Pino Fire Restoration Project 14-16

Pre-treatment Monitoring Report

2015

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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
MRCGD	Middle Rio Grande Conservancy District
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
VSWCD	Valencia Soil and Water Conservation District
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 assessment performed on a non-native phreatophyte removal project submitted for the Rio Grande to the Greater Rio Grande Watershed Alliance. Following an explanation of monitoring methods, we will discuss 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 use in the NMRAM for Montane Riverine Wetlands version 2.0 (see Appendix IV). First, vegetation communities were mapped out by patch (polyon) according to the 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.

While vegetation polygon maps are typically a product of NMRAM assessments, they are not available in this case due to contractor error. Instead, NMFWRI's GIS Specialist used LIDAR to classify vegetation structure.

Estimating Vegetation Cover using LIDAR and eCognition Software

LIDAR, light detecting and ranging, elevation data were used to estimate vegetation height and canopy characteristics a supplement to field monitoring data for some GRGWA pre-treatment project sites, including this one. This analysis is especially useful in large or difficult-to-access areas, but because of the effort involved, analysis with LIDAR and eCognition is not typically performed on small, easily accessible sites. While this area was easily accessible, its use was necessitated by the absence of a field-generated vegetation polygon map.

To perform the analysis, 2012 LIDAR was provided by Bureau of Reclamation (flown in February). One foot 2014 NAIP (National Agriculture Imagery Program) imagery was acquired to get an estimate of vegetation extent. NAIP is a USDA/FSA program to acquire 'leaf on' aerial imagery during the peak growing season. NAIP imagery for New Mexico can be downloaded by Quarter Quadrangle extent in an uncompressed TIFF format via RGIS –Resource Geographic Information System (http://rgis.unm.edu/). Note that in this case, burned areas were masked out of the analysis as post-burn LIDAR was not available.

In order to classify vegetation, the LIDAR point cloud was filtered to isolate first returns and then LIDAR elevations were calculated to represent height above ground level (AGL). Next, the AGL point cloud was exported by height categories that correlate with the Hink and Ohmart height classes as modified for use in the NMRAM (2.0). These separate point clouds were then converted into separate digital surface models and exported as GeoTiffs.

Understory vegetation was classified first. Understory vegetation were classified using first returns of LIDAR elevations less than 15ft and 1 foot 2014 4- band ortho-imagery within eCognition.

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.

Image segmentation within eCognition was based on elevation surface models. NDVI (Normalized Difference Vegetation Index) from the ortho-imagery was calculated and incorporated as a threshold to determine vegetation from dead or non-vegetative areas. The resulting classifications were combined into one image representing total understory vegetation.

The understory vegetation layer was used as an input in the multiple story community classifications (Types 1 and 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 understory vegetation layer was used to identify whether each class had understory vegetation or not and was then classified accordingly.

Personnel Involved

2014/5 New Mexico Forest and Watershed Restoration Institute Monitoring Team:

- Jacob Key, Monitoring Contractor
- Kathryn R Mahan, Ecological Monitoring Specialist

2014/5 New Mexico Forest and Watershed Restoration Institute GIS Team:

- Patti Dappen, GIS Specialist

Other persons contacted:

- Fred Rossbach, Field Coordinator, Greater Rio Grande Watershed Alliance
- Madeline Miller, Valencia Soil and Watershed Conservation District

Pino Fire Restoration Project

Project Description & Goals

Project 14-16 is located on Valencia SWCD and MRGCD property near the communities of Belen and Rio Communities, NM.

Belen receives an average of 7.6 inches of rain annually. Temperatures range from an average high of 95 in July, average low of 19 in January (City-Stats, 2015). According to the USDA NRCS Web Soil Survey, the project is nearly 90% Typic Ustifluvents and 10% Mixed Alluvial land. The Typic Ustifluvents map unit correlates to ecological site R042XB018NM Bottomland, and Mixed Alluvial land is ecological site R042XA055NM Salty Bottomland.

Bottomland typically supports bottomland grassland plant communities, for example, those dominated by burrograss, alkali sacaton, giant sacaton, dropseeds, galleta, vinemesquite, and/or tobosa (USDA NRCS). Salty Bottomland can support a range of plant communities which typically include cottonwood, tamarisk, mixed exotics (dominated by Russian olive/ Russian knapweed/ etc), saltgrass and saltgrass-sacaton, and bottomland grassland (possibly dominated by saltgrass, giant sacaton, dropseed, muhly, and/or any of the other grasses listed for Bottomland) (USDA NRCS)

The project is located south of the Jarrales bridge, and had not been treated prior to the Pino Wildfire. Restoration activities planned included removal by a variety of methods of Siberian elm, Russian olive, salt cedar, mulberry and tree-of-heaven as well as burnt black willow poles. Restoration goals were to rehabilitate the impacts of the Pino wildfire as well as fire hazard reduction (i.e. improve ecosystem function through removal of nonnative invasive phreatophytes and down woody debris, promote native species, and improve wildlife habitat). Jetty jacks are present on-site, as is a powerline. Section boundaries include the river, a fuelbreak, a dozer line, and levee and canal roads.

The Pino Wildfire

The Pino Fire had a substantial impact on this site. This was a wildfire that burned over 50 acres in and around the bosque during March of 2014.

According to the Valencia SWCD's 2015 Annual Report, the fire was caused by the actions of a private landowner burning slash piles on the east side of the river. The response was a collaboration between New Mexico State Forestry (including inmate crews), the Bureau of Land Management, US Forest Service, and volunteers from Valencia and Socorro Counties and required over 15 engines, 3 tenders, a helicopter, a bulldozer, two hand crews (for a total of over 50 people) working at one time. The fire jumped the river due to high winds. Five to six residences and "several" hay barns were threatened during the course of the fire; ultimately, no structures were burned (NM State Forestry Fire Information Office, 2014).

Local news reported the fire's primary fuel source was the dense salt cedar stands along the river (Chelo Rivera, KRQE News 13, 2014). GRGWA's 2014 RFP noted the presence of dead sapling- and pole-sized salt cedar and Russian olives in the project area but suggested that much of the damaged vegetation was beginning to re-sprout, with heights at 2 to 4 feet by August 2014, just 5 months post-fire (Claunch-Pinto Soil and Water Conservation District on behalf of The Greater Rio Grande Watershed Alliance, 2014). Our contractor's photographs and notes from February 2016 (11 months post-fire; see Appendix II) suggest a patchy burn pattern where some areas experienced significant mortality in all canopy strata.

By contrast, VSWCD's 2015 report noted that the MRGCD's Fuels Reduction research site to the Northwest of the project, with a patchy mosaic of native vegetation, had a "great recovery" in shrub and groundcover species, as well as good survival of overstory trees. (Valencia SWCD)

We suggest VSWCD and the MRCGD consider further exploring the differences in fire severity and vegetation response in these two nearby areas given that they had such different pre-fire native/exotic composition ratios and vegetation densities.

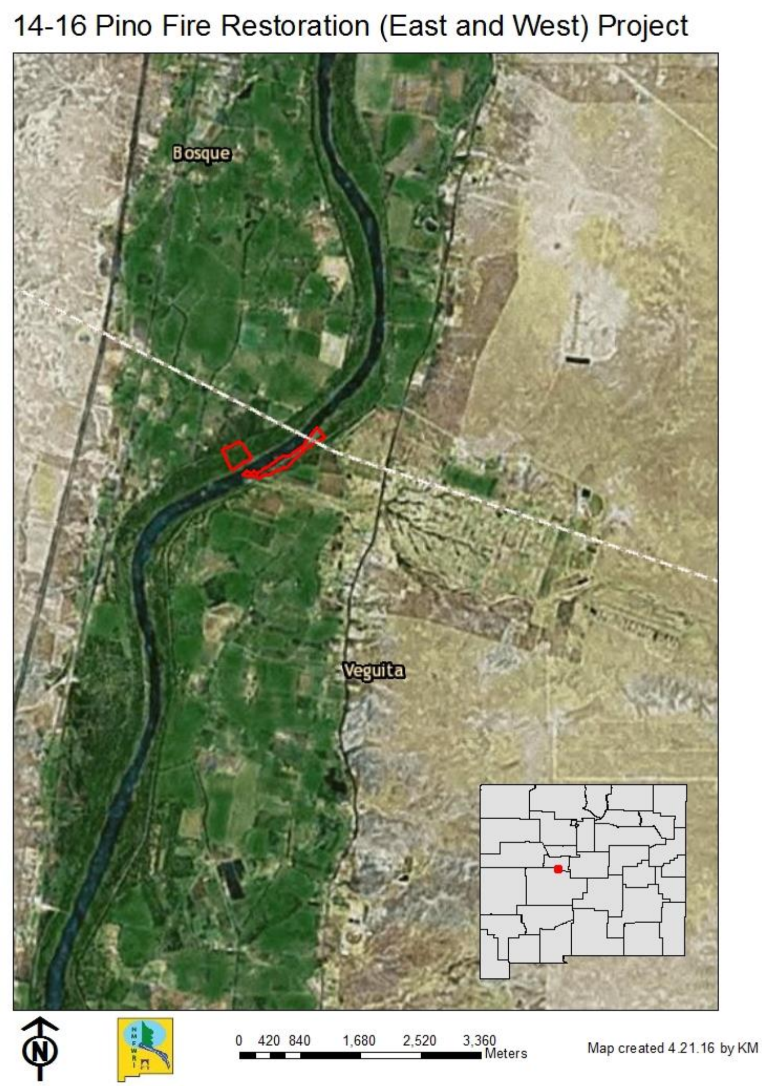

Figure 1. 14-16 Pino Fire in geographic context

Figure 2. KRQE News 13 SkyNews photos of the Pino Fire.
(Chelo Rivera, KRQE News 13, 2014)

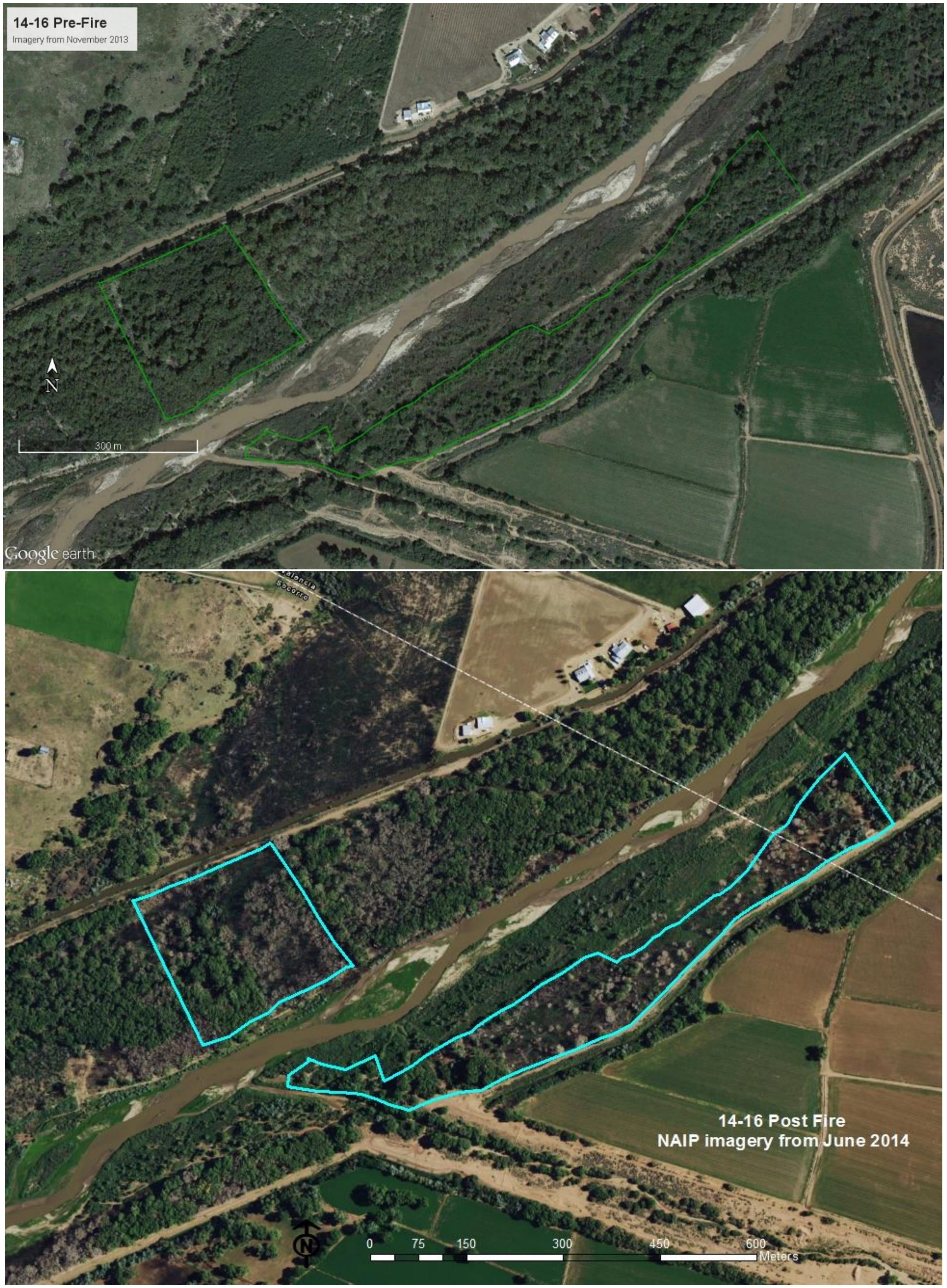

Figure 3. 14-16 Pre- and post-fire imagery (Google and NAIP).

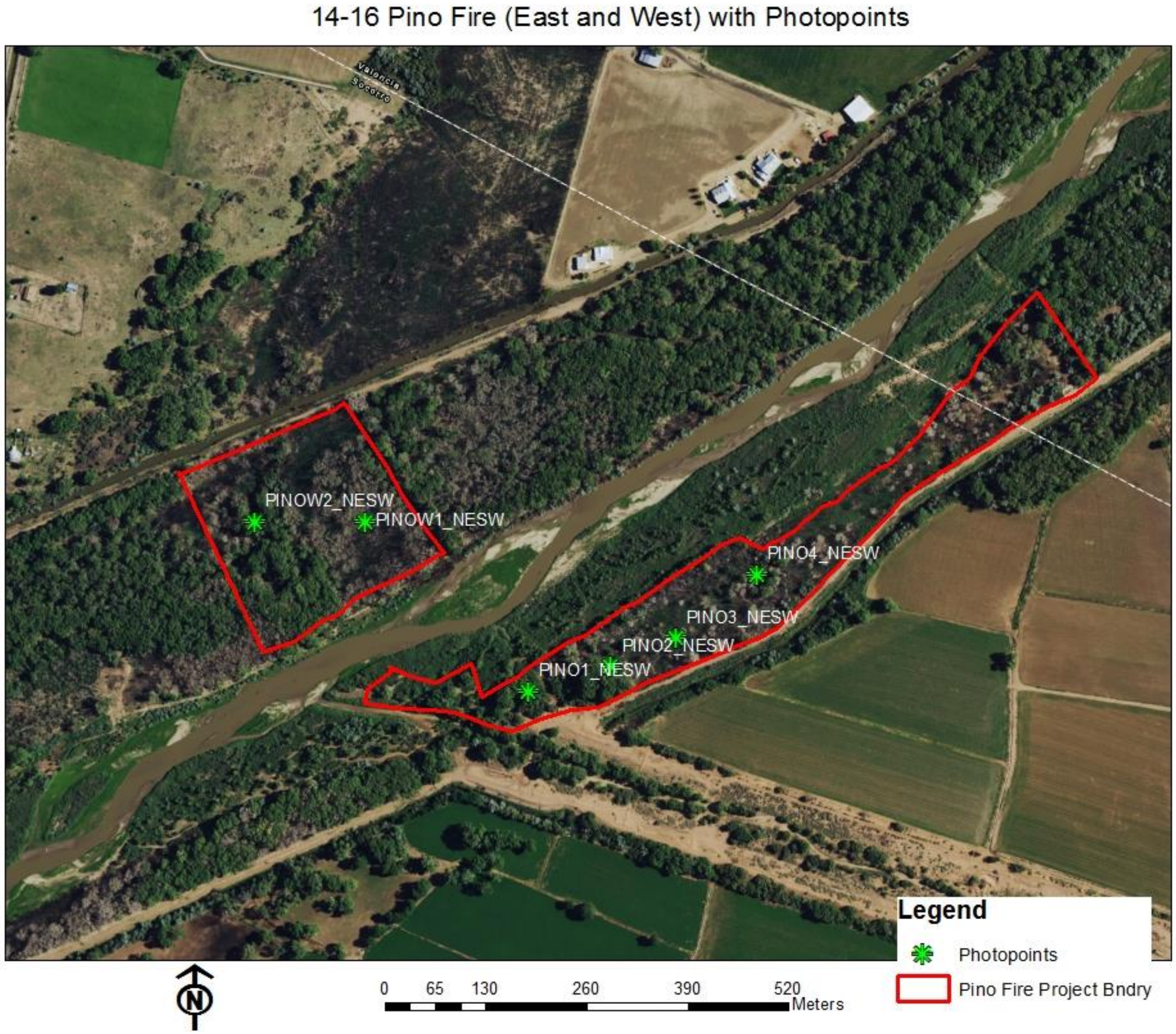

Figure 4. 14-16 Pino Fire monitoring photopoints

Monitoring Results

Monitoring was conducted at this 35.8 –acre project site on February 3, 2015 as part of a restoration project targeting non-native phreatophytes scheduled for 2014-2015.

Our monitoring contractor recorded the east and west portions of the project separately. Please note that approximately the northern quarter of the Eastern project was not recorded in pre-treatment monitoring because implementation contractors had already completed, or were working on, this area at the time of the pre-treatment visit (an initial site visit in January of 2015 saw the presence of 3-4 inches of snow, which made monitoring at that time impossible).

Results are as follows:

Eastern Portion

Metric (14-16 East pre-treatment, 3 Feb 2015)	**NMRAM Score**
Relative Native Plant Community Composition	3
Vegetation Horizontal Patch Structure	3
Vegetation Vertical Structure	3
Native Riparian Tree Regeneration	3
Exotic Invasive Plant Species Cover	1
Project Biotic Score (based on above ratings)	2.6
Project Biotic Rating	B/Good
Soil Surface Condition	4
Surface Fuels	0.33

The lowest scores for the Eastern portion of the project (21 acres) came from the high percentage of invasive plants (e.g. salt cedar). The project scored well in the other metrics indicating a diversity of structure types, patch types and plant species.

Based on the GIS classification (see Figure 5), 10 acres of this site was burned enough to kill overstory (49%). The remaining 51% fell into the following vertical structural classes: 23% was Type 1 High Structure with Understory (on this site, cottonwood and salt cedar with understory including coyote willow); 5.1% Type 2 (cottonwood or salt cedar without understory), 9.4% Type 5 Tall Shrub Stands (salt cedar or coyote willow), 7.1% Type 6S Short Shrub Stands (coyote willow), 4.9% Type 6H Herbaceous (kochia, yerba mansa, grasses), and 1.8% Type 7 Bare Ground.

The project scored highest in the soil surface condition metric, likely due to the lack of development, although the contractor did note the presence of wildfire impacts including erosion. The presence of wildlife was also noted. The surface fuels were generally more concentrated in the southern (less burned) portion of the project, and appear to be primarily salt cedar needles and cottonwood leaves. Overall, this site scored a 2.6 out of 4, which is a “B” or “Fair” biotic rating.

Western Portion

Metric (14-16 West pre-treatment, 3 Feb 2015)	NMRAM Score
Relative Native Plant Community Composition	1
Vegetation Horizontal Patch Structure	2
Vegetation Vertical Structure	2
Native Riparian Tree Regeneration	2
Exotic Invasive Plant Species Cover	1
Project Biotic Score (based on above ratings)	1.5
Project Biotic Rating	D/Poor
Soil Surface Condition	3
Surface Fuels	0.51

The lowest scores for the Western portion of the project (14.8 acres) came from the high percentage of invasive plants (e.g. salt cedar). The project scored fair in other metrics indicating some diversity of horizontal and vertical structure types as well as tree regeneration.

Based on the GIS classification (see Figure 5), 7 acres of this site was burned enough to kill overstory (48%). The remaining 52% fell into the following vertical structural classes: 38% was Type 1 High Structure with Understory (cottonwood and Russian olive with understory); 8.8% Type 2 Low Structure (cottonwood and Russian olive without understory), 2.2% Type 5 Tall Shrub Stands (salt cedar, Russian olive or coyote willow), 1.8% Type 6S Short Shrub Stands (coyote willow), and 1.4% Type 6H Herbaceous (kochia, yerba mansa, grasses).

The project scored highest in the soil surface condition metric, likely due to the lack of on-site development, although the contractor did note the presence of wildfire impacts including erosion. The higher amount of surface fuels in this portion of the project can likely be attributed to native grasses and forbs, down woody vegetation (cottonwood branches), and cottonwood leaves. Overall, this site scored a 1.5 out of 4, which is a “D” or “Poor” biotic rating.

Summary

When scores from the fieldwork are combined using a weighted average, the project received an overall biotic score of 2.145, which is a “C” or “Fair” condition rating. The lowest scores in both portions came in the amount of nonnative species present on-site (salt cedar and Russian olive), while the highest came in the soil surface condition metric.

Based on the GIS LIDAR and NAIP analysis, approximately 48% of the project area was burned and therefore not structurally classified. Of the remaining 52%, the majority was a Type 1 structure of cottonwood and salt cedar overstory with salt cedar, Russian olive, and coyote willow understory.

14.16 Pino Fire Vertical Structure Classification

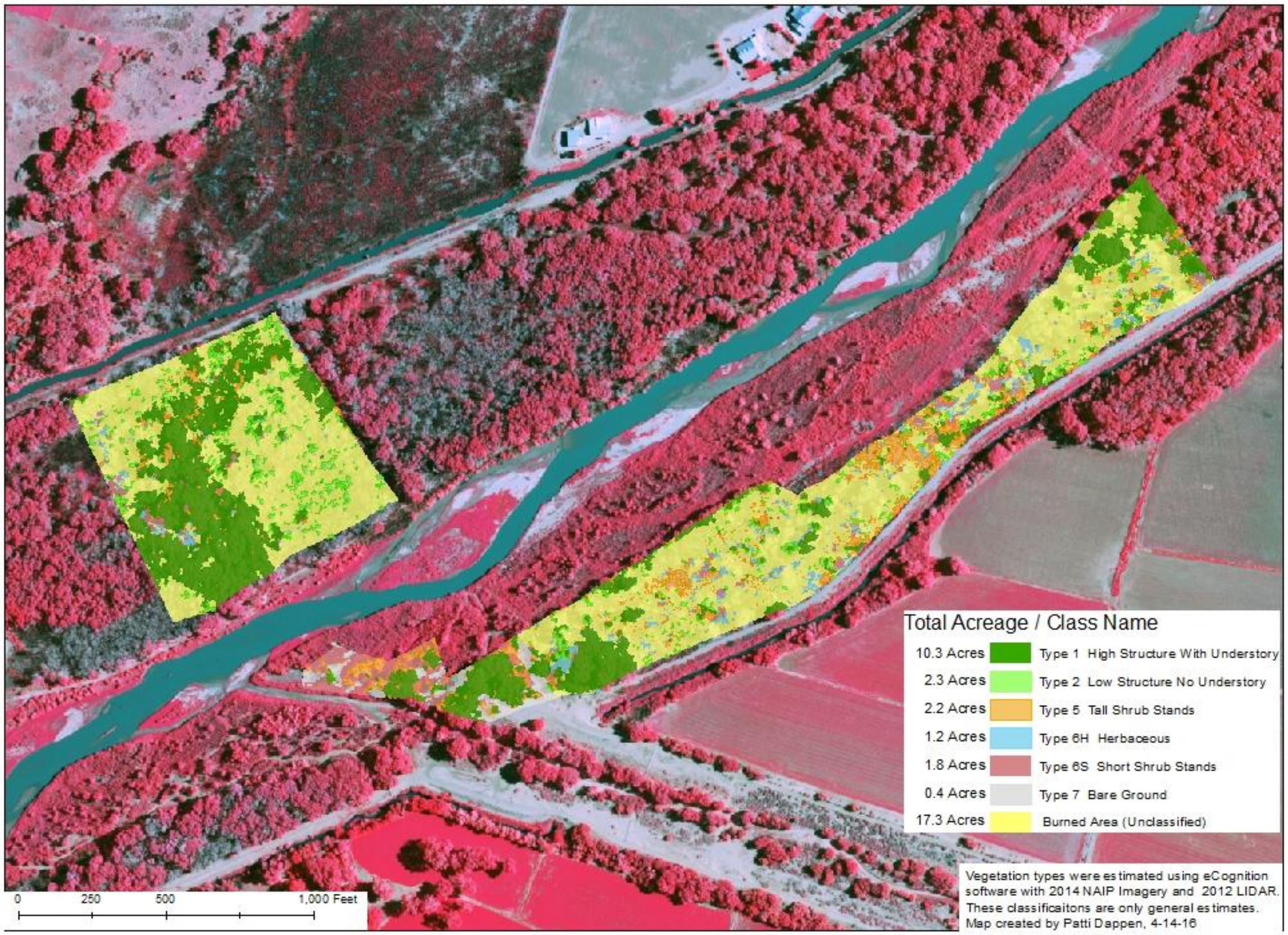

Figure 5. 14-16 Pino Fire Restoration LIDAR and NAIP classification. The map was produced with false-color NAIP imagery to allow the viewer to more easily distinguish between the vegetation and the green color of the Type 1 and Type 2 classifications.

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 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.

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Appendix I – Photopoints

Project Name	Point number in NMFWRI Garmin/ Name on Maps	Direction facing	Coordinates
14.16 pre	PINO1	N	34.529082729, -106.778150378
		E	
		S	
		W	
	PINO2	N	34.5293885, -106.777001387
		E	
		S	
		W	
	PINO3	N	34.529735008, -106.776095806
		E	
		S	
		W	
	PINO4	N	34.530490218, -106.774974726
		E	
		S	
		W	
	PINOW1	N	34.531010482, -106.78049312
		E	
		S	
		W	
	PINOW2	N	34.530996904, -106.782040922
		E	
		S	
		W	

Appendix II – Photos

PINO1, taken facing north.

PINO1, taken facing east.

PINO1, taken facing south.

PINO1, taken facing west.

PINO2, taken facing north.

PINO2, taken facing east.

PINO2, taken facing south.

PINO2, taken facing west.

PINO3, taken facing north.

PINO3, taken facing east.

PINO3, taken facing south.

PINO3, taken facing west.

PINO4, taken facing north.

PINO4, taken facing east.

PINO4, taken facing south.

PINO4, taken facing west.

PINOW1, taken facing north.

PINOW1, taken facing east.

PINOW1, taken facing south.

PINOW1, taken facing west.

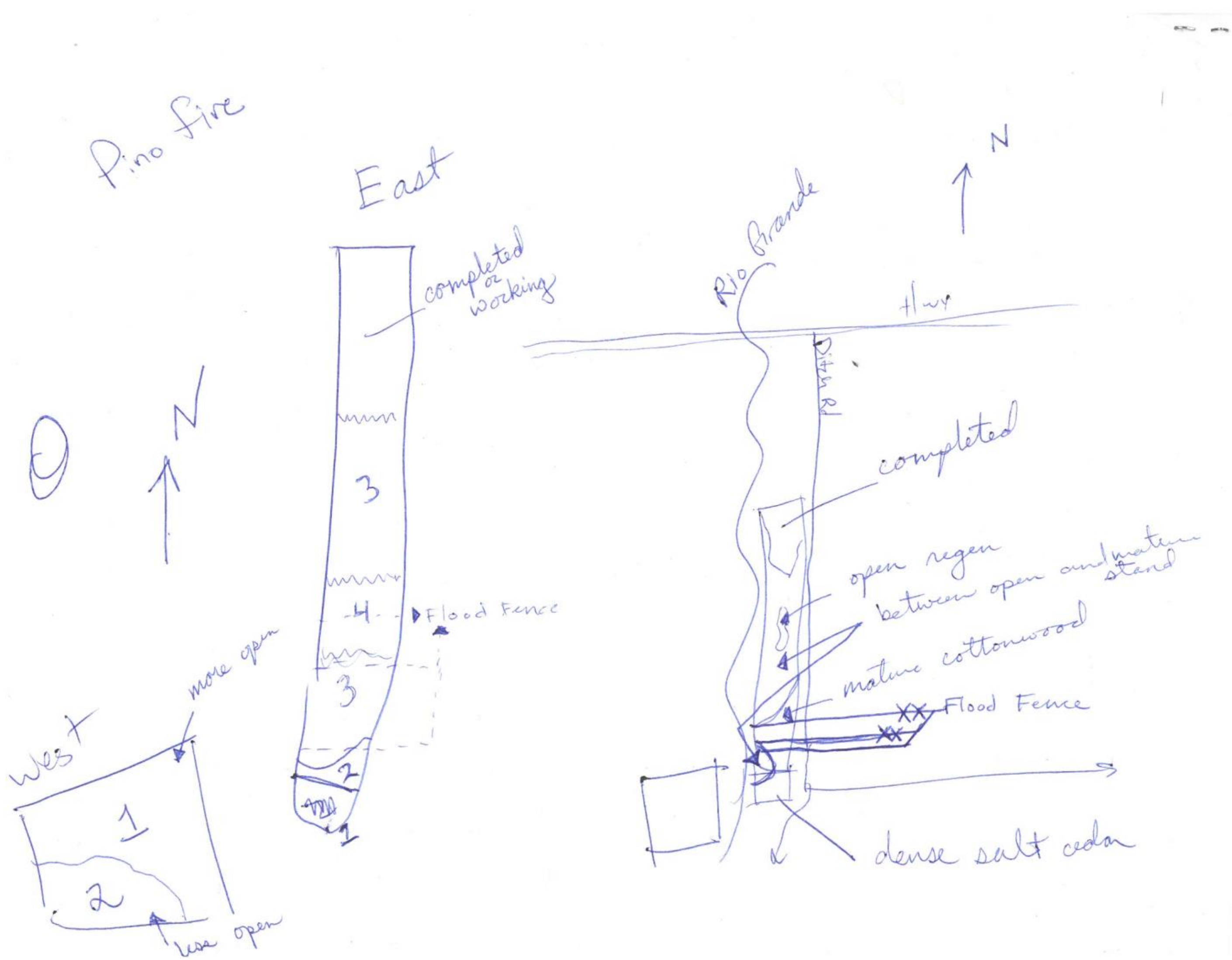
PINOW2, taken facing north.

PINOW2, taken facing east.

PINOW2, taken facing south.

PINOW2, taken facing west.

Appendix III – Contractor’s Vegetation Polygon Sketch



Appendix IV – Monitoring Methods Available

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 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.

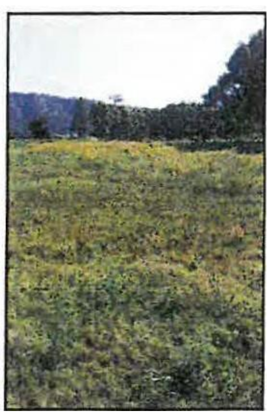
Young tree and shrub layer only (15-5 m [4.5-15 feet]) covering >25% of the area of the community (polygon). Stands dominated by tall shrubs and young trees, may include herbaceous vegetation underneath the woody vegetation. Photograph on San Francisco River by Y. Chauvin, 2012.

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.