Lava SWCD Grants Projects 15-15 and 15-20

5-Year Post-treatment Monitoring Report

2021

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Lava & McKinley SWCDs

Contents

Acronyms and Abbreviations

Acronym, Abbreviation, or Term	Explanation or Definition as used by NMFWRI
AGL	above ground level; GIS term
BBIRD plots	Breeding Biology Research and Monitoring Database, larger circular plot types
BEMP plots	Bosque Ecosystem Monitoring Program, small rectangular plot types
FEAT	Fire Ecology Assessment Tool
FFI	FEAT/ FIREMON Integrated
FIREMON	Fire Effects Monitoring and Inventory System
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 low-intensity pre-treatment vegetation monitoring assessments performed on two non-native phreatophyte removal projects submitted by the Lava SWCD to the Greater Rio Grande Watershed Alliance. Following a discussion of the ecological context, and our monitoring methods, we present pertinent background, observations, and assessment results for each project.

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.

Monitoring and Field Methods

Low intensity Field Methods

Low intensity pre-treatment vegetation monitoring was done using an adapted version of the biotic portion of the New Mexico Rapid Assessment Method (NMRAM), v 2.0, updating recommendations made in the Field Manual for Greater Rio Grande Watershed Alliance (GRGWA) Riparian Restoration Effectiveness Monitoring and the GRGWA Monitoring Plan, developed by Lightfoot & Stropki of SWCA Environmental Consultants in 2012. (For a brief overview of both low and high intensity monitoring methods used by the NMFWRI on GRGWA projects, please see Appendix III.)

For those not familiar, NMRAM was developed by the New Mexico Environment Department Surface Water Quality Bureau Wetlands Program and Natural Heritage New Mexico as a "cost effective, yet consistent and meaningful tool" (Muldavin, 2011) for wetland ecological condition assessment in terms of anthropogenic disturbance as negatively correlated with quality and functionality. The portions of NMRAM we utilized are Level 2 "semi-quantitative" field measurements taken at less detail than plot level (Muldavin, 2011).

Measurements taken included relative native plant community composition, vegetation horizontal patch structure, vegetation vertical structure, native riparian tree regeneration, and invasive exotic plant species cover. The underlying method for these biotic assessments was a version of the 1984 Hink and Ohmart vertical structure classification system, modified for wetland assessment for use within the NMRAM (see Appendix IV). First, vegetation communities were mapped out by patch (polyon) according to the modified Hink and Ohmart system. Next, the presence of (state-listed) invasives, wetland species, and the two dominant species in each strata ("tree" >15 ft, "shrub" 4.5-15 ft, and "herbaceous" <4.5 ft) were recorded for each plant community. The native/exotic ratio in each of the patches was scored and weighted based on the percent of the project area each patch comprised. These scores were then combined with the additional biotic metrics of vertical and horizontal diversity, native tree regeneration, and overall (listed) invasive presence. The NMRAM rating system is based, on all levels, on a scale of 1 to 4, where 4 is considered excellent condition, 3 good, 2 fair, and 1 poor.

We also assessed soil surface condition, which is a metric typically included in the abiotic section of the NMRAM, as well as the presence of surface fuels, which is not part of the NMRAM. Unlike the other 6 metrics we used, surface fuels were recorded on a rating scale from 0 to 1.0 where 1.0 is a continuous fuel matrix.

Photopoints were established to capture images where vegetation shifts were observed. Waypoints were marked with a Garmin GPS unit and named sequentially by site. Photos were taken in the direction that most effectively captured the diverse vegetation community(ies). Where appropriate, one waypoint was used for photos taken in multiple directions.

Prior to entering the field, our GIS specialist created a map with the project boundaries as provided by GRGWA. She combined these polygons with recent aerial imagery and identified relevant roads and other landscape features. Once on the ground, the vegetation community polygons (as determined by the modified Hink and Ohmart classification system) were hand-drawn onto this map and served as the basis for other biotic metric assessments. Upon return to the office, this polygon map and the photopoints were digitized by the monitoring specialist.

Personnel Involved

2021 New Mexico Forest and Watershed Restoration Institute Monitoring Team:

- Kathryn R Mahan, Monitoring Program Manager
- Carmen Briones, Crew Logistics Support/ Assistant Manager
- Raymundo Melendez, Ecological Monitoring Technician
- Alex Makowicki, Ecological Monitoring Technician

2021 New Mexico Forest and Watershed Restoration Institute GIS Team:

- Patti Dappen, GIS Program Manager
- Katie Withnall, GIS Specialist

Other persons contacted:

- Fred Rossbach, Field Coordinator, Greater Rio Grande Watershed Alliance

Grants Projects

Projects 15-15 and 15-20 are located in and to the south of the city of Grants, New Mexico.

Grants receives an average of 10.4 inches of rain annually. Temperatures range from an average high of 88 degrees Fahrenheit in July, and an average low of 14 degrees Fahrenheit in January (City-stats, 2016). According to the NRCS Web Soil Survey, project area 15-15 is 44% Warm Springs loam, which is ecological site type R036XB009NM Salt Meadow, 30% Lava flows, 17% Viuda-Penistaja-Rock outcrop complex (ecological sites R036XB007NM Malpais and R035XA112NM Loamy), and 8% Venadito clay loam, ecological site type R035XA119NM Clayey Bottomland.

Project area 15-20 is 100% Venadito clay loam and R035XA119NM Clayey Bottomland.

The Salt Meadow ecological site typically supports a grassland state dominated by alkali sacaton and inland saltgrass; fourwing saltbush is the dominant shrub. In a deteriorated state, the site supports a plant community dominated by inland saltgrass, seepweed, iodinebush, salt cedar and bare ground. Other common grasses could include salsedge, foxtail barley, mat muhly, western wheatgrass, nuttall alkaligrass and alkali cordgrass. (Sylvester, 2002)

The Clayey Bottomland ecological site typically supports a grassland state dominated by western wheatgrass, blue grama, galleta, and alkali sacaton. It can also be found in a shrub-dominated state where dominant vegetation is rabbitbrush, fourwing saltbush, galleta and other grasses, as well as a bare state with sparse annual vegetation. (USDA NRCS, 2005)

The Malpais ecological site typically supports a grassland state dominated by blue grama and sideoats grama. Other common vegetation includes western wheatgrass, little bluestem, spike muhly, black grama, galleta, New Mexico feathergrass, alkali sacaton, winterfat, fourwing saltbush, broom snakeweed, and scattered piñon and juniper. In a detoriated state the grass community may become sod-bound, dominated by blue grama sod, threeawns, wolfstail and snakeweed. (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, 2002)

Project 15-15, Southeast Grants

Monitoring was conducted at this site on December 7, 2021 as part of a restoration project targeting non-native phreatophytes scheduled for 2015-2016. The project is located within Cibola County, NM, on the southeast side of the city of Grants (see Figure 2 below). It is an upland site, bordered by urban development, the Atchison-Topeka railroad, and US I-40. The project was sponsored by the Lava SWCD. Planned treatment includes removal of nonnative phreatophytes. Restoration goals are to remove predominantly salt cedar, with some Russian olive and Siberian elm in order to create a more natural state, reduce fire hazard, promote native species, and increase awareness of bosque restoration efforts.

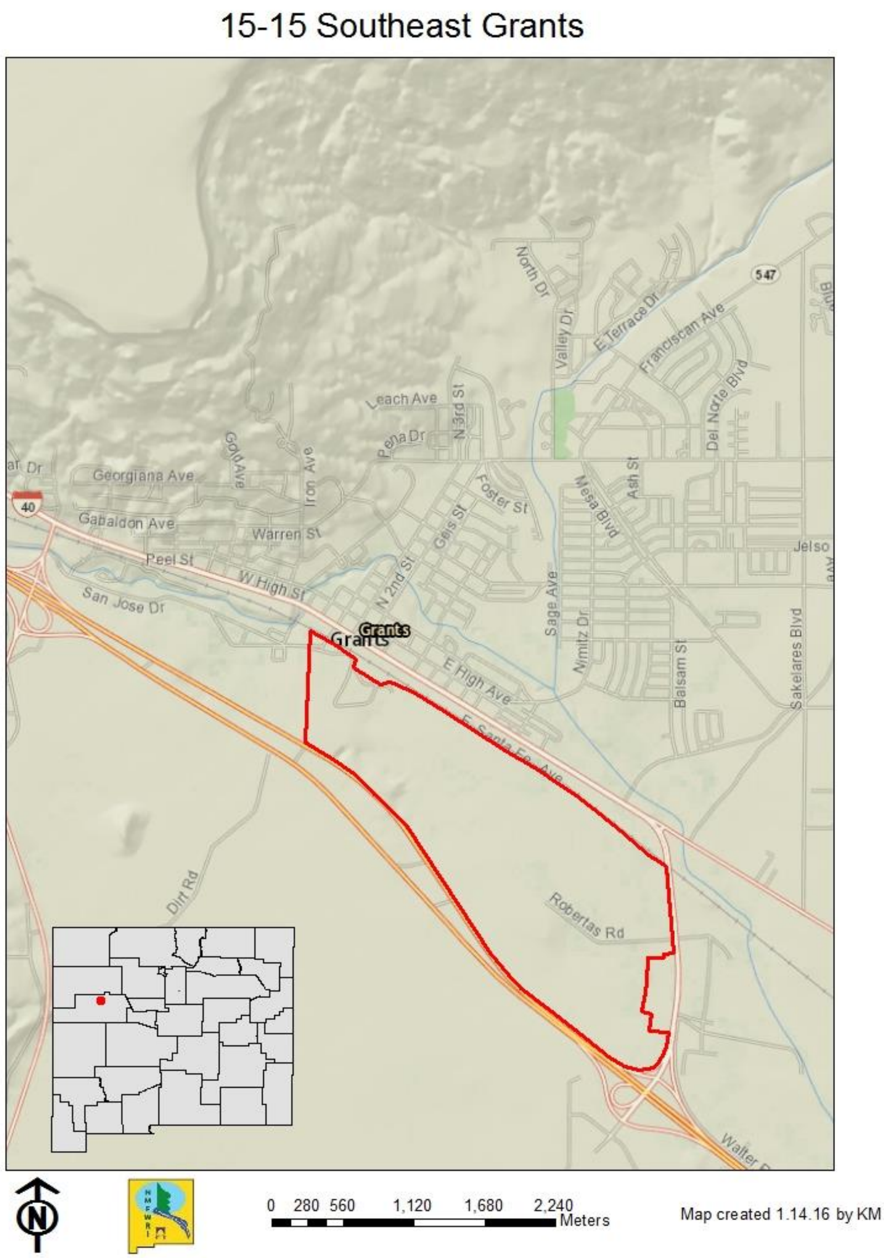


Figure 1. 15.15 Southeast Grants relative to the city of Grants.

Project 15-15 covers a large area along the railroad and US I-40 which is largely undeveloped. There are salt flats/alkali sink/playas on the NE side, and saltgrass scattered across the southern half of the site. There is no evidence of water movement across most of the site. Salt cedar is common, particularly in the eastern half of the site. One main road (Robert Rd) leads to a building near the center of the project, and several smaller two-tracks crisscross the project allowing access to billboards on the south side. Color balance has been altered in Figure 3 for better visibility of the sketched-in roads.

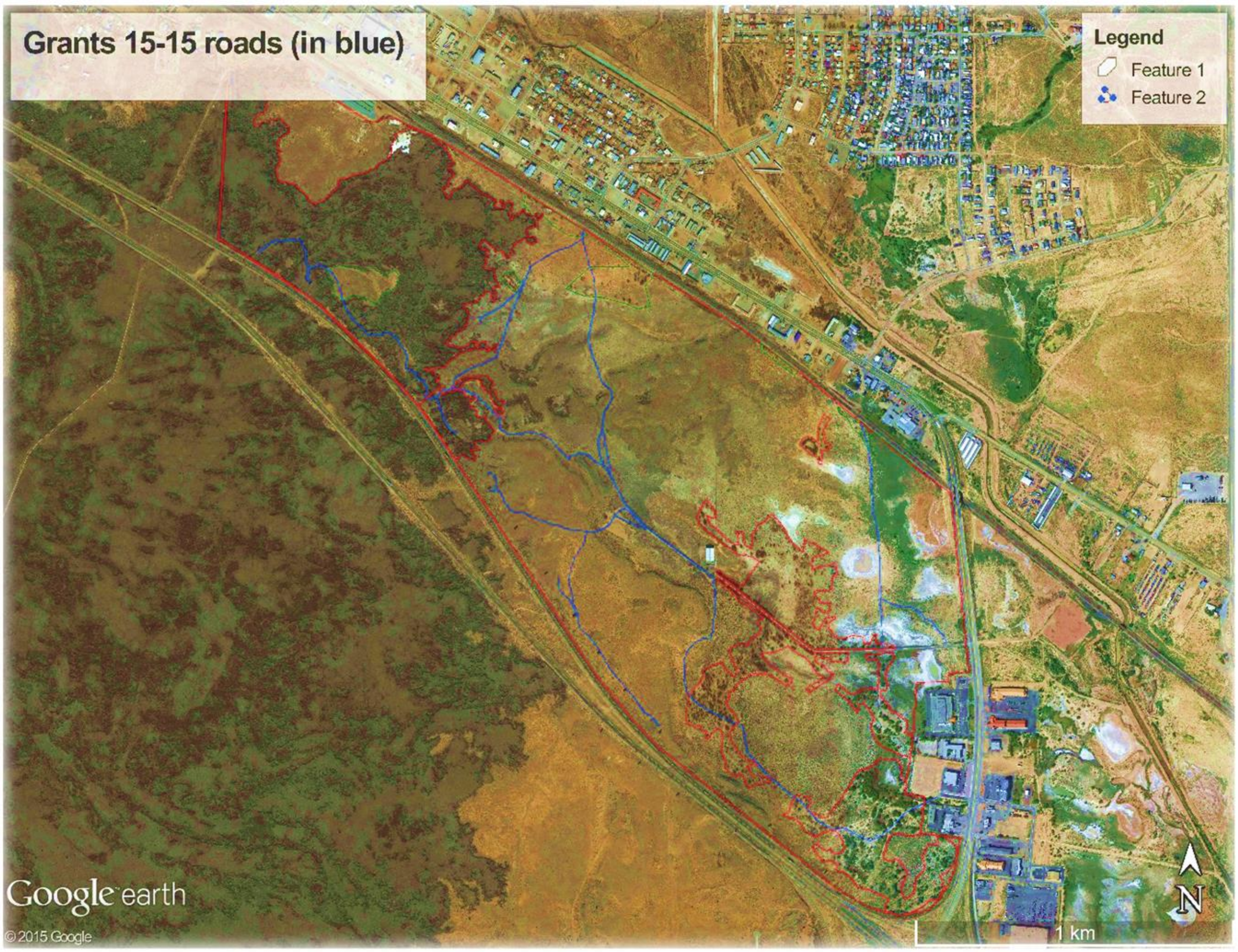


Figure 2. Sketch of two-track roads visible on aerial imagery within the 15.15 project area.

Metric (15.15 December 7, 2021)	2021 Score	2015 Score
Relative Native Plant Community Composition	2	2
Vegetation Horizontal Patch Structure	2	4
Vegetation Vertical Structure	1	2
Native Riparian Tree Regeneration	1	1
Exotic Invasive Plant Species Cover	1	1
Project Biotic Score (based on above ratings)	1.6	2.1
Project Biotic Rating	D/Poor	C/Fair
Soil Surface Condition	3	3
Surface Fuels	0.85	0.80

Low scores for the project came in Vegetation Horizontal Patch Structure and Vegetation Vertical Structure. Vegetation Horizontal Patch Structure score dropped from 2015 because of the loss of vegetation structure types. In 2015 four different vegetation structure types were observed which included stands of tall shrubs, this vegetation type occupied 25% of the area monitored. In 2021 only two different vegetation structure types were observed: herbaceous ground cover taking up 90% of the sample area. The other 10% of the area was covered by short shrub stands under four and a half feet. The decrease in Vegetation Vertical Structure was due to the conversion of tall shrub land to low growing herbaceous vegetation which does not provide as beneficial of a habitat as tall shrubs. In 2015 Type 5 structure covered enough of the sample area to be considered dominant, but was not seen in 2021 due to their mastication during treatment. Overall, the site received a “D” or “Poor” condition which was a decrease from 2015 which received a rating of “C” or “Fair”.

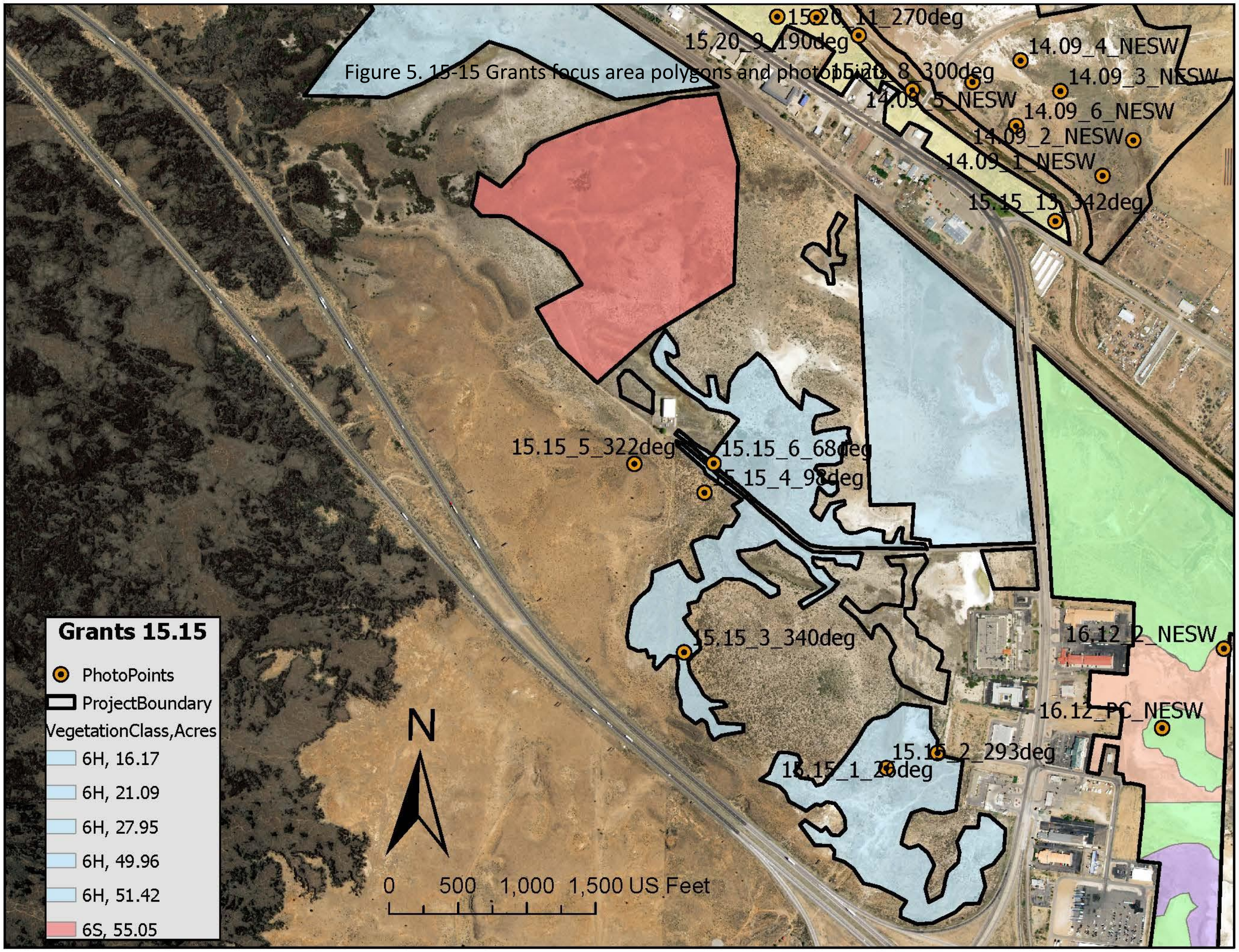
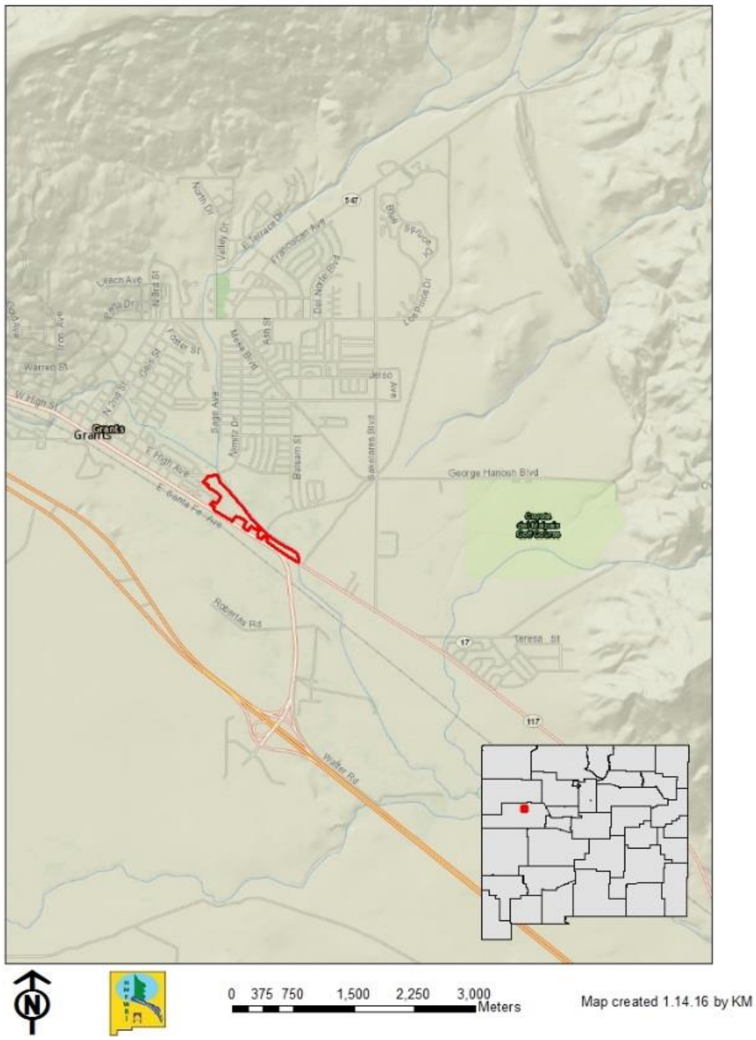


Figure 3. Vegetation polygons created from NMRAM

Project 15-20, Grants Phase 3/ Mount Taylor

Monitoring was conducted at this 32 –acre project site on December 7th, 2021 as part of a restoration project targeting non-native phreatophytes scheduled for 2015-2016. The project is located on a number of private parcels in the town of Grants in Cibola County (see Figure 8). The project was sponsored by the Lava SWCD. Planned treatment includes removal of varying density salt cedar as well as Russian olive and Siberian elm. Restoration goals are to reduce fire hazard, promote native vegetation and raise awareness of bosque restoration projects in the local area.

15-20 Grants Phase 3/ Mt Taylor



15-20 Grants Phase 3/ Mt Taylor

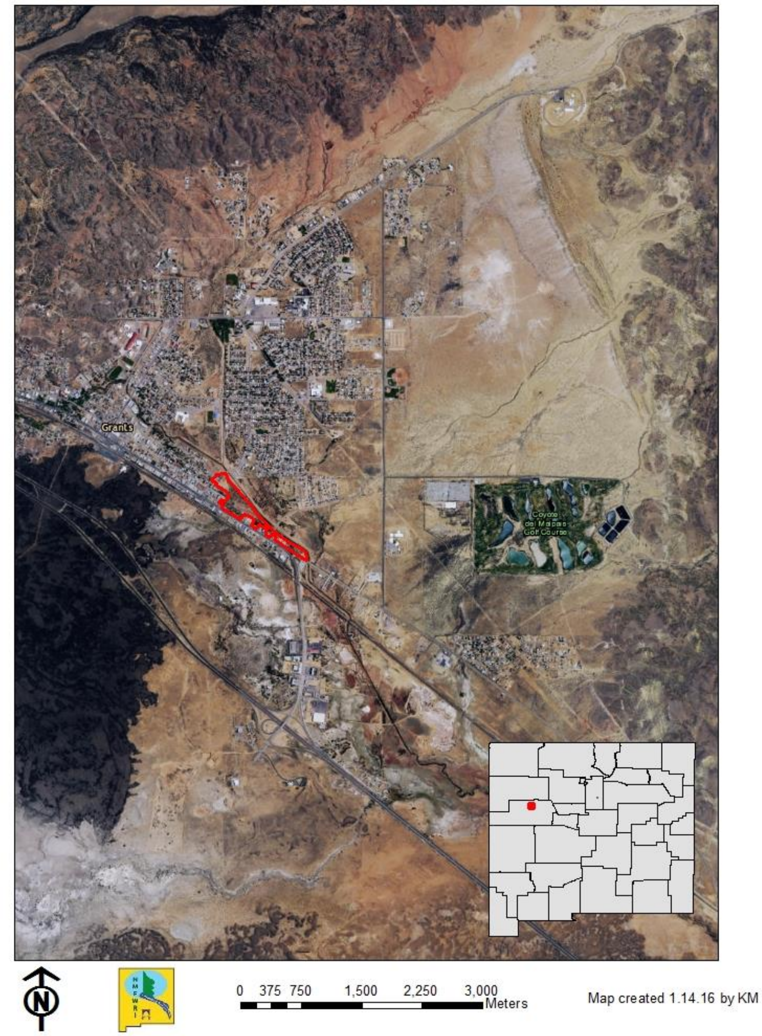


Figure 4. Project 15.20 Mount Taylor relative to the town of Grants

Project 15-20 is comprised of a number of private properties in the city of Grants. The project can be accessed either through these private properties or from levees on the north side. The closest levee road has a hole along the edge which could get larger if not addressed in maintenance. There is a road through the middle of the project which is not driveable but which makes for easy walking. Exotic species observed during the September 2015 site visit included salt cedar of various age classes, Russian thistle and kochia. Native species included fourwing saltbush, *Suaeda nigra* (Mojave seablite), chamisa (rubber rabbitbrush), *Senecio wootonii* (Wooton's ragwort), alkali sacaton, Helianthus, greasewood and *Xanthium strumarium (*cocklebur).

Metric (15.20 December 7, 2021)	**2021 Score**	**2015 Score**
Relative Native Plant Community Composition	1	1
Vegetation Horizontal Patch Structure	1	4
Vegetation Vertical Structure	1	2
Native Riparian Tree Regeneration	1	1
Exotic Invasive Plant Species Cover	1	1
Project Biotic Score (based on above ratings)	1.1	1.8
Project Biotic Rating	D/Poor	C/Fair
Soil Surface Condition	2	1
Surface Fuels	0.30	0.52

Low scores for this project came in Vegetation Horizontal Patch Structure and Vegetation Vertical Structure. These scores were reduced because there was a loss in the number of different vegetation structure types. In 2015 four different vegetation types were observed; tall shrubs (4-15ft), short shrubs (0-4.5ft), herbaceous ground cover and bare ground. Tall shrubs can include tamarisk and treatment on this site included the removal of salt cedar, this could explain the lack of tall shrubs observed during 2021. In 2021 herbaceous vegetation occupied the entire sample area; plants in the area included four-wing saltbush and greasewood. These plants would easily be able to take over an area with abundant open spaces and lack of competition from taller shrub species.

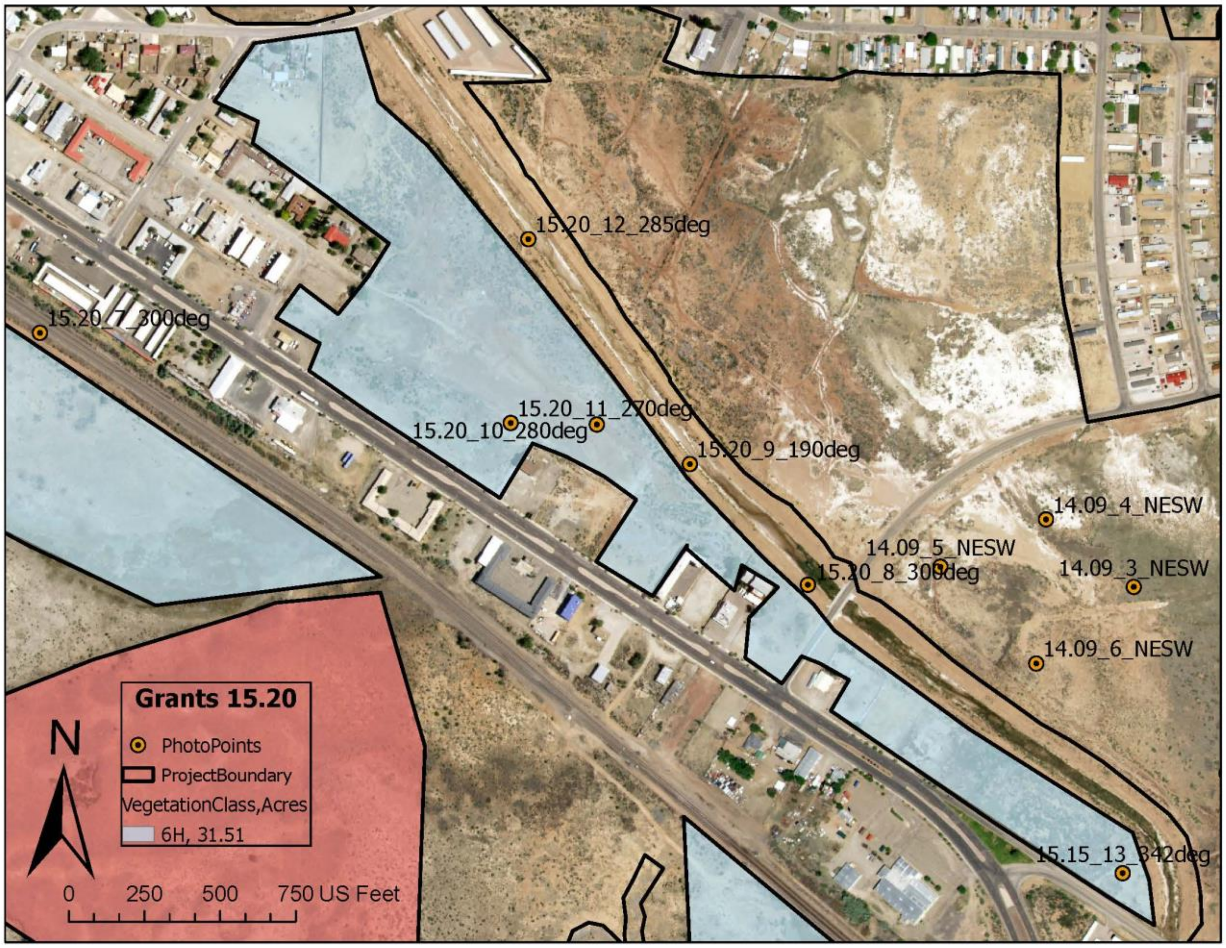


Figure 5. Vegetation polygons created from NMRAM

Discussion

We would like to clarify that we are adapting these NMRAM metrics for our own purposes. That is, we are using them both inside and outside their intended site ranges, including on larger sites (NMRAM is designed to handle a site around 100 x 200 meters), sites further from the river (NMRAM is currently in use primarily for assessing riverine wetlands), and sites defined by exotic vegetation presence rather than hydrologic boundaries and upland vegetation indicators/apparent wetland extent. Site delineation and size is likely to be variable for a number of other reasons, including landowner participation, available funds, proposals received from contractors, etc – many of which cannot be directly correlated to site disturbance or ecological function. For this reason, we do not use the entire NMRAM assessment, or place confidence in the weighted score roll-ups that are typically part of an NMRAM report. Should one be interested, rationale for the weighting in the NMRAM score roll-up can be found in the yet-to-be-published field manual for version 2.0. For more information, contact Maryann McGraw of the NMED or NMFWRI.

While we provide a biotic site score and rating for your reference, we recommend comparisons be done with individual metrics from pre-treatment and post-treatment assessment from the same site, rather than across multiple sites. Also of note is that statistical analysis is not appropriate for NMRAM, or other low intensity, rapid field methods.

Please note that should the project area change significantly from what was originally proposed and monitored, all metrics will lose some amount of confidence on comparison as it is impractical to re-examine the original site assessment scores using new boundaries. This is an issue of concern of which GRGWA should be aware. We recommend that GRGWA attempt to minimize alterations in project boundaries once pre-treatment monitoring data has been approved for collection. Another, somewhat alternative, recommendation is that the initial monitoring regime include high-intensity modified BEMP-type plots which could be repeated in their exact initial locations, allowing collection of comparable data regardless of boundary change. We recognize that this is not always practical: boundaries change for a number of reasons and time and cost constraints can necessitate the sole use of a rapid assessment method for monitoring. We have reason to hope our outlined assessment method will still be a satisfactory indicator for site function improvement or degradation primarily because metrics in rapid assessment methods such as this are set up to have relatively low sensitivities (i.e. for a change to be reflected in the metrics, either positive or negative, disturbance on site has to be significantly altered).

From here on out, the goal of the GRGWA/ NMFWRI is that all sites will be revisited for post-treatment monitoring in 5-year intervals. 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.

References

Audubon New Mexico. (2013). Water Matters: Water for New Mexico Rivers. Albuquerque, New Mexico: Utton Transboundary Resources Center.

City-stats. (2016). *Grants (New mexico) Climate*. Retrieved from City-stats.org: http://city-stats.org/nm/grants/climate/grants-climate-data

Claunch-Pinto Soil and Water Conservation District on behalf of the Greater Rio Grande Watershed Aliance. (2015). *Request for Proposals for Greater Rio Grande Watershed Alliance Riparian Restoration Projects.* Mountainair, NM: Claunch-Pinto Soil and Water Conservation District.

Committee on Riparian Zone Functioning and Strategies for Management, et al. (2002). *Riparian Areas: Functions and Strategies for Management.* Washington, D.C.: National Academy Press.

Lightfoot, D. &. (2012). *Greater Rio Grande Watershed Alliance Riparian Restoration Effectiveness Monitoring Plan.* Albuquerque, NM: SWCA Environmental Consultants.

Lightfoot, David & Stropki, C. (2012). *Field Manual for Greater Rio Grande Watershed Alliance Riparian Restoration Effectiveness Monitoring.* Albuquerque, NM: SWCA Environmental Consultants.

MRGCD. (n.d.). *Mapping and GIS Department*. Retrieved from MRGCD: http://mrgcd.com/Mapping-GIS_Overview.aspx

Muldavin, E. B. (2011). New Mexico Rapid Assessment Method: Montaine Riverine Wetlands. Version 1.1. Final report to the New Mexico Environment Department, Surface Water Quality Bureau. 90 pp. and appendices.

New Mexico Department of Game and Fish Conservation Services Division. (2012). *Bridge and Road Construction/Reconstruction Guidelines for Wetland and Riparian Areas.*

Sylvester, D. (2002). Ecological Site Characteristics - Salt Meadow. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_067086.pdf

USDA NRCS. (2002). *Ecological Site Description - Loamy*. Retrieved from USDA NRCS ESD: https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&rptLevel=all&id=R035XA112NM

USDA NRCS. (2005). *Ecological Site Characteristics - Clayey Bottomland*. Retrieved from USDA NRCS ESD: https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&rptLevel=all&id=R035XA119NM

USDA NRCS. (2013, December 6). *Web Soil Survey*. Retrieved from http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

USDA NRCS. (2016). The PLANTS Database. Greensboro, North Carolina, USA: National Plant Data Team. Retrieved January 19, 2016, from http://plants.usda.gov

USDA NRCS. (n.d.). *Ecological Site Characteristics - Malpais*. Retrieved from USDA NRCS ESD: https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&rptLevel=all&id=R036XB007NM

USDA NRCS. (n.d.). *Section I: Ecological Site Characteristics, Bottomland.* Retrieved from USDA NRCS ESD: https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&rptLevel=all&id=R042XA057NM

USDA NRCS. (n.d.). *Section I: Ecological Site Characteristics, Salty Bottomland.* Retrieved from USDA NRCS ESD: https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&rptLevel=all&id=R042XA055NM

USDA USFS. (1996, September). Ecology, Diversity, and Sustainability of the Middle Rio Grande Basin, RM-GTR-268. (D. M. Finch, & J. A. Tainter, Eds.) Fort Collins, Colorado.

Appendix I: Photopoint Table

Project Name	Point number in NMFWRI GPX files	Point name on NMFWRI maps	Direction facing (azimuth)	Description	Coordinates
15-15pre	Pp1	GPP1	26		35.128866909, -107.829818716
15-15pre	Pp2	GPP2	293		35.128536914, -107.831047922
15-15pre	Pp3	GPP3	340		35.130732721, -107.836041106
15-15pre	Pp4	GPP4	approx 92 to 102		35.133930501, -107.835656209
15-15pre	Pp5	GPP5	322		35.13446602, -107.837377433
15-15pre	Pp6	GPP6	68		35.134519665, -107.835455295
15-15pre	Pp13	GPP7	200		35.144166666, -107.839444444
15-20pre	Pp7	GPP8	300	polygon 1	35.142081985, -107.830888918
15-20pre	Pp8	GPP9	190		35.143145481, -107.832229771
15-20pre	Pp9	GPP10	280	type 7 & road	35.143479751, -107.833268959
15-20pre	Pp10	GPP11	270	polygon 5	35.143471537, -107.834219635
15-20pre	Pp11	GPP12	285		35.14514205, -107.834082507
15-20pre	Pp12	GPP13	342	polygon 12	35.13954889, -107.827324346

Figure 7. Photo point table for sites 15.15 and 15.20

15.15_1_26deg	10/4/2021 3:00pm	100-0104	35.12890107	-107.8298091	26° N	4-wing saltbrush @21' @26°	Salt cedar; NM olive @113' @26°	-	Olympus Red	CB, RM, LW	Next to fence. Cross fence salt cedar, fourwing saltbush. Fence @37' and @26°.
15.15_2_293deg	10/4/2021 3:28pm	100-0105	35.12855271	-107.8310468	293°	4-wing saltbrush @75' @293°	4-winged salt bush as far as you can see	-	Olympus Red	CB, RM, LW	In open area fourwing saltbush. DWD in and out of the area.
15.15_3_340deg	10/5/2021 8:55am	100-0106	35.13075117	-107.83606	340°	4-wing saltbrush @17' @340°	Lava hill @994' @340°	-	Olympus Red	CB, RM	Very open, grassy, fourwing saltbush, and DWD in/out of the area.
15.15_4_98deg	10/5/2021 9:13am	100-0106	35.13393673	-107.8356789	98°	Rubber rabbit brush @25' @98°	Telephone post @3000' @98°	-	Olympus Red	CB, RM	Alkali sascatoon, fourwing saltbush, rubber rabbit brush and very open.
15.15_6_62deg	10/5/2021 9:32am	100-0109	35.1345187	-107.8354851	62°	Fence @18' @62°	4-wing saltbush @181' @62°	-	Olympus Red	CB, RM	On side of dirt road and next to fence. Fourwind saltbush and tumbleweed. Train in background and bridge too. Big mountains.
15.15_5_322deg	10/5/2021 9:55am	100-0110	35.13447157	-107.8374131	322°	Cholla/edge of cliff @42' @338°	4-wing & other shrubs down hill @431' @338°	-	Olympus Red	CB, RM	On top of hill, rocky, fourwing saltbush, and ring muhly grass.
15.15_13_342deg	12/7/2021 12:32pm	100-0365	35.1395261	-107.8273343	342°	4-wing saltbush @31' @342°	Electrical line post @145' @0°	-	Olympus Red	CB, RM, AM	Bare ground(PC). Road 200° with a hill/mountain NW. Town @292°

15.20_7_300deg	12/7/2021 1:09 pm	100-0366	35.14416682	-107.8394661	300deg	4 wing salt bush @22' @290o	Salt cedar @792 @300o	-	Olympus Red	CB, AM, RM	At hillside next to train tracks. Next to dirt road. 210° is I-40.
15.20_10_280deg	12/7/2021 2:04 pm	100-0367	35.14348447	-107.8332707	280deg	4 wing salt bush @18' @280o	Building, white building @1469' @280o	-	Olympus Red	CB, AM, RM	Next to dirt road, 4wing saltbush, @210° road and 2 hotels. Salt cedar at 330°
15.20_9_190deg	12/7/2021 2:21 pm	100-0368	35.14314	-107.8322546	190deg	4 wing salt cedar @16' @190o	Motel building @410' @190o	-	Olympus Red	CB, AM, RM	In middle of dirt road. @ 40° drainage ditch. @270° main road and many buildings.
15.20_8_300deg	12/7/2021 2:36 pm	100-0369	35.14207799	-107.8308995	232deg	dirt road @1-15' @232o	Building with red roof @140' @232o	-	Olympus Red	CB, AM, RM	Matches old photo. Bareground next to drainage, many cattails
15.20_11_270deg	12/7/2021 2:57 pm	100-0371	35.14345037	-107.8342237	270deg	4 wing salt bush @29' @270o	Pizza 9 red @708' @270o	-	Olympus Red	CB, AM, RM	4 wing saltbush, main road, Pizza 9 restaurant, and train tracks.

Appendix II: Photo pages, by site

15-15 Photos

2015: GPP1, view of salt cedar in polygon 1, near Walgreens. Taken facing 26 degrees NE.

2021: 15.15_1_26DEG_26DEG

2015: GPP2, view of saltgrass and salt cedar in Polygon 1 and Polygon 4. Taken facing 293 degrees

2021:
15.15_2_293DEG
_293DEG

2015: GPP3, view of polygon 5. Taken facing 340 degrees.

2021: 15.15_3_340DEG _340DEG

2015: GPP4, view of Polygon 5 and 6. Taken facing 92 degrees SE.

2021: 15.15_4_98DEG _98DEG

2015: GPP5, view of polygon 6. Taken facing 322 degrees.

2021: 15.15_5_322DEG _322DEG

2015: GPP6, view of polygon 8. Taken facing 62 degrees.

2021: 15.15_6_62DEG_62DEG

2015: GPP13, view of NE end of project. Taken facing 200 degrees SW.

Unable to locate matching 2021 photo

15-20 Photos

2015: GPP7, view of salt cedar and kochia in Polygon 1. Taken facing 300 degrees

2021: 15.20_8_300Deg_232Deg

2015: GPP8, view of salt cedar, greasewood and two-track through project area. Taken facing 190 degrees SW.

2021: 15.20_9_190Deg _190Deg

2015: GPP9, view two-track, salt flat, and sparsely vegetated area (Polygon 8). Taken facing 280 degrees NW.

2021: 15.20_10_280Deg_280Deg

2015: GPP10, view of salt cedar and Polygon 5. Taken facing 270 degrees W.

2021: 15.20_11_270Deg_270Deg

2015: GPP11, salt cedar and erosion along levee road.

No 2021 matching photo was found

2015: GPP12, view of polygon 12. Taken facing 342 degrees NW.

2021: 15.15_13_342Deg_ 342Deg

Appendix III: All current monitoring options

Low-intensity methods

- Where: happens on all sites with GRGWA projects
- Method name: NMRAM (New Mexico Rapid Assessment Method v 2.0)
- Time required: 3 hours – half day/ site
- Repeat: done once pre-treatment and in 4-5 year intervals post-treatment
- Basics: mapping vegetation communities (by vertical and horizontal structure), recording dominant vegetation in each strata (trees, shrubs, herbaceous), assessing fuel load, noting soil surface condition and native/exotic ratio at all vegetation levels, photo points
- Any on-site impacts or materials: none

High-intensity methods

- Where: happens on select sites, in addition to low-intensity monitoring

Submethod name 1: BBIRD or BEMP vegetation plots (depends on treatment area size)

- Time required: approx. 2 hours/site
- Repeat: both pre-treatment and in 4-5 yr intervals post-treatment
- Basics: larger plots and transects documenting vegetation, photo points
- On-site impacts or materials: rebar and cap

Submethod name 2: Brown's transects

- Time required: 1-1.5 hours/site
- Repeat: both pre-treatment and in 4-5 yr intervals post-treatment
- Basics: transects to calculate fuel loading and fire behavior, photo points
- On-site impacts or materials: rebar and cap

Submethod name 3: BEMP-adapted Groundwater Well Monitoring

- Time required:
  - Initial installation: 1-2 hours/ well (ideally 2+ wells/site)
    - Repeat: maintenance as needed, should be minimal
  - Data offloading: 10-20 minutes/well
    - Repeat: at least annually (this is when we anticipate datalogger will be full and batteries will need to be changed)
- Basics: install a well with a sensor which records groundwater level and temperature once an hour year round; this will reflect changes due to seasonal variation, vegetation growth, irrigation, etc.
- On-site impacts or materials: shallow monitoring well (consists of capped PVC pipe extending into the ground about 3 feet below the water table and above ground approx. 2 feet (can be painted earth tones); well contains a datalogger (pressure transducer) suspended on a cable into the water); well should be protected from cattle grazing (so may require rebar around pvc visible above ground)

Appendix IV: 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)

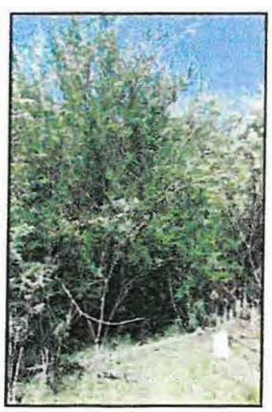
Type 1–High Structure Forest with a well-developed understory.

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.

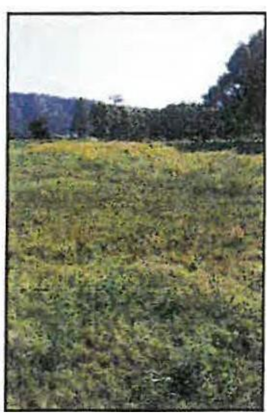
Young tree and shrub layer only (1.5-5 m [4.5-15 feet]) covering >25% of the area of the community (polygon). Stands dominated by tall shrubs and young trees, may include herbaceous vegetation underneath the woody vegetation. Photograph on San Francisco River by Y. Chauvin, 2012.

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.