or tap here to enter text.

24. Vegetation Response Comments

Click or tap here to enter text.

25. Treatment Comments

Click or tap here to enter text.

26. Overall Project Comments

Click or tap here to enter text.

Modified Hink & Ohmart Categories

The following are examples of the modified Hink & Ohmart Vegetation Vertical Structure Type Definitions categories with text from (Muldavin E. , 2021). All photos credit NMFWRI.

Vegetation Vertical Structure Type Definitions for NMRAM

Multiple-Story Communities (Woodlands/Forests)

Type 1- High Structure Forest with a well-developed understory. Trees (>6 m) with a canopy covering >25% of the area of the community polygon and woody understory layer of tall shrubs or short trees (1.5-6 m) covering >25% of the area of the community (polygon). Substantial foliage is in all height layers.

Type 2 -Low Structure Forest with little or no understory. Trees (>6 m) with canopy covering >25% of the area of the community polygon and minimal woody understory layer (1.5-6 m) covering <25% of the area of the community (polygon). Majority of foliage is over 7 m above the ground.

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

Type 5 -Tall Shrubland. Young tree and shrub layer (1.5-6 m) 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.

Type 6S- Short Shrubland. Short stature shrubs or very young trees (>1.5 m) covering >25% of the area of the community (polygon). Stands dominated by short woody vegetation, may include herbaceous vegetation among the woody vegetation.

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 <25% cover.

Type 6H- Herbaceous vegetation. 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 <25% cover.

Type 7-Sparse Vegetation, Bare Ground. Bare ground, may include sparse woody or herbaceous vegetation, but total vegetation cover <10%. May be natural disturbance in origin (e.g., cobble bars) or anthropogenic (e.g., roads).

Original Hink & Ohmart

Date ________ Recorder ________________ UTM • E ______________ Polygon ID ____________

N ______________ Waypoint ____________

H&O Classification:

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100%

40'

.... ☐ 25-75% ☐ 75-100%

35'

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100%

30'

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100%

25'

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100%

20'

.... ☐ 25-75% ☐ 75-100% 15'

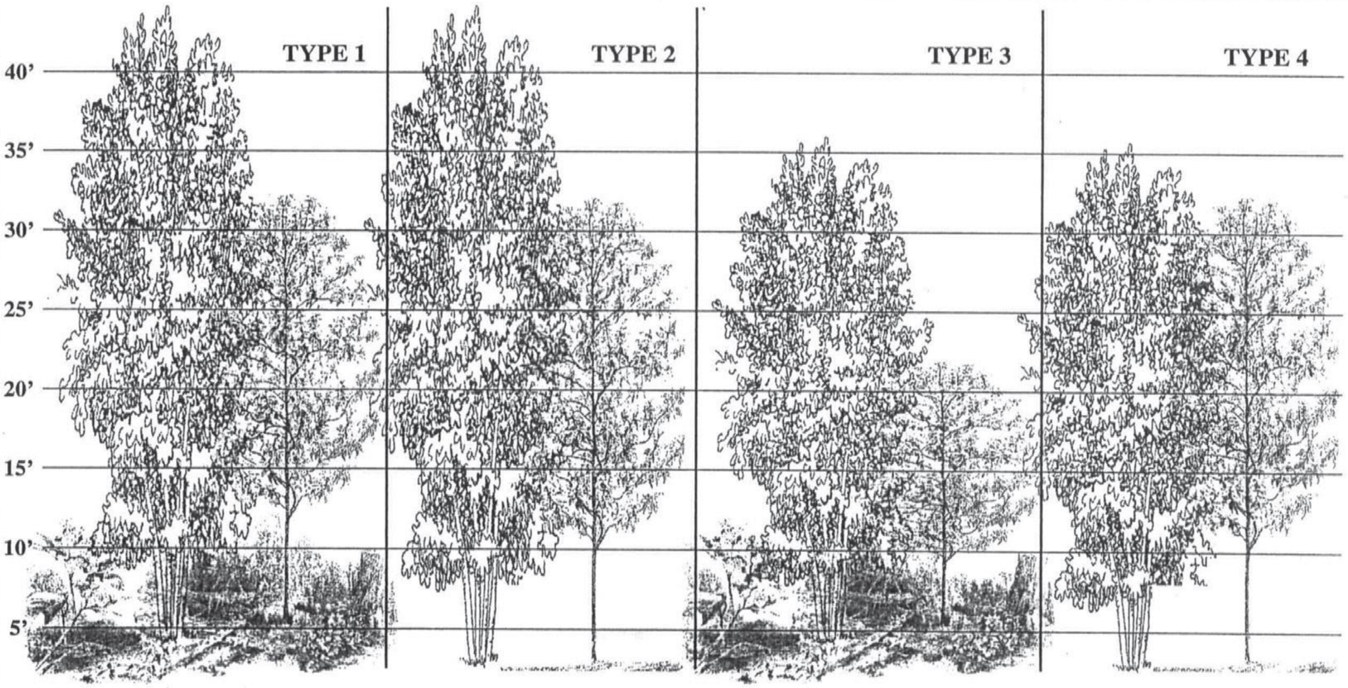
.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100% 10'

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100% 5'

.... ☐ 25-75% ☐ 75-100%



SPECIES:

A	= False Indigobush	LC	= New Mexico Locust
ATX	= Fourwing Saltbush	LY	= Wolfberry
B	= Baccharis (seep willow)	MB	= Mulberry
BD	= Broom Dalea	NMO	= New Mexico Olive
C	= Cottonwood	RO	= Russian Olive
CAT	= Cattail	SB	= Silver Buffaloberry
CR	= Creosote	SBM	= Screwbean Mesquite
CT	= Catalpa	SC	= Salt Cedar
CW	= Coyote Willow	SE	= Siberian Elm
HL	= Honey Locust	SS	= Sand Sage
HMS	= Honey Mesquite	TH	= Tree of Heaven
J	= Juniper	TS	= Threeleaf Sumac
		TW	= Tree Willow

.... ☐ 25-75% ☐ 75-100% 15'

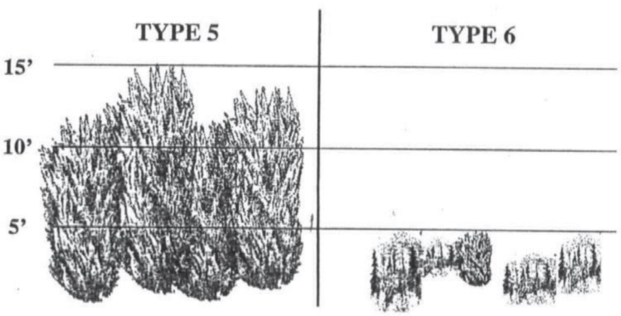
.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100% 10'

.... ☐ 25-75% ☐ 75-100% 5'

.... ☐ 25-75% ☐ 75-100%

.... ☐ 25-75% ☐ 75-100%



STRUCTURAL CLASS WORKSHEET (SWCA 2006) BASED ON HINK AND OHMART (1984)

GRGWA Project Photopoint log											
Project (e.g. 19-01)	Date & Time	Photopoint ID (format: 19.01_1_NESW)	Lat (dd.ddd)	Long (ddd.ddd)	Direction Facing (N, E, S, W)	Foreground Landmark: Description Distance, Bearing, Flagging color	Background Landmark: Description, Distance, Bearing	Whiteboard Distance (usu. 11.78 ft if standalone PP 37.24 ft if part of plot	Camera Used (e.g. red olympus, black ricoh)	Field Crew Initials	Comments/ Veg polygons

Soil Texture by Feel Flow Chart

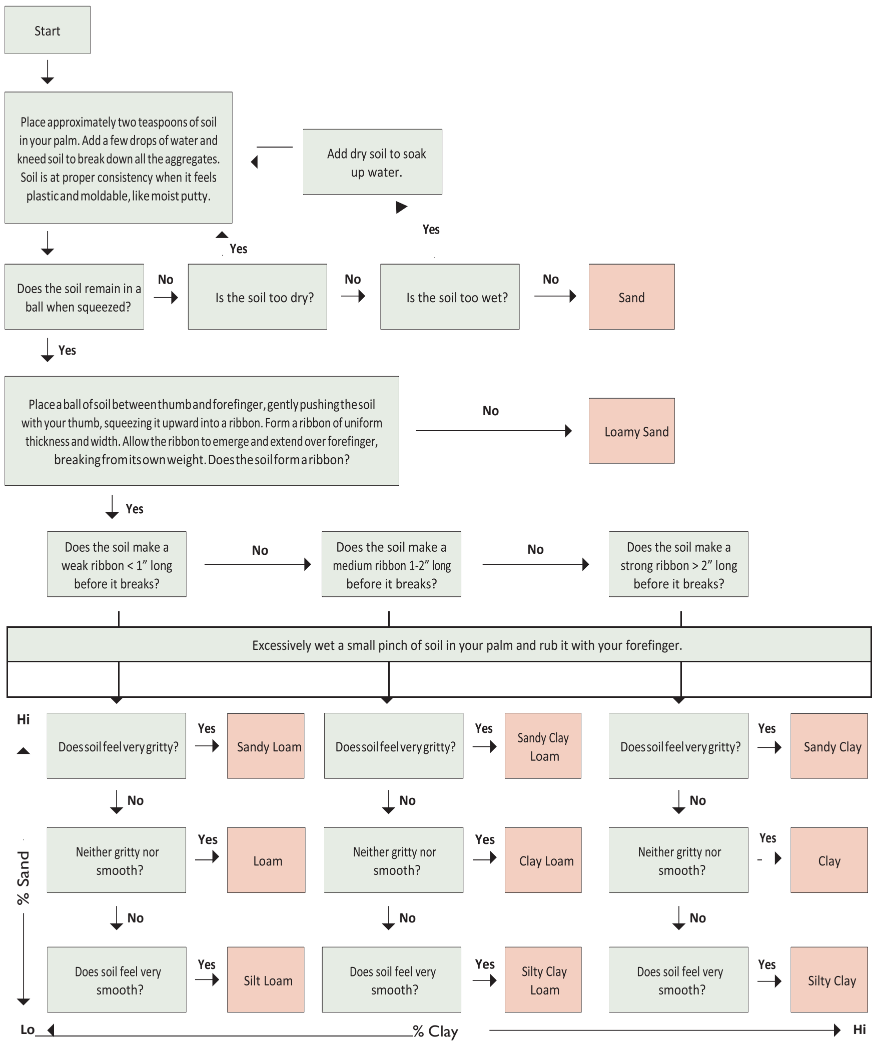


FIGURE 16. SOIL TEXTURE BY FEEL (THIEN 1979)

Materials Needed

• water • squirt bottle • texture by feel instruction sheet • distilled water