Enhanced Resilience of Riparian and Wet Meadow Habitats in the Upper Gunnison Basin, Colorado: Phase II

Final Report
Colorado Parks and Wildlife
Colorado Wetlands for Wildlife Wetlands Program Project #634

By
The Nature Conservancy in Collaboration with the
Gunnison Climate Working Group
June 8, 2017

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SUMMARY

In 2016, the Gunnison Climate Working Group Project Team (GCWG)[1] completed its fifth year of restoring riparian areas and wet meadows in the Upper Gunnison River Basin to help the Gunnison sage-grouse, other species and ranchers maintain their livelihoods in the face of a changing climate. Sage-grouse brood-rearing habitats, already impacted by erosion and lowered water tables, are likely be further degraded by increasing drought and intense precipitation events, decreasing available food supplies and potentially chick survival. To address these challenges, the team built 385 structures to restore 50 acres over 8.2 stream miles, benefiting approximately 400 acres of Gunnison sage-grouse brood-rearing habitat in six watersheds in 2016. The 2016 work contributes to the team's five-year accomplishments of restoring 140 acres along 21 stream miles, enhancing approximately 1,000 acres of brood-rearing habitat. The restoration structures, e.g., one rock dams, are improving hydrologic/ecological function of riparian areas and wet meadows. Wetland plant cover increased an average of 160% (ranging from 28-245%) at four treated sites, compared to a 15% increase at untreated sites (four years' post-treatment). This project serves as an important demonstration of simple yet effective tools that have high potential to increase resilience of wet meadow and riparian systems across the region.

INTRODUCTION

Riparian and wet meadow habitats within the sagebrush ecosystem across the Upper Gunnison River Basin (Gunnison Basin) upstream of Blue Mesa Reservoir provide critical brood-rearing habitat for the federally threatened Gunnison sage-grouse (*Centrocercus minimus*). These ecosystems also provide important habitat for neo-tropical migratory birds, amphibians, elk, mule deer, as well as ranchers for grazing domestic livestock. Many of these areas have been adversely impacted by head cuts, erosion, lowered water tables, soil compaction by trailing, roads and invasive plant species. Further degradation of these habitats is likely to result in increased moisture deficits, contraction or disappearance of habitats, increased erosion, and/or shifting of key habitats to higher elevations, resulting in diminished food supplies and decreased sage-grouse chick survival. These areas are likely be further altered by drought, invasive plant species, and high intensity rainstorms associated with a changing climate. For these reasons, the GCWG prioritized enhancing the resilience of wet meadows and riparian habitat as a key climate adaptation strategy to reduce the adverse effects of climate change on wet meadows and riparian areas, Gunnison sage-grouse, other wildlife species, and ranchers' livelihoods.

In 2016, the GCWG Project Team (team) completed its fifth year on this collaborative project working to restore hydrologic/ecological function to enhance resilience of riparian and wet meadow habitats to help the Gunnison sage-grouse and other wildlife adapt to a changing climate. Restoring priority riparian and wet meadow habitat by raising water tables, re-connecting abandoned floodplains and former wetland surfaces, and prolonging base flows will help provide important food supplies (insects) necessary to increase sage-grouse chick survival. This work is also helping to increase the overall health and extent of

[1] GCWG Project Team Members: Gay Austin and Andrew Breibart (Bureau of Land Management-Gunnison Field Office), Teresa Chapman (TNC), Jim Cochran (Gunnison County), Shawn Conner (BIO-Logic, Inc.), Jonathan Coop, Tom Grant and Pat Magee (Western State Colorado University), Frank Kugel (Upper Gunnison River Water Conservancy District), Betsy Neely (TNC), Imtiaz Rangwala (Western Water Assessment), Renée Rondeau (Colorado Natural Heritage Program), Nathan Seward (Colorado Parks and Wildlife), Theresa Childers (National Park Service), Brooke Vasquez (Gunnison Conservation District), Matt Vasquez (US Forest Service), Liz With (Natural Resources Conservation Service), and Bill Zeedyk (Zeedyk Ecological Consulting).

riparian and wetland habitat in critical tributaries to Tomichi Creek, Ohio Creek, and the Gunnison River within the Gunnison Basin.

Overall vision of the project: The GCWG's vision for long-term success of this project is: *Natural wet meadows and riparian habitats within the sagebrush landscape of the Gunnison Basin are resilient and support a sustaining population of Gunnison sage-grouse and other species, biological communities, ecosystem services and livelihoods in the face of a changing climate. Sustained and long-term community commitment to stewardship of wet meadows and riparian areas helps nature and people adapt to a changing climate.*

Objectives of the project are to:

1. Increase ecosystem resilience to climate change by restoring hydrologic function of priority wet meadow and riparian habitats within the sagebrush landscape at a scale large enough to help the Gunnison sage-grouse, neo-tropical migratory birds, big game species and people who depend on these habitats for their livelihoods cope with projected impacts of a changing climate.
2. Build a sustainable and enduring program to increase restoration across the Basin.
3. Ensure scientific rigor of this project through a long-term monitoring program.
4. Develop and evaluate cost-effective tools, methods, and planning to help scale up the project.
5. Share best practices and lessons learned to encourage application of methods within and outside of the Basin.

DATE OF PROJECT COMPLETION

The Nature Conservancy and our partners with the GCWG completed Project #634 funded by the CPW Wetlands Program on May 31, 2017. However, the team plans to continue restoration of mesic meadows and riparian areas in the Gunnison Basin in 2017 and beyond. TNC is transitioning its role and responsibilities of coordinating this project to the Upper Gunnison River Water Conservancy District, who in close collaboration with the CPW, TNC and other team members, has hired a local coordinator to lead the project moving forward.

HOW PROJECT RESULTS DIFFERED FROM PROPOSED PROJECT

There were no major changes to the project scope or problems with the project during the reporting period for this final report.

DETAILED FINANCIAL CONTRIBUTION FROM EACH PARTNER AND FUNDING SOURCE

Matching funds in the amount of $106,268.78 were provided via a mix of private and public funding. The sources and use of these matching funds is detailed below. Funding from this CPW Wetlands Program grant ends with the completion of this report in 2017, but the Project Team will continue to expand the work to other drainages across the Gunnison Basin. The detailed budget of expenditures is in Appendix E.

1. $21,398.84 from TNC private donations for TNC staff salary and benefits;
2. $25,000.00 from NRCS for retention of Restoration Ecologist from BIO-Logic, Inc.;
3. $11,197.39 from USFS and BLM for contract services to complete wetland permitting;
4. $29,153.77 from BLM and USFS for retention of the Colorado Natural Heritage Program to complete vegetation monitoring; and
5. $19,518.75 from TNC private donations to cover indirect expenses.

PRE- AND POST-HABITAT ACREAGES AND HABITAT TREATMENTS USED

Habitat Acres

In 2016, the team restored approximately 50 acres of wet meadow habitat along 8.2 stream miles within six watersheds in the Gunnison Basin. This work enhanced approximately 400 acres of Gunnison sage-grouse brood-rearing habitat, delineated by a 50-meter buffer from the stream channel. See Table 1 for stream miles, restored acres and buffered acres, Figure 2 for locations of watersheds/sites within the Gunnison Basin, and Appendix A for individual site maps). Wet meadows vary in topography and size, and the area restored will likely increase over time as the structures store more water.

The 2016 work contributes to the team's five year accomplishments of treating 143 acres along 21 stream miles, benefiting approximately 1,000 acres of Gunnison sage-grouse brood rearing habitat from both new and maintained treatments. While the team did not measure pre-treatment habitat acres, our GIS Manager conducted GIS analyses using NDVI and other tools to calculate the differences in pre-and post-habitat productivity and greenness. See GIS Polygons section below for results and data.

Table 1. Stream miles, restored acres and buffered acres (estimate of brood-rearing habitat benefiting the Gunnison sage-grouse) at six priority sites treated with restoration structures during July-October 2016. Results are broken out by landownership within each site.

Site Name/Manager	Stream Miles	Restored Acres	Riparian Acres Buffered (50-meter)
Chance Gulch BLM	2.23	17.48	107.28
Chance Gulch Private	0.18	1.17	7.77
Chance Gulch Private State Habitat Area	0.63	3.18	33.91
Redden Ranch at West Flat Top Mountain BLM	0.29	2.07	17.97
Redden Ranch at West Flat Top Mountain Private	0.58	3.41	26.02
Redden Ranch at West Flat Top Mountain USFS	0.02	0.05	1.96
Sage Hen Gulch BLM	2.07	10.70	94.75
South Cottonwood at Flat Top Mountain Private	0.22	0.54	10.51
South Cottonwood at Flat Top Mountain USFS	1.60	6.19	71.92
West Flat Top Mountain at Henkel Road USFS	0.21	1.67	12.61
Yogi at West Flat Top Mountain USFS	0.20	3.06	16.85
Total	**8.21**	**49.52**	**401.55**

Preliminary Treatment Designs for 2017 Implementation

In 2016, restoration experts Bill Zeedyk and Shawn Conner, along with team members Nathan Seward (CPW), Andrew Breibart (BLM), and Matt Vasquez (USFS), conducted field work to evaluate and design preliminary treatments for five new sites. Rock was purchased and delivered to Dutch and Graflin Gulches. Shawn Conner, Andrew Breibart and Nathan Seward provided GPS data. The preliminary estimate of this proposed treatment is approximately 46 acres along six stream miles. The sites are listed below. See Figure 2 for locations of new sites.

1. Dutch Gulch State Wildlife Area, southeast of Gunnison (CPW and BLM)
2. Centennial State Wildlife Area, north of Blue Mesa Reservoir, west of Gunnison (CPW)
3. Graflin Gulch, Lypps-Ballantyne State Habitat Area (Private)
4. Teachout, north of Gunnison at the base of Flat Top Mountain (USFS)
5. Sapinero Mesa, south of Blue Mesa Reservoir, west of Gunnison (BLM)

Restoration Treatments

Restoration treatments used during this project were designed by Bill Zeedyk, well-known restoration expert and co-author of the book, *Let the Water do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels* (2014), and Shawn Conner, BIO-Logic, Inc. The treatments are intended to restore hydrologic and ecological function of streams by raising the water table, re-connecting the channel to the floodplain, restoring livestock and wildlife compacted trails and increasing native wetland plant cover at priority sites in the Upper Gunnison Basin. The structures help to capture sediments, hold/spread water, allow water to percolate beyond compacted areas, enabling wetland plant species to expand. See Appendix B for descriptions of sites and treatments.

Restoration techniques include grade control structures (one rock dams, sod dams and low water crossings), flow dispersal structures (media lunas, low water crossings, plug and spread structures, filter dams) and headcut control structures (Zuni bowls, rock rundowns, laybacks and log and fabric structures) following methods of Zeedyk and Clothier (2014). Most of the structures are built out of rock, but several other techniques were used depending on site conditions, e.g., drift fences are used to reduce trailing and soil compaction by livestock and wildlife. See Figure 1 for diagrams of selected structures used in this project.

The team also experimented with the “plug and spread” structure, a relatively new technique built with a bulldozer and a skid steer, to reduce channel incision, restore hydrologic connectivity with adjacent wet meadows, and hold and spread water across meadows. This technique can be used in areas where transporting rock is not practical or where channel incision is so deep that hand-built rock structures are not feasible. These structures are most effective in low gradient systems with wide floodplains and can restore more acres of former wetland with a small number of structures (Zeedyk, 2015). The team also used hardened low water crossings and/or re-grading roads to harvest water using Zeedyk’s methods for low-standard rural roads (2006).

Over the 2016 field season, the team built a total of 385 structures at six priority sites, using 14 different types of structures. The most widely used structure was the one rock dam, but rock rundowns and rock mulches were commonly used structures, depending on the sites. Most of the work was focused on Sage Hen Gulch, (148 structures) followed by Redden Ranch (97). The team maintained or expanded rock structures built in 2012 to increase their effectiveness by adding a second layer of rock at Redden Ranch. See Table 2 for summary of structures built in 2016 by priority site and Appendix A for site maps with locations of restoration structures.

Most of the rock structures were built by Western Colorado Conservation Corps (WCCC), Youth Conservation Corps (YCC), and student volunteers from Western State Colorado University organized by the Wildlands Restoration Volunteers (WRV).

Figure 1. Selected restoration structures used in this project designed by Bill Zeedyk. Sources: Zeedyk (2014), Zeedyk (2015) and Sponholtz and Anderson (2010).

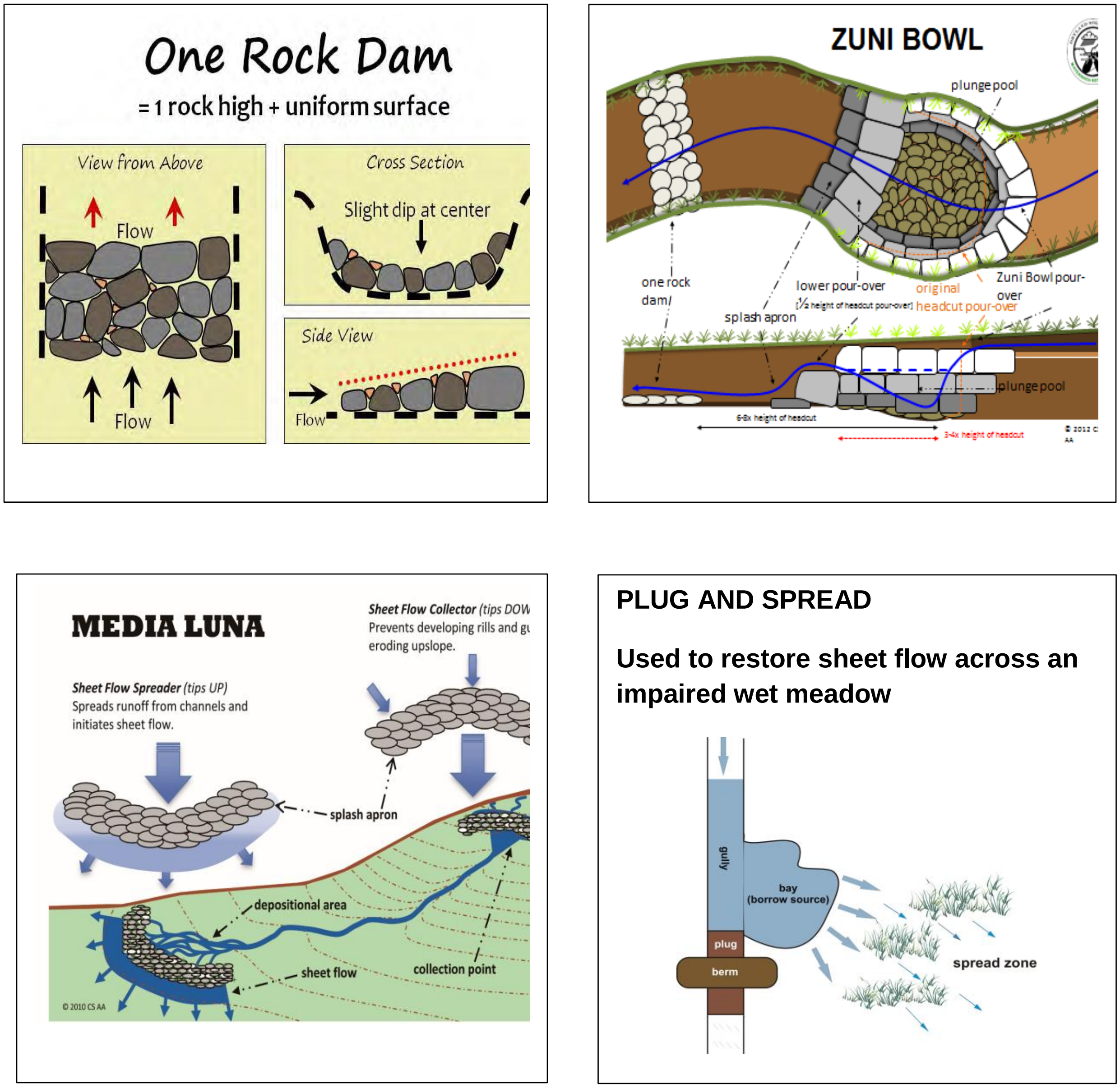


Table 2. Number and types of structures completed during 2016. Note: Redden Ranch (private) structures are listed separately to indicate whether they are new or maintained (with an *).

Site/ Land Manager	**Chance Gulch**		**Redden Ranch at West Flat Top Mountain**			**Sage Hen Gulch**	**South Cottonwood at Flat Top Mountain**		**West Flat Top Mountain at Henkel Road (Bebb's Willow Reach)**	**West Flat Top Mountain at Yogi**	
Structure Type	BLM	Private State Habitat Area	BLM	Private	Private *	BLM	Private	USFS	USFS	USFS	
Contour Swale	0	0	1	0	0	0	0	1	0	0	
Filter Dam	1	0	0	0	0	0	0	0	0	0	
Lay Back	0	0	2	0	0	5	0	1	6	2	
Low Water Crossing	0	0	0	0	0	2	0	0	0	0	
Media Luna	1	0	0	0	0	2	0	0	0	0	
One Rock Dam	8	1	17	15	28	52	8	12	13	4	
Plug and Spread	3	2	2	0	0	3	1	2	0	0	
Rock Baffle	0	0	0	0	0	1	3	0	0	0	
Rock Mulch	0	0	7	2	0	22	8	2	9	0	
Rock Rundown	0	0	7	7	5	51	3	12	26	0	
Sod Plugs	0	0	0	0	0	0	0	0	1	0	
Water Bar	0	0	0	0	0	0	0	7	0	0	
Worm Ditch	2	0	0	0	0	2	0	0	0	0	
Zuni Bowl	0	0	2	1	1	8	0	0	1	0	Total
Total 2016	**15**	**3**	**38**	**25**	**34**	**148**	**23**	**37**	**56**	**6**	**385**

PROJECT LANDOWNERSHIP AND THE LENGTH AND EXPIRATION DATE OF MANAGEMENT AGREEMENTS

Landownership of Priority Project Sites

See Figure 2 for locations of the 2016 priority restoration sites and planned 2017 restoration sites by landownership. See individual site maps in Appendix A. See Table 3 for a list of priority sites with landownership, tributary and watershed.

Figure 2. Overview of 2016 Priority Restoration Sites and Planned 2017 Priority Restoration Sites.

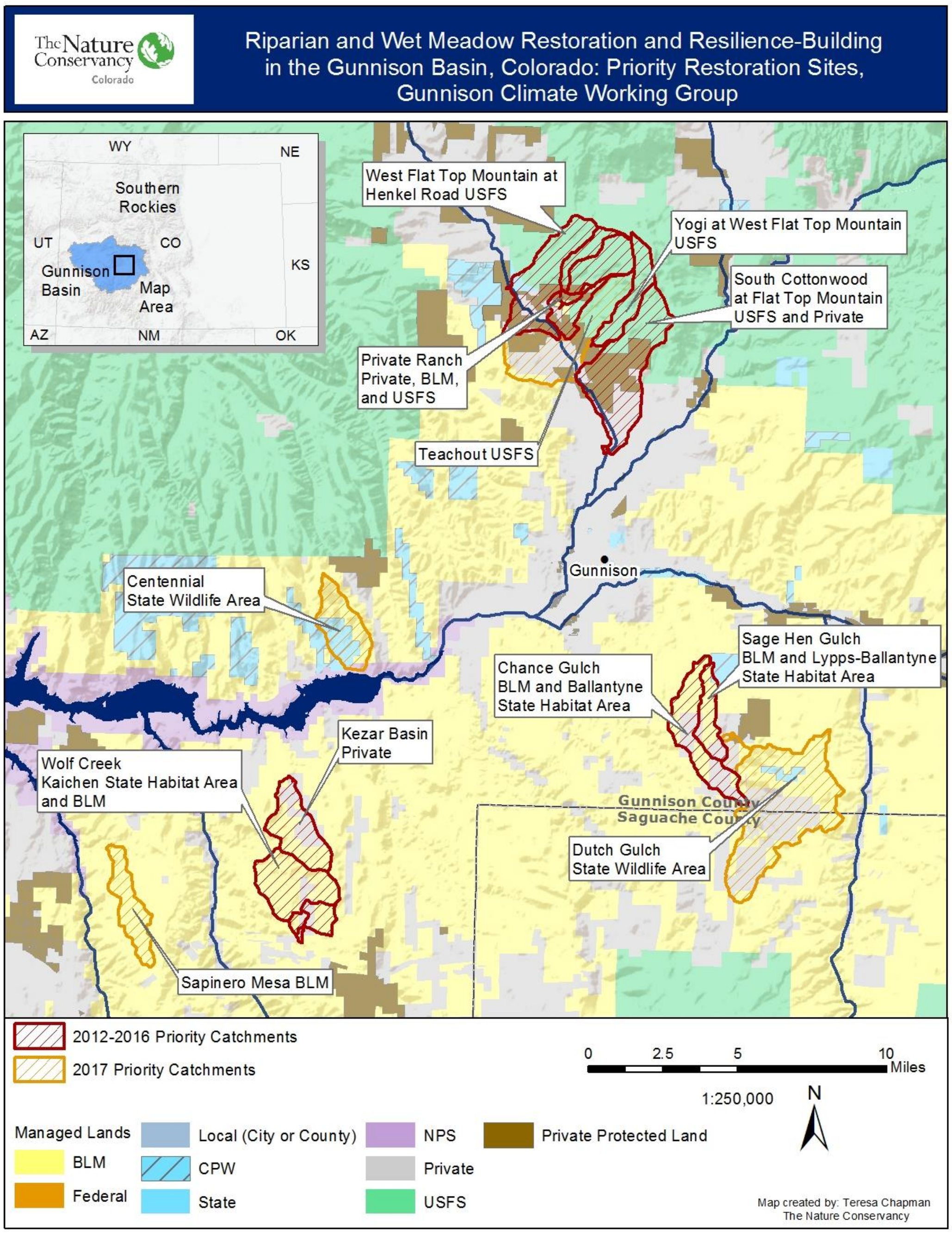


Table 3. Priority restoration sites treated with new structures, maintained or monitored in 2016. The asterisk indicates sites monitored but not treated with new structures in 2016.

Site Name and Stream Reach	Landownership	Tributary / Priority watershed
1. Chance Gulch	BLM and Private: CPW Ballantyne State Habitat Area	Tomichi Creek / Chance Gulch- Tomichi Creek
2. Kezar Basin*	Private	Cebolla Creek / Willow Creek Blue Mesa Reservoir
3. Redden Ranch, West Flat Top Mountain	Private and BLM	Ohio Creek / Lower Ohio Creek
4. Sage Hen Gulch	BLM and Private: CPW Lypps-Ballantyne State Habitat Area	Tomichi Creek / Chance Gulch- Tomichi Creek
5. South Cottonwood at Flat Top Mountain: Lower, Upper and East Fork	USFS and Private	Ohio Creek / Lower Ohio Creek
6. West Flat Top Mountain at Henkel Road USFS: Bebb's Willow Reach, Section 36 & Exclosure	USFS	Ohio Creek / Lower Ohio Creek
7. Wolf Creek: East Fork, Middle Fork, Lower and Upper*	BLM and Private: CPW Kaichen State Habitat Area	Cebolla Creek / Outlet Cebolla Creek
8. Yogi, West Flat Top Mountain	USFS	Ohio Creek / Lower Ohio Creek

Landowner Agreements

TNC developed landowner agreements for the following private lands (with length and expiration dates):

1. Chance Gulch, Ballantyne CPW State Habitat Area: May 1, 2014 - December 31, 2016
2. Eagle Ridge Right of Entry-letter for access to Redden and South Cottonwood-July 20, 2015 (no-expiration, so needs to be updated in the future)
3. Graflin Gulch, Lypps-Ballantyne CPW State Habitat Area: May 1, 2014 - December 31, 2016
4. Kaichen State Habitat Area at Wolf Creek: August 8, 2012 - August 31, 2015
5. Moncrief Ranch, Kezar Basin: August 1, 2013 - August 31, 2015
6. Redden Ranch: new agreement with new landowner signed in 2016 to update original agreement: July 16, 2015 - December 31, 2017.
7. South Cottonwood: June 3, 2015 - December 31, 2017.

VEGETATION MONITORING RESULTS

The primary monitoring objective of this project is to increase average cover of sedges, rushes, willows, and wetland forbs and decrease upland species in the restored portion of the treated properties between 2012 and 2017. In 2016, Renée Rondeau (CNHP), Gay Austin (BLM), Suzie Parker (USFS) conducted vegetation monitoring of 77 Line Point Intercept transects within the treated stream reach, 29 transects for controls, and 270 photo-points at West Flat Top Mountain and Flat Top Mountain.

In late 2016, the monitoring team completed a vegetation monitoring report summarizing five years of data collection for all priority sites (see Appendix C). Data analysis was conducted on sites with at least two years of data. To assess progress towards the management objectives, the team pooled all wetland species and graphed differences in cover between years. At least three years of post-treatment are needed to detect vegetation response. The increase in wetland species cover varied by reach and the number of growing seasons post treatment and ranged from 0-245%. The team categorized the response rate into three categories: fast, slow and no response yet.

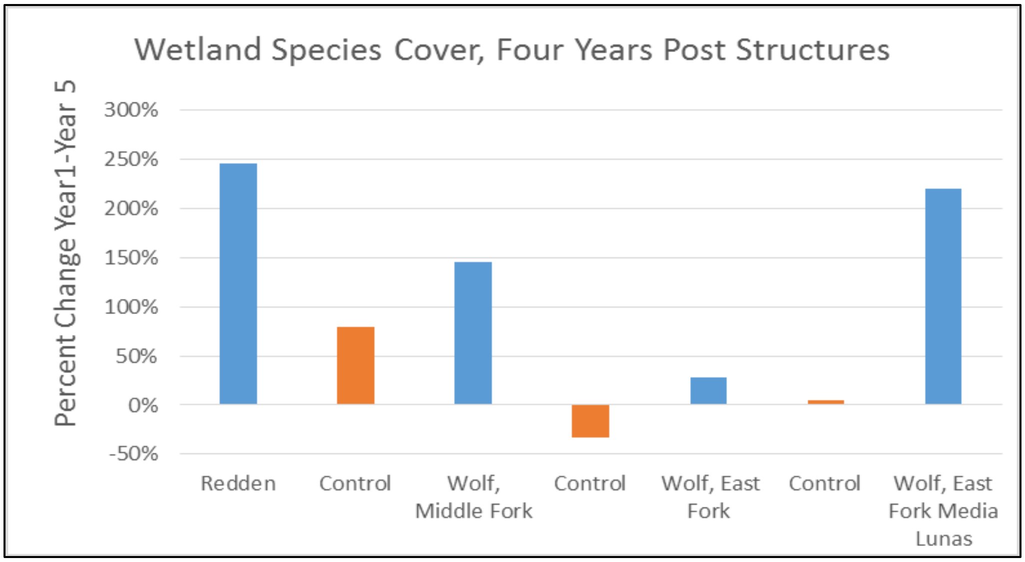
See Table 4 and Figure 3 below for a summary of wetland plant species cover change from the year restoration structures were installed (baseline) at all priority sites (except South Cottonwood).

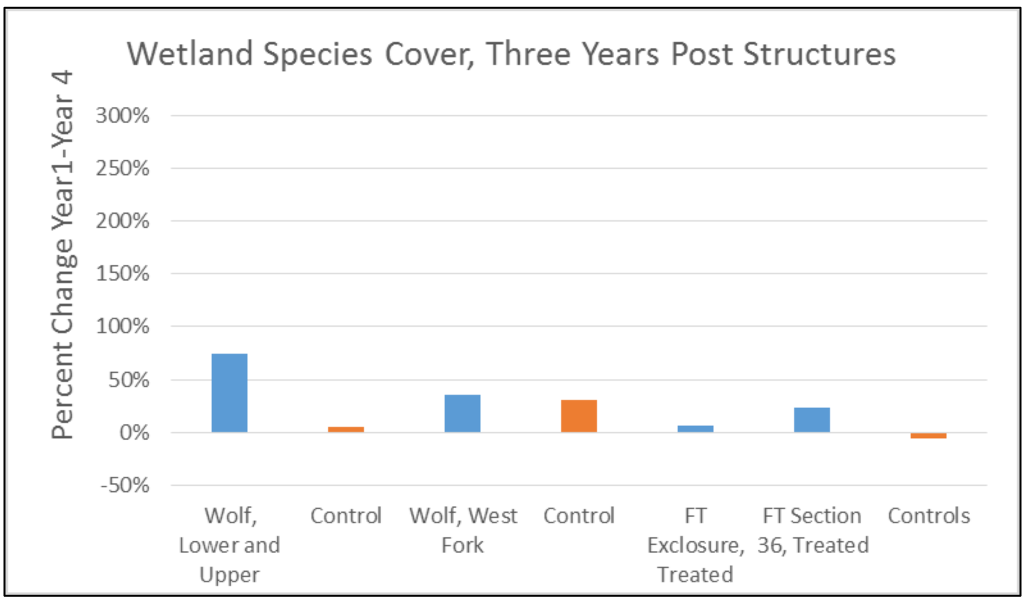
Management objectives are being met but at different rates of response across sites. The increase in wetland species cover varied by reach and the number of growing seasons post treatment. Redden Ranch at West Flat Top, an ephemeral reach, experienced one of the fastest and largest percent changes in wetland plant species cover (245%) four years' post treatment. West Flat Top at Henkel Road, also an ephemeral reach, experienced a slower percent change in wetland plant species cover (24%) three years' post treatment. Several factors may be influencing this, e.g., differences in flow rates, floodplain width, geology, snowmelt and/or precipitation events. Further study is needed to understand the importance of these variables. In addition, other metrics, aside from wetland plant species cover, are changing, e.g., sediment is building and raising the stream bed, reducing down-cutting and head cutting.

Table 4. Wetland plant species cover response rates grouped into fast, slow and no response yet categories for priority sites and stream reaches (from Rondeau et al. 2016).

Site/Stream Reach	Wetland Species Cover Increase	Number of Years Post Treatment	General Characteristics/Comments
Fast Response			
Wolf Creek-East Fork Media Lunas	220%	4	Perennial water from spring; wide flood plain with approximately 25% of floodplain occupied by wetlands prior to treatment
Redden	245%	4	Ephemeral; snow melt and storm events are primary water source; medium wide floodplain; sediment source upstream
Wolf Creek-Middle Fork	37%	4	Ephemeral; snow melt and storm events are primary water source; narrow floodplain
Wolf Creek-Upper and Lower	37%	3	Perennial water from spring; wide floodplain with approximately 25% of floodplain occupied by wetlands prior to treatment
Kezar Basin	27%	2	Perennial water from springs; wide floodplain with approximately 25% of floodplain occupied by wetlands prior to treatment
Slow Response			
Wolf Creek-East Fork above Media Lunas	28%	4	Mixed water source with some perennial, snow melt and storm events; narrow to medium flood plain width
Flat Top-Henkel Road	24%	3	Ephemeral snow melt and storm events are primary water source; narrow to moderately wide floodplain
No Response Yet			
Flat Top-Exclosure	6%	3	Ephemeral; snow melt and snow events; preventing the migration of a large headcut was the primary goal
Flat Top-Above Exclosure	0%	2	Repeat photos show that sediment is building and we expect to see a positive response next year
Above Redden	0%	2	Purpose was to provide additional ground water to meadow below (not to increase wetland plant cover)
Wolf Creek-West Fork	5%	3	Multiple upstream ponds capture snow melt, water from storm events and sediment; low water crossing has been problematic
Chance Gulch	0%	2	More time is needed to determine trends

Figure 3. Percent change in wetland species cover for reaches with four years (top) and three years (bottom) after structures were built. Blue bars represent treated areas and orange bars represent controls (untreated areas). Source: Rondeau et al. 2016.





DIGITAL MAPS SHOWING FINAL PROJECT BOUNDARIES, WETLAND BOUNDARIES AND OTHER WATER FEATURES

See Appendix A for maps of project boundaries for the priority sites treated in 2016. Digital files are available at the following link: https://tnc.box.com/s/h89g7pl69ptmog86ssx5dv61n4prcfw1

GIS POLYGONS OF THE FINAL PROJECT BOUNDARY AND WETLAND BOUNDARIES

To measure enhancement of riparian productivity and increased riparian vegetation cover, we used a Normalized Differenced Vegetation Index (NDVI) derived from NASA Landsat satellite imagery at 30 m resolution. NDVI is a common vegetation index calculated from a ratio of near infrared and red wavelength reflectance and ranges from -1 to 1. Healthy, greener, and more photosynthetic vegetation reflects more near infrared radiation and therefore has a higher NDVI value.

To compare pre- and post-treatment riparian vegetation improvement within years of similar climate, we calculated the Palmer Drought Severity Index (PDSI) from January to July of all years from 2000 to the present. We determined a comparable pre-treatment year with a comparable drought index to every post-treatment year, so that vegetation would be compared to years of equal precipitation and temperature stress. Table 5 shows the selected years and the associated PDSI. We downloaded a Landsat-derived Normalized Differenced Vegetation Index (NDVI) from July or August from each year in the analysis and calculated the average NDVI for all years prior to and following treatment. Increased productivity and riparian condition was measured as the difference between post-treatment average NDVI and pre-treatment NDVI for all years. Table 6 shows the pre-, post-, and increased NDVI values for each site. Figures 4-5 show six sites with the pre-post-treatment changes, and increased NDVI.

Our team will use USDA 1 m NAIP aerial imagery to measure pre- and post-treatment acres of riparian habitat. However, this data is only available every two years; thus, we are waiting for the release of 2017 data to quantify actual riparian acres improved and area increased in comparison to 2011 images.

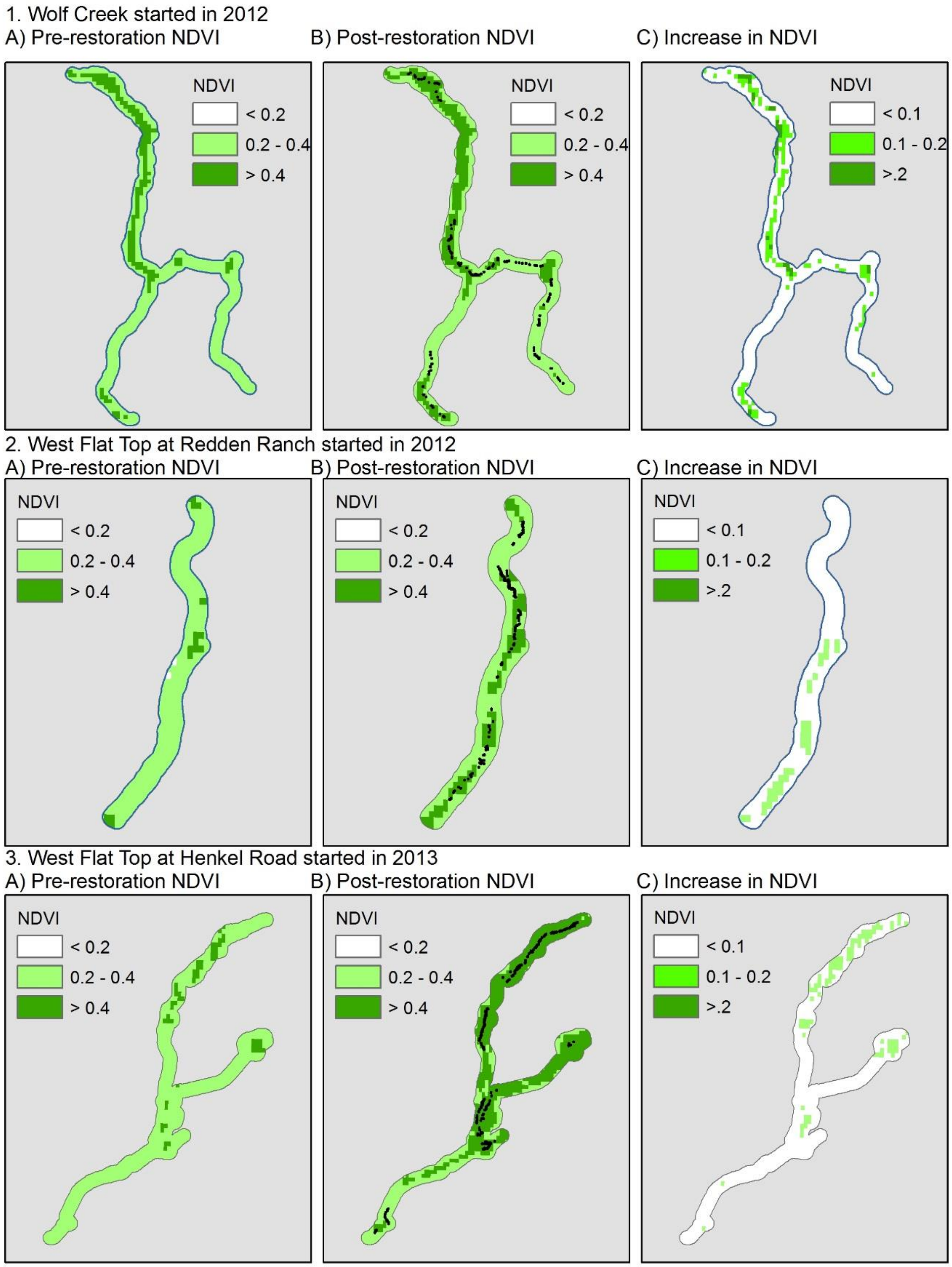
Table 5. Pre- and post-treatment years and associated drought index. The post-treatment vegetation index was compared in years of similar drought index to account for the influence of precipitation and temperature on riparian productivity.

Pre-treatment Years	PDSI	Post-treatment Years	PDSI
2003	-4.32	2013	-4.83
2007	-0.13	2014	1.59
2009	0.36	2015	0.12
2011	1.65	2016	0.06
Average PDSI	-0.61		-0.76

Table 6. Increases in NDVI between pre-treatment years and post-treatment years show that on average the restoration has improved riparian greenness by .08 NDVI.

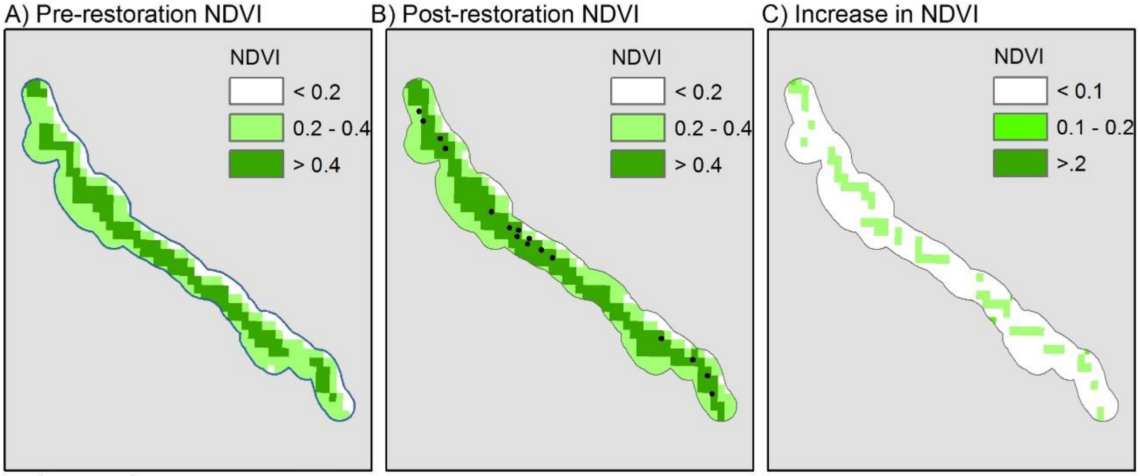
Site and Land Manager	First Year of Structures	Most Recent Year of Structures	Pre-treatment NDVI	Post-treatment NDVI	Increase in NDVI
Chance Gulch BLM	2014	2016	0.26	0.345	0.081
Chance Gulch CPW Ballantyne SHA	2014	2015	0.22	0.304	0.083
Chance Gulch Private	2016	2016	0.19	0.291	0.098
Kezar Basin Private	2013	2014	0.34	0.401	0.060
Redden Ranch BLM	2016	2016	0.26	0.347	0.084
Redden Ranch Private	2012	2016	0.30	0.371	0.069
Redden Ranch USFS	2014	2014	0.26	0.328	0.064
Sage Hen BLM	2015	2016	0.22	0.307	0.086
Sage Hen CPW Lypps/Ballantyne SHA	2015	2015	0.26	0.347	0.088
South Cottonwood at Flat Top Mountain Private	2015	2015	0.25	0.348	0.097
South Cottonwood at Flat Top Mountain USFS	2015	2016	0.27	0.372	0.098
West Flat Top at Henkel Road USFS	2012	2016	0.35	0.424	0.077
Wolf Creek BLM	2012	2015	0.35	0.428	0.083
Wolf Creek CPW Kaichen SHA	2012	2015	0.29	0.369	0.079
Yogi at West Flat Top USFS	2016	2016	0.29	0.371	0.082
Average			0.27	0.357	0.082

Figures 4-5. Increased greenness and improved riparian condition is shown through a comparison of pre- and post-treatment years of a Landsat – derived Normalized Differenced Vegetation Index (NDVI, 30 m resolution). NDVI is a proxy for vegetation production and health. Black dots represent structures installed between 2012 and 2016.



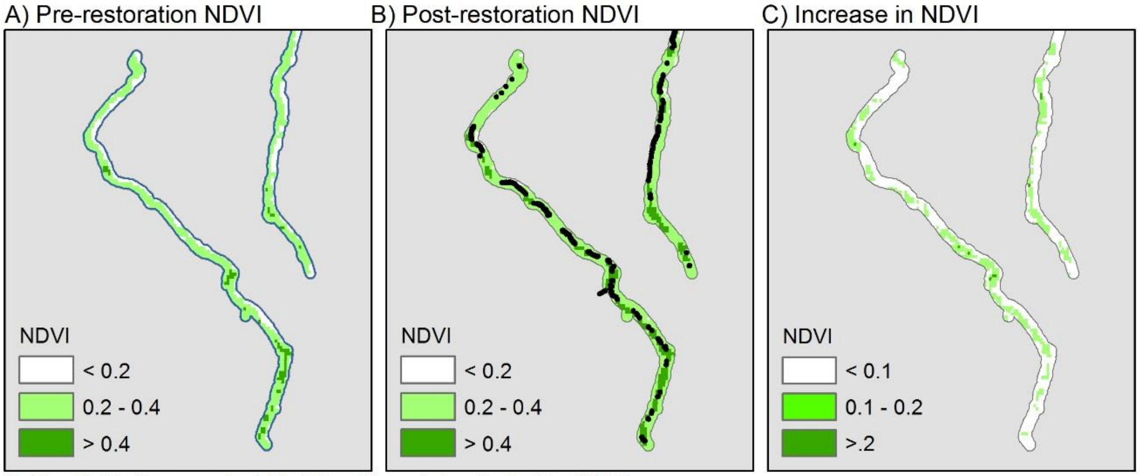
4. Kezar Basin started in 2014

A) Pre-restoration NDVI B) Post-restoration NDVI C) Increase in NDVI



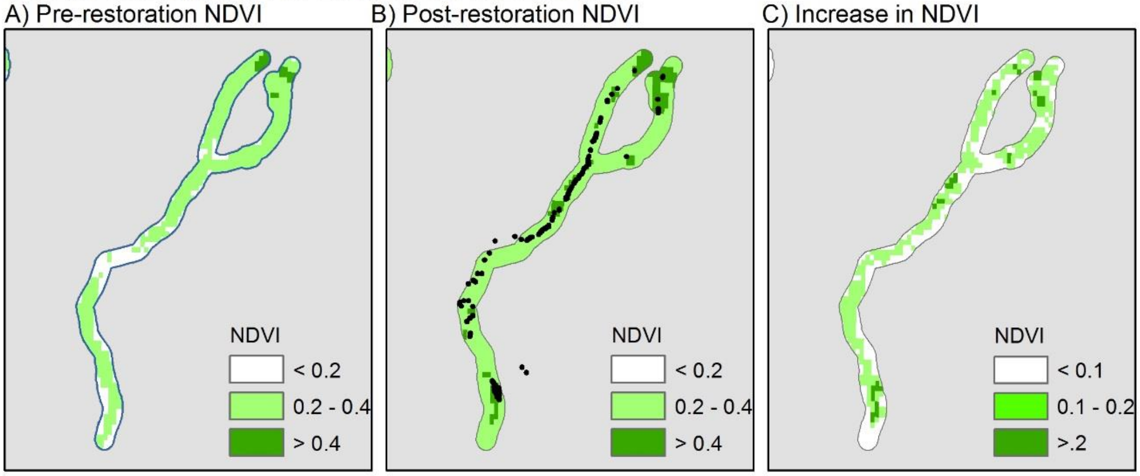
5. Chance Gulch started in 2014

A) Pre-restoration NDVI B) Post-restoration NDVI C) Increase in NDVI



6. South Cottonwood at Flat Top Mountain started in 2015

A) Pre-restoration NDVI B) Post-restoration NDVI C) Increase in NDVI



PRE-AND POST-PROJECT PHOTOGRAPHS

Figure 6. Wolf Creek Private: Fast response to Media Luna Structures

R. Rondeau, CNHP
C. Strijek, WSCU

Wetland area increased from 25% to 80% of floodplain between 2012 & 2016 at CPW's Kaichen State Habitat Area.

Figure 7. West Flat Top Exclosure (USFS): Before and after installation of Log and Fabric Structure to control headcut.

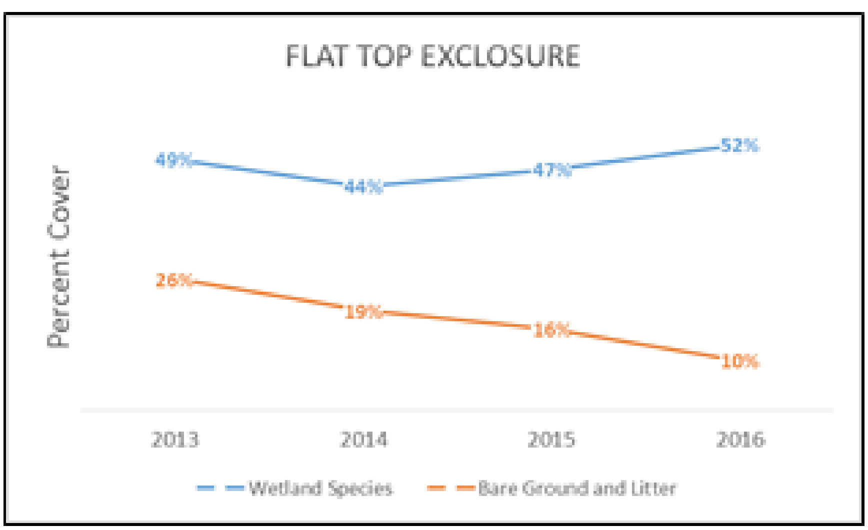
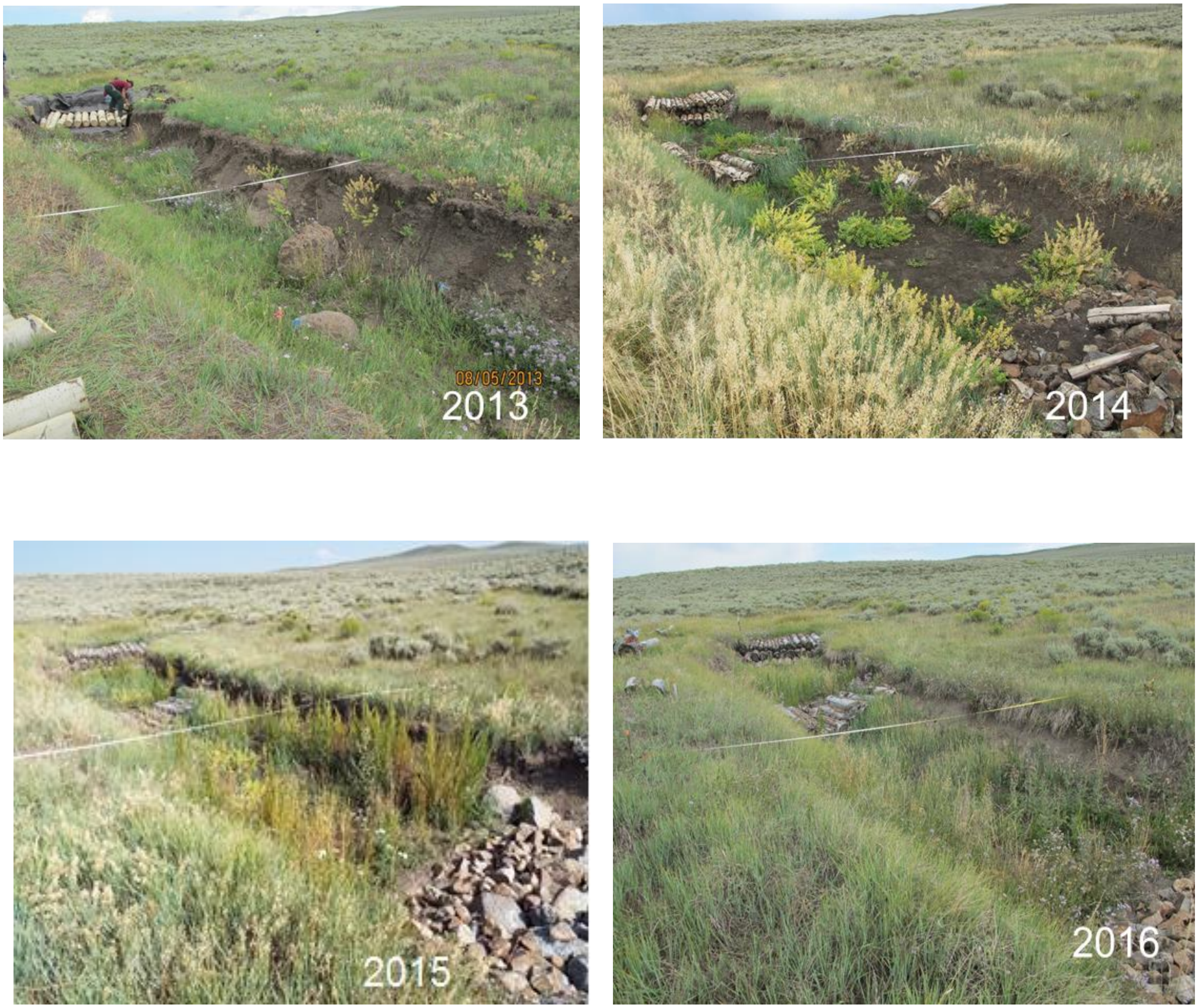
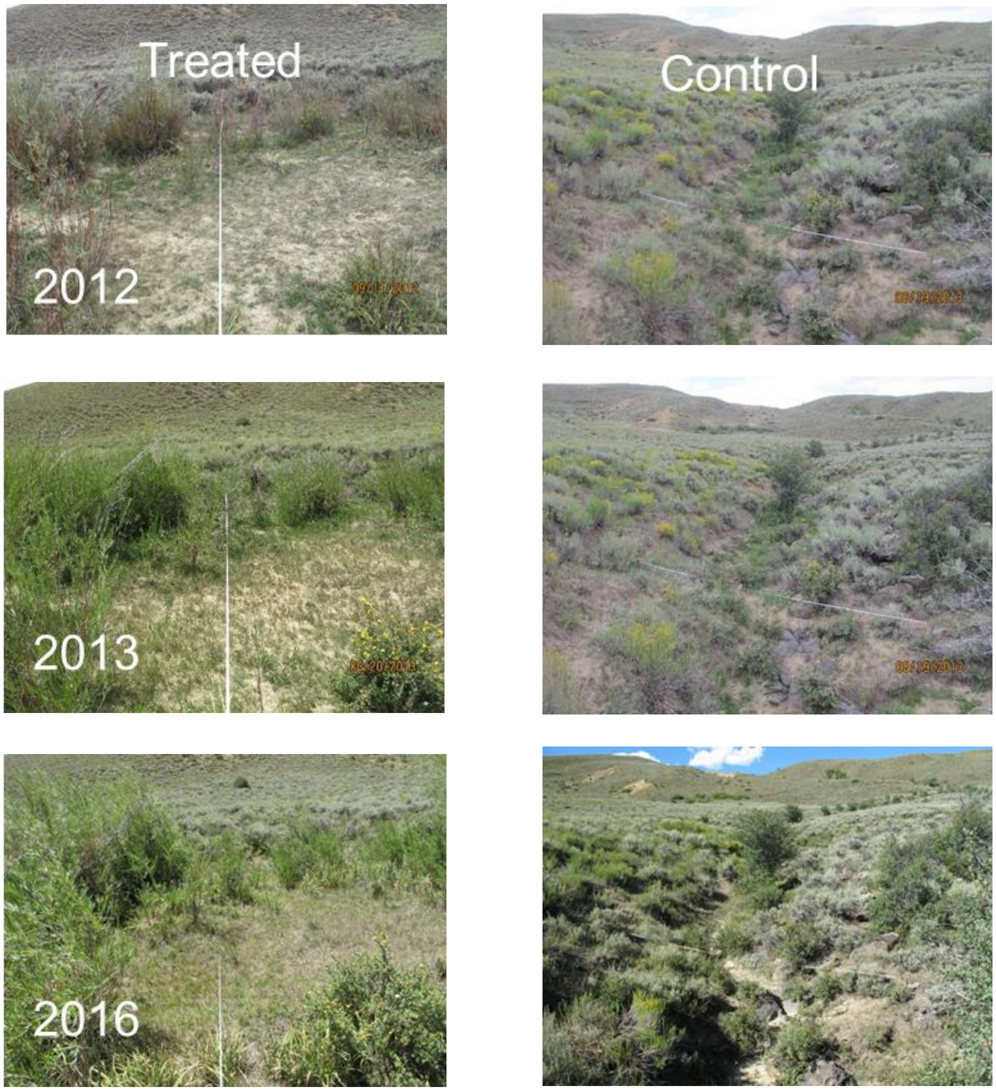


Figure 8. West Flat Top (USFS): Slow response to Log & Fabric Structure to reduce head cut. The banks are stabilizing & there is less bare ground.



R. Rondeau, CNHP

Figure 9. West Flat Top Private Ranch: Response between 2012-2016. All 15 transects associated with the structures had an increase in wetland species cover. A second layer of rocks was added in 2016, post monitoring.



R. Rondeau, CNHP

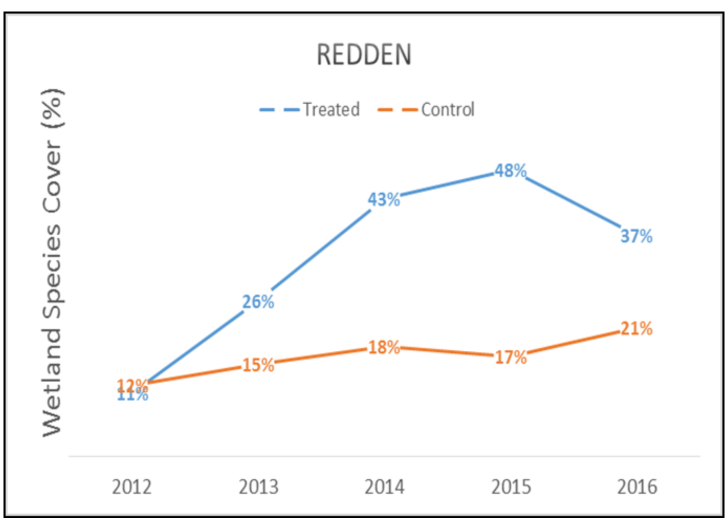


Figure 10. Kezar Basin Private: Before, during and post construction of Double Bay Plug and Spread Structure

Pre-structure, September 2014

Building plug and spread in September 2014 (B. Neely)

The wetland species cover was 12% in 2014 and 30% in 2016, a 150% increase in wetland species cover.

R. Rondeau, CNHP

Figure 11. West Flat Top at Henkel Road (USFS): The drift fence, a line of fence built across the stream channel, has reduced trailing and soil compaction by livestock and wildlife in this meadow.

2013

2014

2015

R. Rondeau, CNHP

Figure 12. South Cottonwood Private: Vegetative response to a Rock Mulch Structure

South Cottonwood Private

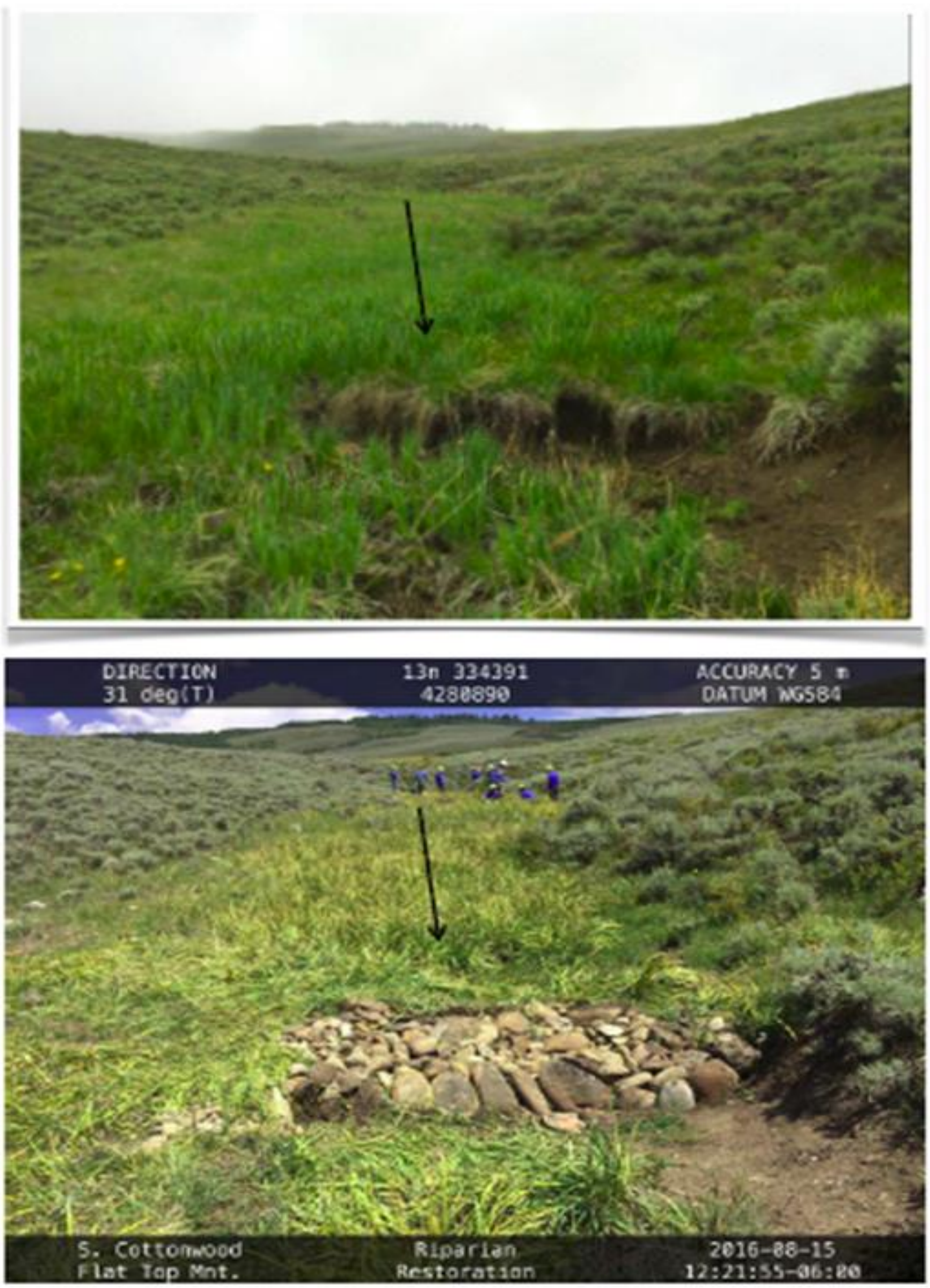
Top Photo: August 20, 2015 (structure completion date); Bottom Photo: May 26, 2016, Page 5

> - *Arrows indicates direction of water flow and matches 2015 and 2016 photo positions*

M. Vasquez, 2016

Figure 13. Upper South Cottonwood (USFS): Pre-and post-construction of a Layback Structure to control the headcut. Photos were taken during the same year (2016).

USFS South Cottonwood Upper



2016 - Pre (May) and Post (August) Treatment Photos, Page 1

➢ *Arrow indicates direction of water flow and matches pre and post photo positions*

M. Vasquez, 2016

SUMMARY OF LESSONS LEARNED AND BEST PRACTICES

It will take many years to build resilience of wet meadows and riparian areas at a landscape scale across the Gunnison Basin and the region, as there are many drainages that would benefit from this work. Restoration is an ongoing task, given that heavy precipitation, runoff events, and drought can degrade wet meadows and riparian areas, resulting in erosion, gullies, lowered water tables and invasive species. The project team identified the following best practices and lessons learned, based on the past five years of this project.

1. Working at the watershed-scale across land ownership/management boundaries is important for optimal response. Collaboration and partner engagement are key for working across property boundaries on watershed level restoration projects.
2. Conducting a climate-informed site selection analysis can help prioritize streams that could benefit from these restoration techniques. It is important to convene wildlife biologists, hydrologists, ecologists and restoration experts to review and narrow down the list of potential sites to incorporate local knowledge. The results provide a starting point for field evaluation to further prioritize stream reaches for on-the-ground treatment.
3. Developing and maintaining a workplan for priority sites can help organize complex projects, e.g., a table including team lead, team members for each project, restoration contractor, clear roles and responsibilities, timeline, tasks, and permits needed.
4. Restoration treatments need technical planning, design and oversight during installation by restoration experts to ensure quality and effectiveness. Restoration experts are needed to evaluate sites, assess restoration needs, design treatments and train and provide technical oversight for field crews and volunteers building structures. Experts can determine specific structures needed to address restoration needs and objectives of different sites.
5. Technical training and building local capacity can help ensure long-term engagement and success. When working with youth field crews, it is also important to emphasize the importance of developing skill sets, e.g., leadership, land management, restoration, good stewardship, work ethic, and a positive attitude. Building skills of crew leaders helps to maintain motivation, quality control, work ethic, and dedication to service of field crews. Recruit and train local private contractors to build structures to enable private landowners to implement restoration work on their lands.
6. Establishing credibility, communication and trust with local landowners is essential. Develop agreements with landowners and ranchers well in advance of project implementation, outlining details of visitation, access, gate protocols, objectives, etc.
7. Design and stake all treatments well in advance of arrival of field crews, volunteers and/or contractors to increase efficiency and effectiveness of installation.
8. Consult with the US Fish and Wildlife Service and US Army Corps of Engineers (environmental consultants can assist) to determine permits needed. Complete necessary wetland delineations and permit applications per agency requirements a year in advance of proposed works.
9. Monitoring, modification and maintenance of existing structures are critical to ensure effectiveness. Revisit/monitor previously treated sites to determine needs for modification, adding a second layer, and/or expansion early in the season. These projects require repeated visits to treated stream reaches to monitor effectiveness, identify maintenance needs, and need for additional layers to ensure long-term successful response.

10. Vegetation monitoring is critical to document ecological response to the restoration treatments. Collecting vegetation data and before-and-after photographs help to convey the effectiveness of treatments. Monitoring should continue for a minimum of five years on any given treated reach to document response. Control sites/transects are exceedingly hard to find; we recommend that the established control transects be considered permanent and no structures built on them for at least five years. Without these controls, it is very difficult to detect/document the effectiveness of the structures.
11. Purchase and transport rock to sites to prevent overuse of local rock and disturbance of nearby sagebrush and roosting habitat, if treating wet meadows within Gunnison sage-grouse habitat.
12. Coordinate closely with graduate students and professors on research projects regarding access protocols for restoration sites, objectives, methods and outcomes to ensure success.
13. Share best practices with managers and landowners to ensure high-quality work and adoption of methods in new drainages.

ACKNOWLEDGEMENTS

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Nathan Seward, CPW, served as the sponsor of this project. He has been instrumental in the planning, design and implementation of this project, serving as local leader and liaison to private landowners, Western State Colorado University, UGRWCD and others. He designed treatments with the restoration contractors and enthusiastically led field crews, students and volunteers in building structures. He led numerous field trips and gave presentations to NRCS, Intermountain West Joint Venture, Sage Grouse Initiative and others. He generously provided the use of CPW's Miller Ranch State Wildlife Area during the volunteer event and barbecue. He initiated and implemented the remote camera pilot study of wildlife use.

This project would not have been possible without the cooperating landowners (and permittees) and ranch managers; we thank them for enabling these projects to be completed on private lands and for opening their lands to team members, field crews, contractors and/or volunteers.

Bill Zeedyk and Shawn Conner provided extensive restoration expertise and design of treatments. Jim Cochran served as a liaison to the Gunnison Basin Gunnison Sage-grouse Strategic Committee. Bill Zeedyk, Shawn Conner, Nathan Seward, Andrew Breibart, Clayton BonDurant and Matt Vasquez led trainings and oversight of youth field crews and volunteers in building rock structures. Shawn Conner, Andrew Breibart, Renée Rondeau, Gay Austin, Nathan Seward, Liz With, Brooke Vasquez and Bill Zeedyk conducted rapid field assessments of new sites. Gay Austin and Alison Graff completed wetland delineations and permit applications. Nathan Seward, Jim Cochran and Matt Vasquez provided sage-grouse expertise. Renée Rondeau, Gay Austin, Suzie Parker and Wendy Brown conducted vegetation

monitoring; Renee Rondeau completed data analysis and interpretation. Jim Cochran, Nathan Seward, Liz With and Brooke Vasquez provided private landowner connections. Shawn Conner, Andrew Breibart and Matt Vasquez provided GPS locations of structures. Frank Kugel, George Sibley and Jim Cochran hosted team meetings and provided continued programmatic support of the project. Clayton BonDurant, experienced field crew leader, was hired as a subcontractor to BIO-Logic and contracted directly by BLM, oversee work crews in building rock structures.

Gay Austin, Andrew Breibart, and Matt Vasquez completed all NEPA requirements for federally-managed public lands. Mark Flower and Morgan Crowley organized the WRV volunteer event. Professors Jonathan Coop, Tom Grant, Pat Magee and Jeff Sellen kindly recruited their university students to build rock structures during volunteer events. Leo Malloy of Gunnison High School and Jenn Moore of Colorado Mountain College recruited students to participate in the annual WRV events. Tom Grant, Corrie Knapp and Jonathan Coop are overseeing WSCU graduate student projects to address key data gaps.

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REPORT CREDITS

This report was prepared by Betsy Neely with review by Shawn Conner and Nathan Seward. Shawn Conner provided the site and treatment descriptions. Luann Rudolph provided financial information. Teresa Chapman provided analysis of stream miles and acres treated, site maps, NDVI analyses and site prioritization results. Shawn Conner, Nathan Seward, Matt Vasquez and Andrew Breibart provided all GPS data. Renée Rondeau, Gay Austin and Suzie Parker provided the vegetation monitoring results and report. Photographs were provided by Shawn Conner, Betsy Neely, Renee Rondeau, Claudia Strijek and Matt Vasquez.

Cover Photograph: Media Luna, Chance Gulch by Shawn Conner, BIO-Logic, Inc.

APPENDICES

A. Maps (site maps show only structures completed in 2016)
  1. **Chance Gulch**
  2. **Redden Ranch, West Flat Top Mountain**
  3. **Sage Hen Gulch**
  4. **Upper and East Fork of South Cottonwood, Flat Top Mountain**
  5. **West Flat Top Mountain at Henkel Road (Bebb's Willow Reach)**
  6. **Yogi, Flat Top Mountain**

B. Priority Site and Treatment Descriptions (developed by Shawn Conner, BIO-Logic, Inc.)

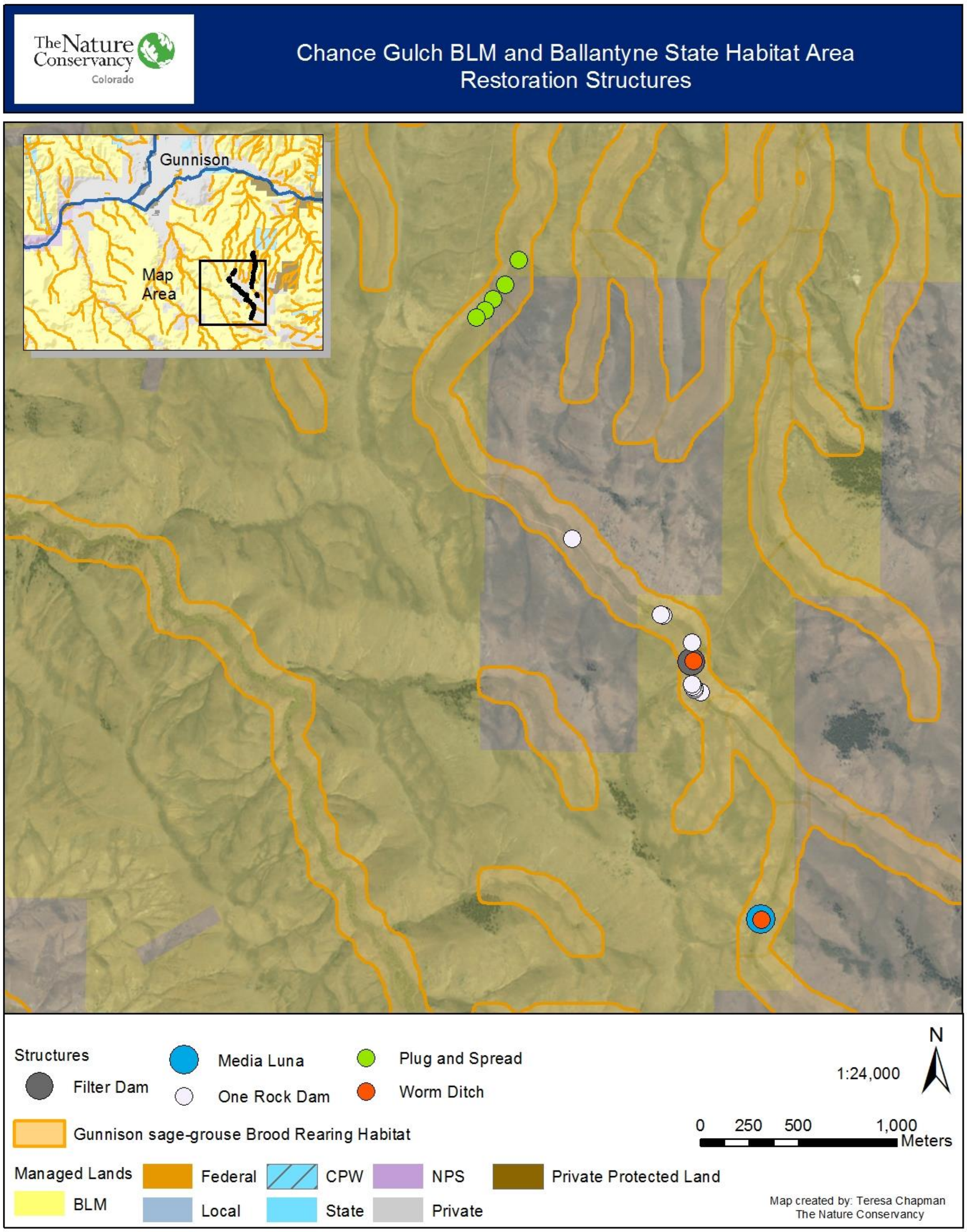
C. Gunnison Basin Vegetation Monitoring (By Rondeau et al. 2016)

D. Prioritizing Sites and Stream Reaches for Potential Restoration (By Teresa Chapman 2016)

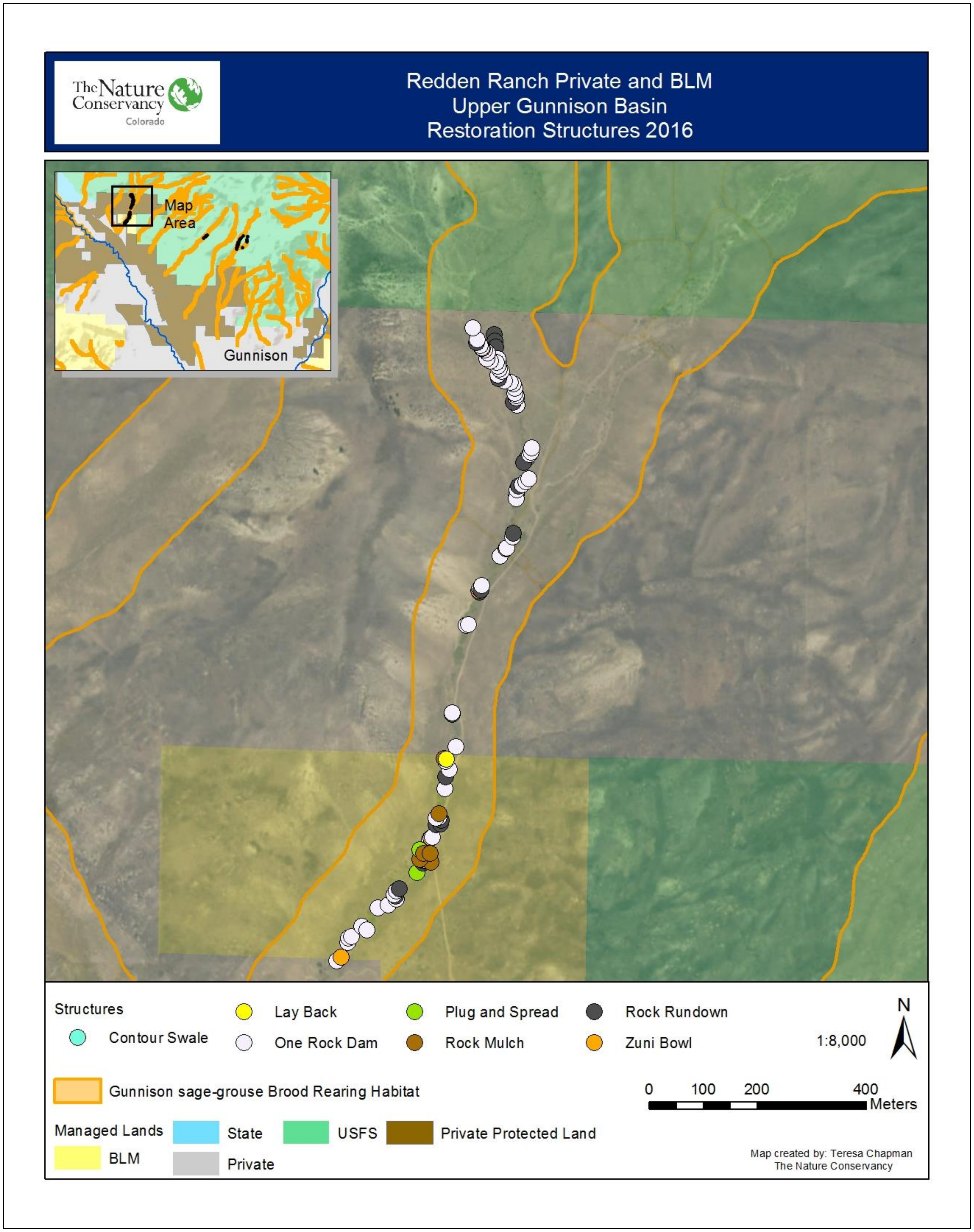
E. Final Total Project Budget Summary (Prepared by Luann Rudolph 2017)

APPENDIX A: MAPS

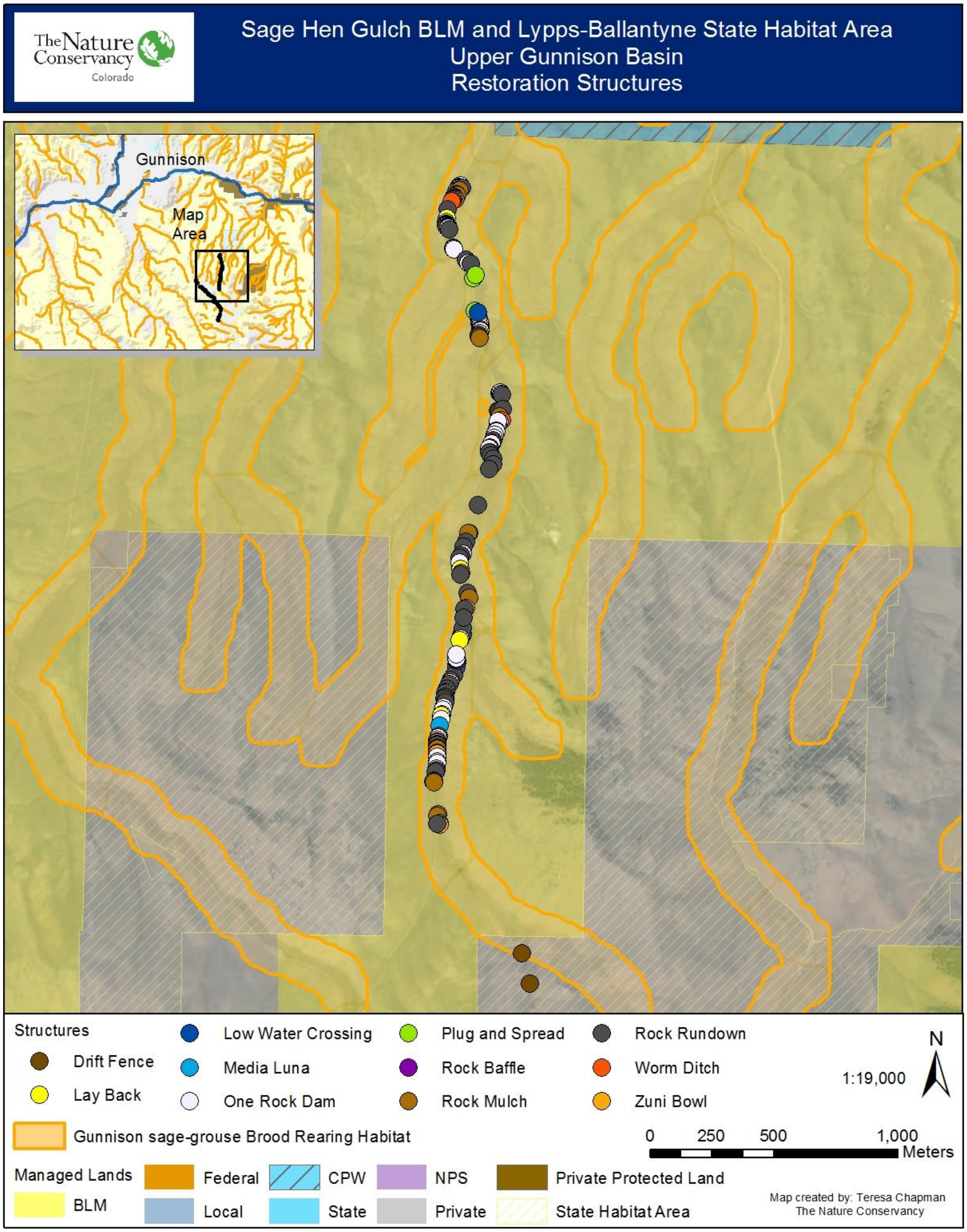
Map 1. Chance Gulch BLM and CPW Ballantyne State Habitat Area Restoration Structures (2016)



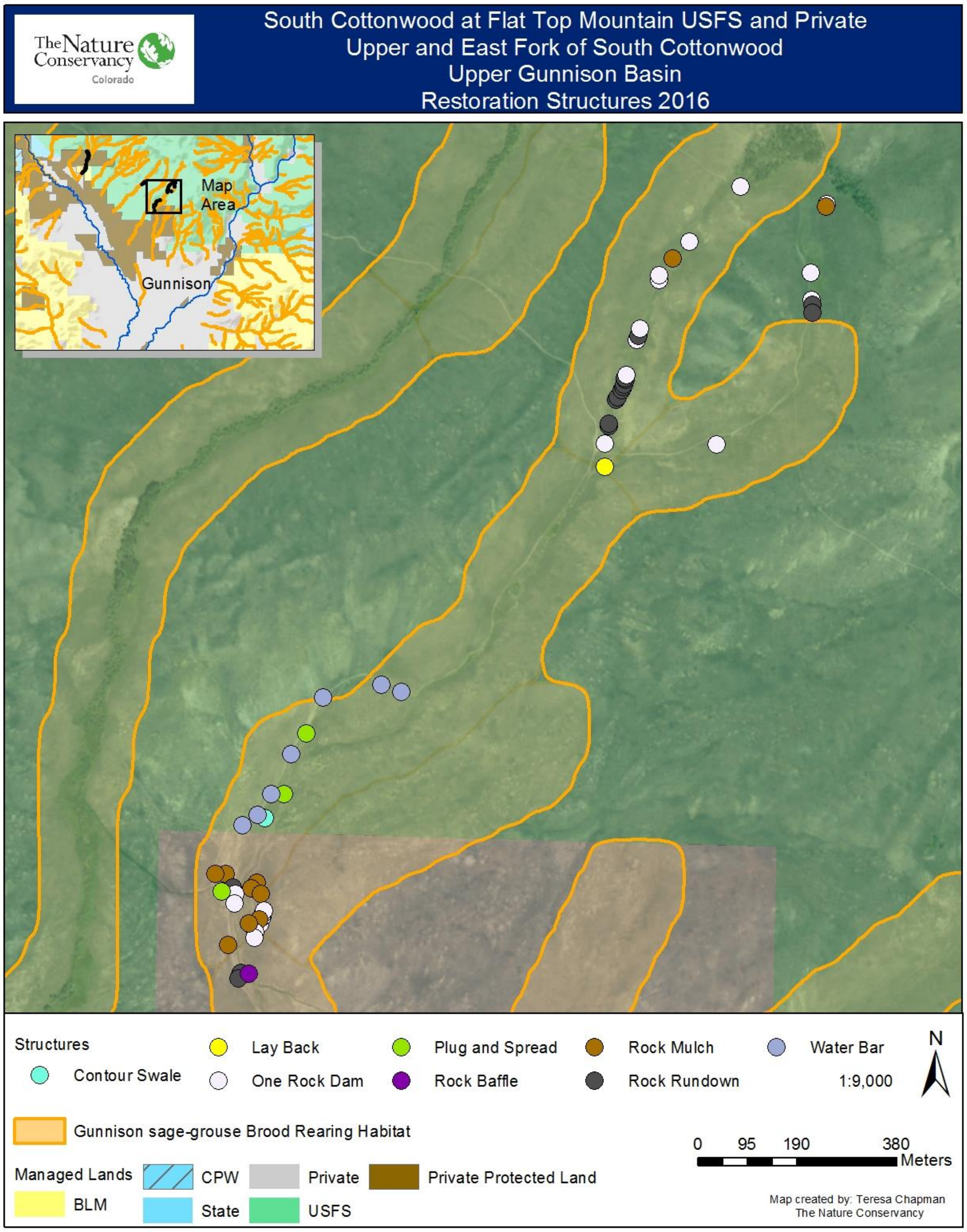
Map 2. Redden Ranch Private and BLM Restoration Structures (2016)



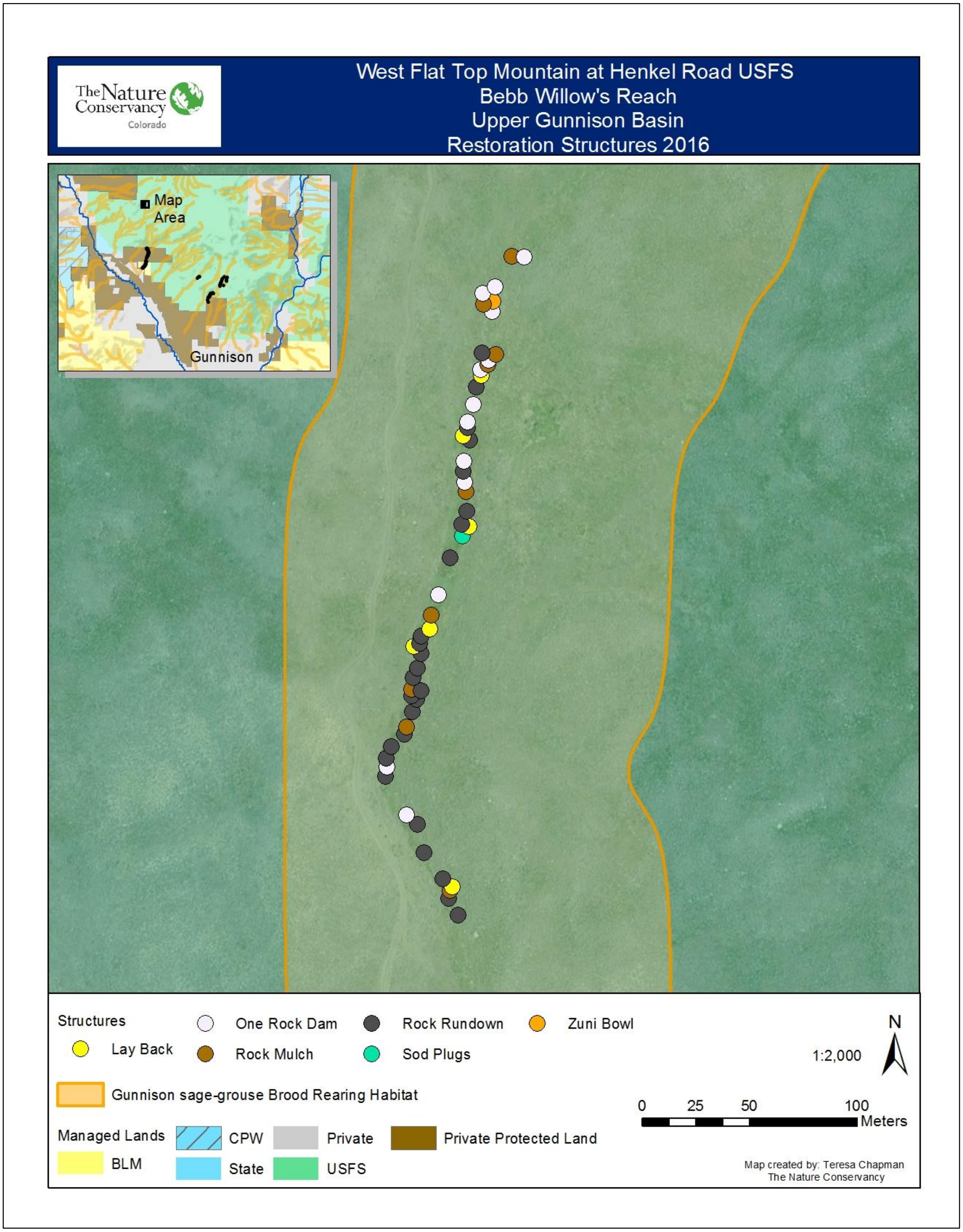
Map 3. Sage Hen BLM and Lypps-Ballantyne State Habitat Area Restoration Structures (2016)



Map 4. South Cottonwood at Flat Top Mountain (Upper and East Fork) Restoration Structures (2016)



Map 5. West Flat Top Mountain at Henkel Road USFS-Bebb's Willow Reach (2016)



Map 6. Yogi, West Flat Top USFS (2016)

APPENDIX B: PRIORITY SITE AND TREATMENT DESCRIPTIONS

By Shawn Conner, BIO-Logic, Inc.

1. **Chance Gulch**: This area is in the south-central region of the Gunnison Basin and combines a section of private lands managed by CPW for Gunnison sage-grouse (Ballantyne State Habitat Area) and BLM managed public lands on either end. Being able to restore entire reaches across land management boundaries is particularly important when treating riparian areas. Working with CPW and the private landowner, TNC secured approval and a landowner agreement to enable treating this entire reach.

   Restoration need: This stream reach is degraded, with frequent and expanding head cuts, old roadways trapping stream flow and runoff, and increased incision of the stream channel. These factors are causing significant decline of traditional wet meadow habitats that are critical for brood-rearing success for the Gunnison sage-grouse.

   Objectives: The objectives for restoration in this area were to restore proper hydrologic function of the stream reach and its associated wet meadow habitats. To achieve this, team members intended to stop or stabilize advancing head cuts and other erosional features, utilize grade control structures to curb increased channel incision, and spread stream flows and surface runoff across a wider area.

   Treatments: Typical treatments used in this area included headcut control structures (Zuni bowls, rock rundowns, lay backs), grade control structures (one rock dams and rock mulches), and flow dispersal structures (media lunas, sod dams, worm ditches and a low-water armored rocked road crossing). In addition to these treatments, the access road along Chance Gulch was re-graded by BLM to include water harvesting techniques that will enhance the riparian zone. In lower reaches, plug and spread structures were used to expand existing mesic meadow surfaces.

2. **Kezar Basin:** This area lies in the southwest corner of the Gunnison Basin, south of Blue Mesa Reservoir. Treatment efforts here were centered on privately owned ranchlands within a large area of BLM managed public lands. The area is remote, provides excellent habitat for Gunnison sage-grouse, and is also a critical over-wintering area for deer and elk herds.

   Restoration need: Riparian areas in the Kezar Basin are degraded, and show signs of increasing channel incision and subsequent loss of adjacent wet and mesic meadow habitats. This area has generally wider and less steep valley bottoms than many adjacent areas. Compaction from livestock and extensive wildlife trailing is also a prominent problem in this area. These trails capture stream flows and runoff and create gullies over time which drains surrounding wet meadow areas, converting them to upland communities. The trails prevent the movement of water out into the surrounding banks through capillary action.

   Objectives: The restoration objectives for this area were to manually restore stream flows onto adjacent wet and mesic meadow habitats, stop increased incision and active gully expansion, and create barriers for trailing ungulates to reduce destructive trailing in riparian zones.

Treatments: Treatment types used in the Kezar Basin included plug and spread treatments, contour swales, and drift-fences. For plug and spread treatments, compacted soil plugs were installed within incised drainages, and outfalls were designed to spread flows evenly across formerly wet adjacent meadow surfaces. Contour swales were used to recollect surface flows and redistribute runoff evenly over meadow surfaces. Drift fence segments were installed perpendicular to the stream channel in specific locations to reduce and eventually eliminate the negative erosional and soil compaction effects of livestock and wildlife trailing. The fences prevent the trailing and seasonal freeze/thaw breaks up the compaction, allowing the water to move farther out into the banks.

3. **Redden Ranch:** This area is in the north central part of the Gunnison Basin, and is where restoration treatment efforts started in 2012 and have continued through the life of the project. The area spans public lands managed by the USFS at the upper elevations, continues downstream through private ranchland, and terminates on a section of public lands managed by the BLM. This area is a classic example of the most effective riparian restoration approach of collaboration among multiple land ownerships and restoring an entire stream reach across jurisdictional boundaries.

   Restoration need: The upper section of this reach on USFS managed public lands begins at the top of a large alluvial fan; the main channel has become moderately incised and was bypassing the historical alluvial fan. The team wanted to slow this water down to recharge the fan, thus enabling longer base flows in the system. Further down the channel, the area is degraded with frequent and expanding head cuts, and increased incision of the stream channel. The channel incision and lowered water table were leading to significant drying of wet meadow and mesic habitats, desiccation of existing willow patches, and exacerbating the negative effects of a flashy runoff.

   Objectives: The objectives for restoration in this area were to restore proper hydrologic function of the stream reach and its associated wet meadow and mesic habitats. To achieve this, team members intended to recharge historical water storage capabilities of alluvial fans, to stop or stabilize advancing head cuts and other erosional features, utilize grade control structures to curb increased channel incision, and spread stream flows and surface runoff across a wider area.

   Treatments: Typical treatments used in this area included headcut control structures (Zuni bowls, rock rundowns, lay backs) grade control structures (one rock dams and rock mulches), and flow dispersal structures (rock baffles, plug and spreads, and contour swales).

4. **Sage Hen Gulch:** This area is in the south-central region of the Gunnison Basin with its headwaters on a parcel of private lands (Lypps-Ballantyne State Habitat Area) and the majority on BLM managed public lands. Working with CPW, NRCS and the private landowner, TNC secured approval and a landowner agreement to enable treating this entire reach.

   Restoration need: This stream reach is largely intact and functioning in the upper section, however, significant livestock and elk trailing is channelizing flows and forming gullies between mesic patches. Further down valley, the area is degraded with frequent and expanding head cuts, historical roadways trapping stream flow and runoff, and increased incision of the stream channel. Current BLM road alignment within the mesic meadow prevents this area from reaching its full potential until BLM has the capacity to move the road into the sagebrush. These factors are causing significant drying of former wet meadow and mesic habitats.

   Objectives: The objectives for restoration in this area were to restore proper hydrological function of the stream reach and its associated wet meadow and mesic habitats. To achieve this, team members intended to stop or stabilize advancing head cuts and other erosional features, utilize grade control structures to curb increased channel incision, modify livestock movement patterns to reduce compacted trailing effects and spread stream flows and surface runoff across a wider area.

Treatments: Typical treatments used in this area included headcut control structures (Zuni bowls, rock rundowns, lay backs) grade control structures (one rock dams and rock mulches), and flow dispersal structures (media lunas, worm ditches plug and spreads, and low water armored rocked road crossing). In addition to these treatments, the access road along Sage Hen Gulch was re-graded by BLM to include water harvesting techniques that will enhance the riparian zone. Drift fences were installed to modify livestock movement patterns and reduce trailing in key areas.

5. **South Cottonwood and Yogi:** The area known as South Cottonwood and Yogi is on the southwestern flanks of Flat Top Mountain and in the north-central part of the Gunnison Basin. This area is comprised of both USFS managed public lands and adjacent private ranchlands. The headwaters of this area are high on the mountain at the aspen/sagebrush interface and the treated project area runs all the way down the mountain ending in private ranchlands near the base of the mountain in a critical area for grouse, as it is near some of the largest and densely attended leks in the Basin. These areas are also critical for wintering elk and deer herds in the area.

   Restoration need: Riparian systems in these areas on Flat Top Mountain are generally snowmelt driven and show signs of increased degradation from erosion and down cutting. Adjacent and formerly wet meadow habitats are drying out resulting from the incised stream channels and a subsequent dropping water table. Historical roads and closed routes are trapping and channelizing runoff.

   Objectives: The restoration objectives in these areas were to restore proper hydrological function to the drainage network by reconnecting the channel with the floodplain, reducing negative effects of old roads trapping runoff, curbing increased channel incision, spreading surface water flows out across meadow surfaces, and improving water storage and ground water recharge capability of existing wet and mesic sites. Improving and restoring willow stands and other important vegetation for wintering big game herds was another objective of this area.

   Treatments: Treatment types used in these areas included grade control structures (one rock dams, rock mulches), headcut control structures (Zuni bowls, rock rundowns, lay backs) and flow dispersal structures (plug and spreads, rock baffles, water bars, and filter dams). A closed route and former road were also ripped to reduce compaction, and water bars were added to utilize runoff from the former road surface and eliminate further erosion of the former roadway surface.

6. **West Flat Top Mountain:** The area known as Flat Top Mountain is in the north-central part of the Gunnison Basin and is comprised of mostly public lands managed by the USFS. Restoration activities in this area are focused in two locations: Henkel Road and an Exclosure. The Henkel Road area of West Flat Top is a higher elevation site for Gunnison sage-grouse and provides excellent habitat for all life phases of the bird. This area is very important, as it is centered on the largest and most abundant known Gunnison sage-grouse sub-population. The Exclosure is an area that was fenced off from livestock use due to a large historical and expanding headcut.

   Restoration need: Riparian systems in these areas on Flat Top Mountain are generally snowmelt driven and show signs of increased degradation from erosion and down cutting. Adjacent and formerly wet meadow habitats are drying out, resulting from the incised stream channels and lowering of the water table. The large historical headcut in the Exclosure site was advancing yearly and adjacent wet meadow habitats were in decline.

Objectives: The restoration objectives in these areas were to restore proper hydrological function to the drainage network by reconnecting the channel with the floodplain, eliminating negative effects of livestock and wildlife trailing, curbing increased channel incision and halting advancing head cuts, spreading surface water flows out across meadow surfaces, and improving water storage and ground water recharge capabilities of alluvial fans.

Treatments: Treatment types used in these areas included grade control structures (one rock dams), headcut control structures (Zuni bowls, rock rundowns, lay backs and log and fabric structures) and flow dispersal structures (media lunas, rock baffles, worm ditches, rock mulches, drift fences and filter dams).

7. **Wolf Creek:** This area is in the southwestern section of the Basin, and is comprised of BLM managed public lands as well as private lands under conservation easement to benefit Gunnison sage-grouse (Kaichen State Habitat Area). Working with CPW and the private landowner, TNC secured approval and a landowner agreement to enable treating multiple areas along privately owned sections of this area. The upper sections of this drainage are ephemeral, snow and storm driven systems, while lower sections are perennial spring fed areas with significant wet meadow resources.

   Restoration need: The upper reaches of ephemeral stream areas of Wolf Creek show signs of increased degradation from erosion and down cutting. Adjacent and formerly wet meadow and mesic habitats are drying out resulting due to the incised stream channels and lowering water table. Lower down within perennial spring fed areas, erosion and channelization has led to significant drying out of former wet meadow and slope wetland habitats. Ranch roads crossing wet meadows negatively impacted historical sheet flow across meadow surfaces, and has led to their degradation by trapping and channelizing runoff. Upstream stock ponds also greatly reduce peak runoff and trap sediments needed for filling in incised and eroded areas on the West Fork of Wolf Creek.

   Objectives: The restoration objectives in these areas were to restore proper hydrological function to the drainage network by reconnecting the channel with the floodplain, eliminating negative effects of roads trapping runoff, curbing increased channel incision, spreading surface water flows out across meadow surfaces, and improving water storage and ground water recharge capabilities of existing wet and mesic sites. Lower Wolf Creek has a monoculture of non-native smooth brome grass, which does not provide good brood-rearing habitat. The objective was to convert the smooth brome to native wetland and riparian vegetation and to support a diverse abundance of insects.

   Treatments: Treatment types used in these areas included grade control structures (one rock dams, rock mulches), headcut control structures (Zuni bowls, rock rundowns, lay backs) and flow dispersal structures (media lunas, worm ditches, rock baffles, armored low water crossings). Abandoning former road routes through wet meadows and relocating them into the uplands was another technique used in this area.

APPENDIX C: GUNNISON BASIN WETLAND RESTORATION VEGETATION MONITORING

By Renée Rondeau (CNHP), Gay Austin (BLM), Suzanne Parker (USFS)

The goal of setting up the monitoring program for the riparian and wetland restoration projects was to determine if management objectives were met. The management and sampling objectives were:

> **Management objective 1**: *Increase* the average cover and density of native sedges, rushes, willows, and wetland forbs (obligate and facultative wetland species) in the **restored** portion of the treated properties by at least 20% within 5 years after treatment.
>
> **Sampling objective 1**: We want to be 90% sure of detecting a 20% change in the absolute cover and density of sedges, rushes, and wetland forbs and will accept a 10% chance that change took place when it did not (false-change error).
>
> **Management objective 2:** *Decrease* the average cover of rabbitbrush, sagebrush, and other upland species in the **restored** portion of treated properties within 5 years after treatment.
>
> **Sampling objective 2**: We want to be 90% sure of detecting a 20% change in the absolute cover of rabbitbrush, sagebrush and other upland species and will accept a 10% chance that change took place when it did not (false-change error).

Introduction:

In 2016, a subset of the Gunnison Climate Working Group completed the fifth year of a restoration project to enhance resilience of riparian and wet meadow habitats in the Gunnison Basin to help the Gunnison Sage-grouse (*Centrocercus minimus*) adapt to a changing climate. These areas are also important habitat for other wildlife species, e.g., neo-topical migratory birds, mule deer, and elk. Already compromised by lowered water tables and erosion, many of these areas are likely to be further impacted by drought, invasive species, and erosion from intense runoff events.

To address these impacts the team used innovative yet simple restoration methods (Zeedyk et al. 2014) e.g. rock structures, plug and spreads, and drift fences, to improve hydrologic and ecological function of wet meadows and riparian areas managed by federal, state and private entities. Restoration Ecologist Bill Zeedyk designed the treatments to raise the water table, reduce erosion, connect the channel to the floodplain and increase wetland plant cover.

This project serves as an important demonstration of simple and effective tools for restoring and increasing resilience of wet meadow and riparian habitats. The techniques provide significant results that have potential to improve hydrologic function over a much larger area.

Monitoring the effectiveness of the restoration project is an important part of the project. The following report documents the results of the vegetation monitoring as it relates to specific management objectives.

Methods:

The vegetation monitoring used a stratified random sample design for each reach. In general, approximately 1/4 of the structures were sampled for species composition, utilizing a random start within the first set of structures. If our random sampling design did not pick up at least one of each type of structure, we manually chose the structure; for example, if there are three media lunas within the drainage yet none were randomly chosen, we choose at least one media luna. A total of 203 vegetation transects were established, of which 49 were control transects and are not influenced by the structures. Table 1 summarizes the number of transects for each reach and what year they were established.

Table 1. Vegetation transects and associated attributes by site.

Site Name	Year established	No. of years, post construction	No. of transects associated with structures	No. of controls	Total	No. of photopoints
Wolf Creek, East Fork	2012	4	9	4	13	33
Wolf Creek, Middle Fork	2012	4	7	3	10	30
Redden	2012	4	15	5	20	60
Flattop, exclosure	2013	3	9	6	15	27
Flattop, Section 36	2013	3	13	6	19	45
Wolf Creek, Upper and Lo	2013	3	11	4	15	39
Flattop, above exclosure	2014	2	19	6	25	66
USFS, above Redden	2014	2	6	3	9	18
Chance	2014	2	21	3	24	72
Kezar	2014	2	9	3	12	30
Cottonwood	2015	1	15	3	18	54
Sage Hen	2016	0	20	3	23	69
Total			**154**	**49**	**203**	**543**

Vegetation transects were generally placed above the restoration structure except in the case of the media lunas and plug and ponds. Transects crossed the stream channel and ran from bank to bank, thus transect length was variable. Using the line-point-intercept method, a methodology accepted by BLM (AIM 2011) and the Forest Service, we collected cover data every 0.5 m along a transect, including bare ground, rock, or litter if the point was not occupied by a plant. Height of vegetation was collected at every meter by measuring the droop height of the tallest plant within a 10 cm^2 frame. Photos were taken from the 0-m mark and end of transect, with the transect line in the middle of the photo. UTM's and bearing of transect were noted for the beginning of each transect. Photo time was also noted. Additional photos (labeled as photo points) were taken, generally looking upstream (i.e. downstream of the transect) with the transect in the photo. This was meant to capture a view of the area that is most likely to change. UTM's (NAD83), time, date, camera height, compass bearings were recorded for each photo.

Subsequent year's data collection occurred within weeks of the original sample period and repeat photos were generally within two hours of the original photo time.

We identified plants to the species level, except for rare instances. To analyze the data, we classified each species into the following groups, using the NRCS list. For the purposes of this project, a species was considered a wetland species if it was an obligate or facultative wetland species.

Obligate wetland (OBL). Almost always occurs in wetlands (estimated probability > 99%) under natural conditions

Facultative wetland (FACW). Usually occurs in wetlands (estimated probability 67% – 99%), but occasionally found in non-wetlands.

Facultative (FAC). Equally likely to occur in wetlands (estimated probability 34% – 66%) or non-wetlands.

Facultative upland (FACU). Usually occur in non-wetlands (estimated probability 67% – 99%), but occasionally found in wetlands (estimated probability 1% – 33%).

Obligate upland (UPL). Occur almost always (estimated probability > 99% in non-wetlands under natural conditions.

Data Analysis

Data analysis was conducted on sites with at least two years of data. To assess meeting the management objectives, we pooled all wetland species and graphed differences in cover between years. Data was analyzed by stream reach and is presented rate of response: fast, slow, no response yet.

Results

The increase in wetland species cover varied by reach and the number of years' post treatment and ranged from 0-245%. We have categorized the response rate into three categories: fast, slow and no response yet (Table 2).

Fast Response: Those reaches that responded quickly include reaches with and without perennial water and narrow to wide flood plains. Wolf Creek-East Fork media lunas and Redden had very significant increases in wetland species cover, 220% and 245% respectively. These two reaches are very different from each other with Wolf Creek media lunas in a large floodplain with low gradient and a perennial flow from a spring. Redden is a steep gradient stream with a narrow to medium wide floodplain that relies on snow melt and storm events. Wolf Creek- Middle Fork is more similar to Redden than Wolf Creek East Fork, while Wolf Creek, Upper and Lower as well as Kezar Basin are more similar to Wolf Creek East Fork at the media lunas.

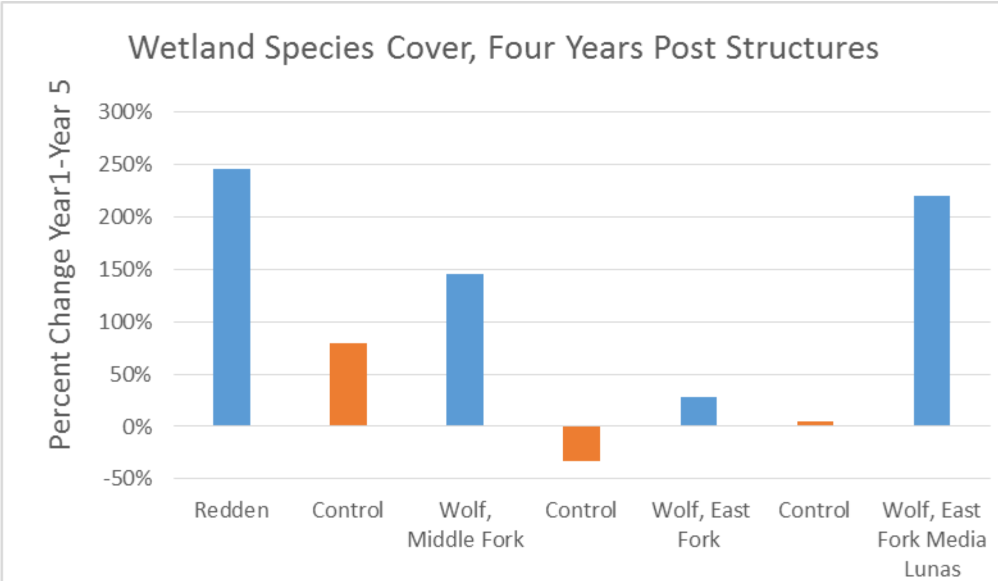
Slow Response: Two reaches had a relatively slow response rate, one at Wolf Creek, East Fork (above media lunas) and Flat Top, Henkel Road. Once again, these two reaches are very different from one another. Wolf Creek, East Fork has a range of water availability, from snow melt to perennial water while Flat Top, Henkel Road is snow melt and more similar to Redden than Wolf Creek. Flat top continues to have moderate to heavy cattle grazing and the grazing may be slowing the response rate down but that is not the case at Wolf Creek.

No Response Yet: Out of the five reaches mentioned, two of them (Flat Top above exclosure, and Chance) require more monitoring before we can make a definitive call and we expect these reaches will move into either the slow or fast response rate category. The other three reaches, Flat Top-Exclosure, Wolf Creek-West Fork, and Above Redden are worth further explanation. The Flat Top Exclosure reach had a deep (approx. 3 foot) headcut that was migrating upstream. The primary management goal for this reach was to stop the head cut from migration upstream. Thus, our general management objective of increasing wetland species cover may never be met, or will slowly be met, but our primary goal for that reach was met (see Appendix for more details). Wolf Creek-West Fork appears to have numerous issues that may keep the reach from responding. There are two ponds on the immediate drainage and additional ponds on side drainages that prevent much of the natural water from reaching the stream, in addition to capturing the sediments that are so critical to building up the stream bottom. While fixing the low-water crossing may help this reach respond positively, it is unlikely that the response rate will ever be high due to water holding ponds.

We can also compare the percent change in wetland species cover across all sites by number of years' post treatment. It does appear that the structures continue to increase wetland species cover the longer they are in place, and that at least three years' post construction is generally when we start to see a response (Fig. 1). With that said, Redden, East Fork media lunas and Kezar Basin all had a response one to two years' post construction (Table 3).

Table 2. Wetland species cover response rates grouped into fast, slow and no response categories.

Site/Stream Reach	Wetland Species Cover Increase	Number of Years Post Treatment	General Characteristics/Comments
Fast Response			
Wolf Creek-East Fork Media Lunas	220%	4	Perennial water from spring; wide flood plain with approximately 25% of floodplain occupied by wetlands prior to treatment
Redden	245%	4	Ephemeral; snow melt and storm events are primary water source; medium wide floodplain; sediment source upstream
Wolf Creek-Middle Fork	37%	4	Ephemeral; snow melt and storm events are primary water source; narrow floodplain
Wolf Creek-Upper and Lower	37%	3	Perennial water from spring; wide floodplain with approximately 25% of floodplain occupied by wetlands prior to treatment
Kezar Basin	27%	2	Perennial water from springs; wide floodplain with approximately 25% of floodplain occupied by wetlands prior to treatment
Slow Response			
Wolf Creek-East Fork above Media Lunas	28%	4	Mixed water source with some perennial, snow melt and storm events; narrow to medium flood plain width
Flat Top-Henkel Road	24%	3	Ephemeral snow melt and storm events are primary water source; narrow to moderately wide floodplain
No Response Yet			
Flat Top-Exclosure	6%	3	Ephemeral; snow melt and snow events; preventing the migration of a large headcut was the primary goal
Flat Top-Above Exclosure	0%	2	Repeat photos show that sediment is building and we expect to see a positive response next year
Above Redden	0%	2	Purpose was to provide additional ground water to meadow below (not to increase wetland plant cover)
Wolf Creek-West Fork	5%	3	Multiple upstream ponds capture snow melt, water from storm events and sediment; low water crossing has been problematic
Chance Gulch	0%	2	More time is needed to determine trends



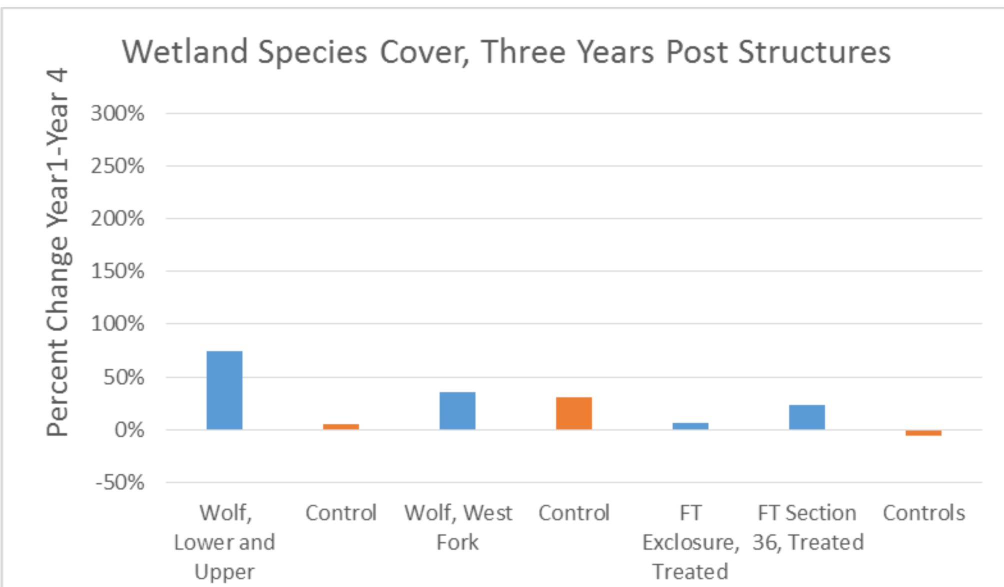


Figure 1. Percent change in wetland species cover for reaches with four years (top) and three years (bottom) after structures were built. Blue bars represent treated areas and orange bars represent controls.

Table 3. Average wetland species cover by year and total percent change in wetland species cover for all reaches for two or more years of post-construction.

Reach	Year 1	Year 2	Year 3	Year 4	Year 5	Diff 1st yr vs last year (%)	Water Source
Four Years Post-Structures							
Redden	11%	26%	43%	48%	37%	**245%**	*Snow Melt*
Control	12%	15%	18%	17%	21%	**80%**	*Snow Melt*
Wolf, Middle Fork	15%	28%	26%	33%	37%	**146%**	*Snow Melt*
Control		7%	15%	5%	6%	**-33%**	*Snow Melt*
Wolf, East Fork	57%	82%	82%	90%	73%	**28%**	*Spring-fed*
Control			67%	70%	70%	**5%**	*Snow Melt*
Wolf, East Fork Media L	25%	45%	75%	75%	80%	**220%**	*Spring-fed*
Three Years Post-Structures							
Wolf, Lower and Upper	56%	65%	95%	98%		**74%**	*Spring-fed*
Control		67%	70%	70%		**5%**	*Spring-fed*
Wolf, West Fork	67%	89%	81%	90%		**35%**	*Pond-fed*
Control	68%	84%	88%	89%		**30%**	*Snow Melt*
FT Exclosure, Treated	49%	44%	47%	52%		**6%**	*Snow Melt*
FT Section 36, Treated	55%	55%	71%	68%		**24%**	*Snow Melt*
Controls		49%	48%	46%		**-6%**	*Snow Melt*
Two Years Post-Structures							
FT Above Exclosure, Tre	55%	64%	55%			**0%**	*Snow Melt*
Controls		49%	48%			**0%**	*Snow Melt*
Kezar	46%	50%	58%			27%	*Spring-fed*
Control	125%	120%	106%			-15%	*Spring-fed*
Chance	72%	94%	84%			17%	*Spring, Pond, S*
Control	67%	72%	79%			17%	*Spring, Pond, S*
Above Redden	22%	22%	22%			0	*Snow Melt*
Control	7%	12%	10%			46%	*Snow Melt*

Discussion and Conclusions

The simple and repeatable line-point intercept method is adequate for addressing our management objectives. Management objectives are being met at most sites that have had at least 3 years' post treatment. For those sites that management objectives were not met, it is either too early to detect a change or our structures were never intended to improve wetland species cover, but rather stop head cuts or alter the area downstream. The one exception to this is Wolf Creek West Fork where multiple upstream ponds hold water and a partially functioning low water crossing inhibits flow and is likely constraining the recovery time. Note that this low water crossing is to be adjusted in the fall of 2016.

We have highlighted the widely varying response rates in wetland species cover and noted that there is no one pattern that explains this. Further investigation as to why we see such a variation in response rate would help us scale this project up into new areas. It may be possible to provide some guidelines for more detailed management objectives, including metrics such as bare ground, erosion control, or number of wetland acres. Potentially each stream reach could have its own management objectives, just as each structure type could have its own objectives. With more fine scaled analysis and additional monitoring it may be possible to compare the efficiencies in plug and spreads versus rock structures in meeting one's goals.

We suggest that at least 5 years of vegetation monitoring is necessary to observe a real trend and that if a site has additional structures built on top or near the original structures, an additional 3 years of monitoring would be ideal. While all additional sites that we work in do not require monitoring to the level we currently have, we recommend additional monitoring on plug and spreads and contour swales. This would allow us to have good representation across different stream reaches and help us assess the effectiveness and efficiency of plug and spreads and contour swales. In addition, Sapinero Mesa (will be built in 2017) appears to be an excellent one to monitor due to the different design (with numerous plug and spreads) as well as a different geomorphology. On sites where extensive monitoring does not need to take place, we recommend utilizing photo points as a monitoring tool on those sites, recognizing that analyses of photo points can be challenging, but they are still a valuable tool for assessing change. Note that even with photo points, we recommend having controls so that one can compare treated and not treated sites within a reach.

Any good adaptive management project requires that one develops management objectives, and that you monitor to ascertain if the objectives are being met. As one learns from the project, it is necessary to review and adjust your objectives. We are at the point that it is time for us to revisit our objectives and potentially add additional objectives or develop objectives for each reach. An important attribute of a well-designed restoration project is to make sure that one does not treat the entire area, thus providing us with a control area that can be used to convince ourselves and others that any trends we see are due to our treatments and not due to changes in the annual weather.

The wet meadow restoration work in the Gunnison Basin has been very successful and through this monitoring coupled with the design crew and additional analysis, we can provide important lessons learned to others are interesting in applying these restoration methods.

We thank numerous persons for assisting us with field work including, Wendy Brown, Betsy Neely, James Cooper, Liz With, Tom Grant, Cynthia Billings, and BLM summer technicians. Funding for the monitoring was provided by BLM, CPW and Terra Foundation.

APPENDIX D: PRIORITIZING SITES FOR RIPARIAN & WET MEADOW RESTORATION/RESILIENCE BUILDING PROJECT

By Teresa Chapman, The Nature Conservancy

Introduction

Gunnison sage-grouse in the Gunnison Basin rely on riparian and wet meadow habitats during critical life stages, especially in early summer during brood rearing season. These areas also provide important habitat for other wildlife species, e.g., deer, elk, and migratory bird species. The Gunnison Climate Working Group (GCWG), a public-private partnership preparing for change in the Gunnison Basin, is working to restore the hydrologic and ecosystem function of wet meadows and riparian areas to ensure that these species have access to necessary riparian habitat in the face of a changing climate. Both more severe, prolonged droughts and more intensive monsoonal rains are predicted under increased warming. The restoration techniques (designed by Bill Zeedyk) used in this project help to slow and disperse the water within stream channels to expand riparian habitat and reconnect the stream to the floodplain, ultimately increasing the stream's resilience to drought, monsoons, and storm events. The team defined four critical components of a resilient stream and riparian system: a) a properly functioning hydrology/ecology, b) a stream channel that is connected to its floodplain, c) stream banks that retain moisture and reduce erosion during flood events, and d) a native and diverse wetland and mesic species composition. To maximize conservation results and focus on-the-ground efforts, the team devised a site prioritization for restoration, based on a combination of ecological, climate-informed, and topographic GIS variables.

The methods and results presented here are intended to provide a landscape-scale model of the restoration need and potential of stream reaches in the entire Gunnison Basin. As in many restoration projects, narrowing down the best places to work is a critical step. This prioritization model can be used to identify those stream reaches within critically important Gunnison sage-grouse habitat that offer the greatest potential to respond favorably to our restoration techniques. Once reaches with the highest potential are identified using this GIS method, on-the-ground investigations can further refine opportunities and constraints for restoration at each site.

Methods

We used four main criteria to select and prioritize stream reaches for restoration within the Gunnison Basin:

1. Location within potential Gunnison sage-grouse brood rearing habitat
2. Close proximity to lek locations (<= 2 miles)
3. Restoration Potential Index (measuring difference in greenness between a wet year and a dry year)
4. Riparian Condition Index (measuring the extent of the floodplain and the current extent of riparian vegetation).

We used two ecological layers, Gunnison sage-grouse brood rearing habitat and proximity to leks, to narrow priority streams to those most essential for Gunnison sage-grouse habitat. The Gunnison sage-grouse brood rearing habitat was mapped by the Gunnison Basin Gunnison sage-grouse Strategic

Committee in its Habitat Prioritization Tool, specifically created for the grouse. The layer was created from the SSURGO soil database, a vegetation layer, an elevation-derived stream flow model, and numerous potential threats to sage-grouse (such as roads). Although this data layer is not available for other basins, we used it as the foundation of our analysis and only included stream reaches within mapped brood rearing habitat. We used a two-mile buffer surrounding current active Gunnison sage-grouse leks to prioritize areas where the highest percentage of hens are predicted to raise their young (~85% nest and brood rear within two miles of leks).

We created a climate-informed layer, the *Restoration Potential Index*, to identify areas that currently 'green up' during wetter years and maintain some functionality during drought years, implying that the riparian corridor is not too deeply incised and that the area has some source of water during the summer months, including snow melt, seeps and springs, and/or a perennial stream. This layer was generated from a NASA Landsat satellite image vegetation index of greenness. The riparian areas that do not green up sufficiently during drought years (but do during wet years) provide an opportunity to slow down and spread the available water in these stream reaches with the goal of providing needed riparian and mesic habitats during drought.

We created a topographically-based layer, the *Riparian Condition index*, to indicate areas that showed the most promise for improvement based on the floodplain extent and current extent of the riparian area. Stream reaches with little available floodplain due to topography are not ideal candidates for these restoration structures. This layer was generated from a fine resolution elevation model and fine scale aerial imagery. Riparian Condition Index marks areas with topography conducive to spreading out the water and have little current riparian vegetation, indicating channel incision or lack of water. Combining the Restoration Potential index with the Riparian Condition Index allowed the team to estimate which stream reaches have access to water, are not excessively degraded beyond the ability of these structures to repair, and have topography favoring a more expansive floodplain.

The unit of analysis is a stream reach as identified by the National Hydrography Dataset. We used stream miles as measured in the NHD to estimate the number of stream miles within the criteria. We used CPW riparian polygons generated from aerial image interpretation to estimate the area of riparian acreage within the criteria.

Criteria 1: Location within potential Gunnison sage-grouse brood rearing habitat

Select stream reaches from the high resolution 1:24,000 scale National Hydrography Database (NHD) that intersect the potential for Gunnison sage-grouse brood rearing habitat developed by the Gunnison Basin Gunnison sage-grouse Strategic Committee's Habitat Prioritization Tool (HPT; Figure 1).

a. Select unique stream reaches from the high resolution NHD within the basin that intersect the Gunnison County Habitat Prioritization Tool (HPT) Gunnison sage-grouse brood rearing habitat polygons (potential for brood rearing habitat >=1).
b. Convert the NHD stream reach (flowline type = Stream or River) to a raster (grid) at a 30-m resolution and buffer the stream reaches by 60 m using the expand ArcGIS tool to address issues of inaccuracy in the NHD flowlines. Snap the raster to a Landsat image to assure that all pixels in stream reaches align with Landsat imagery (Figure 2).

Figure 1. Stream Reaches with Gunnison sage-grouse Brood rearing habitat (from the Habitat Prioritization Tool). There are 4,410 stream reaches in the Gunnison Basin that contain Gunnison sage-grouse brood rearing habitat.

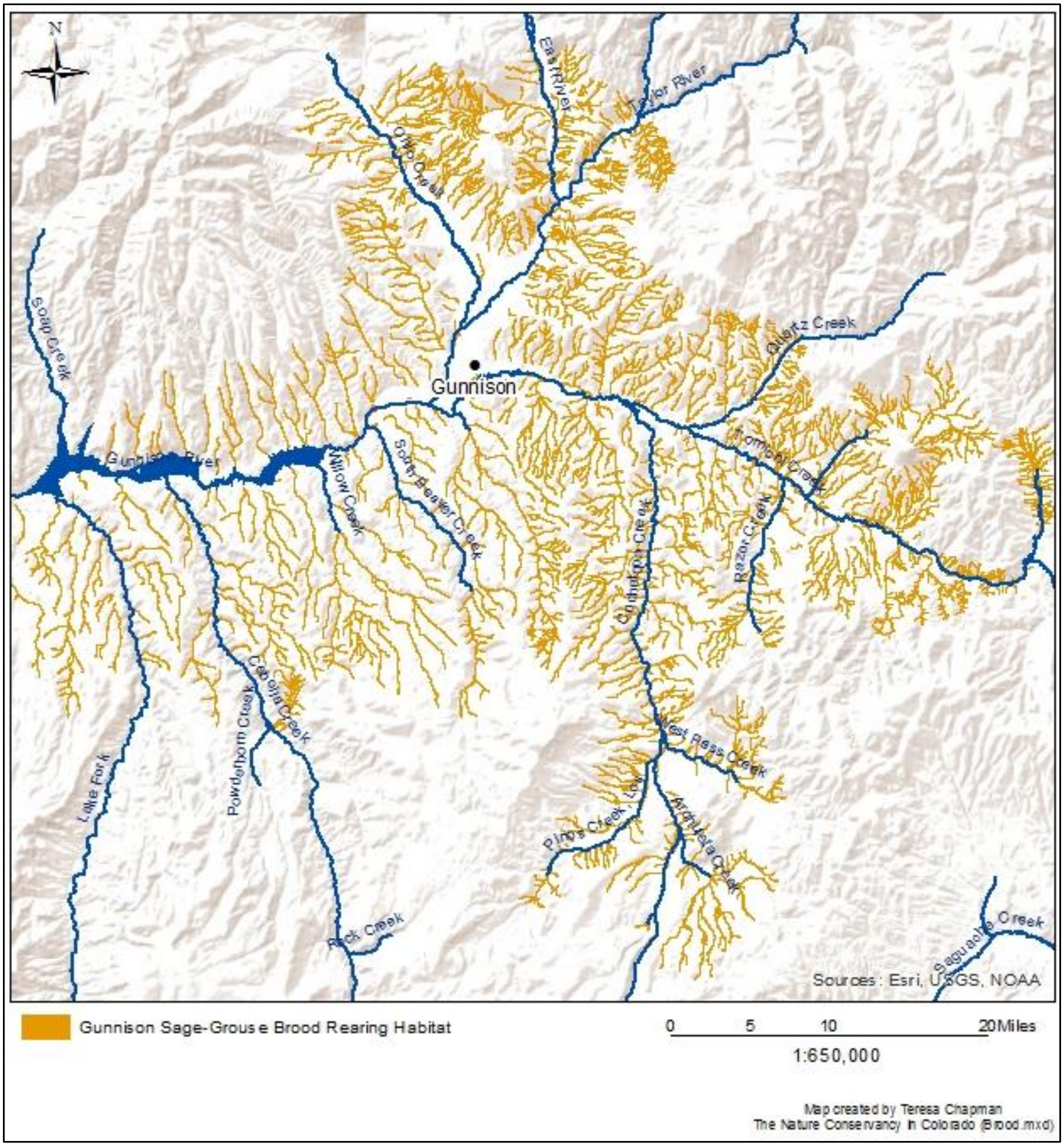
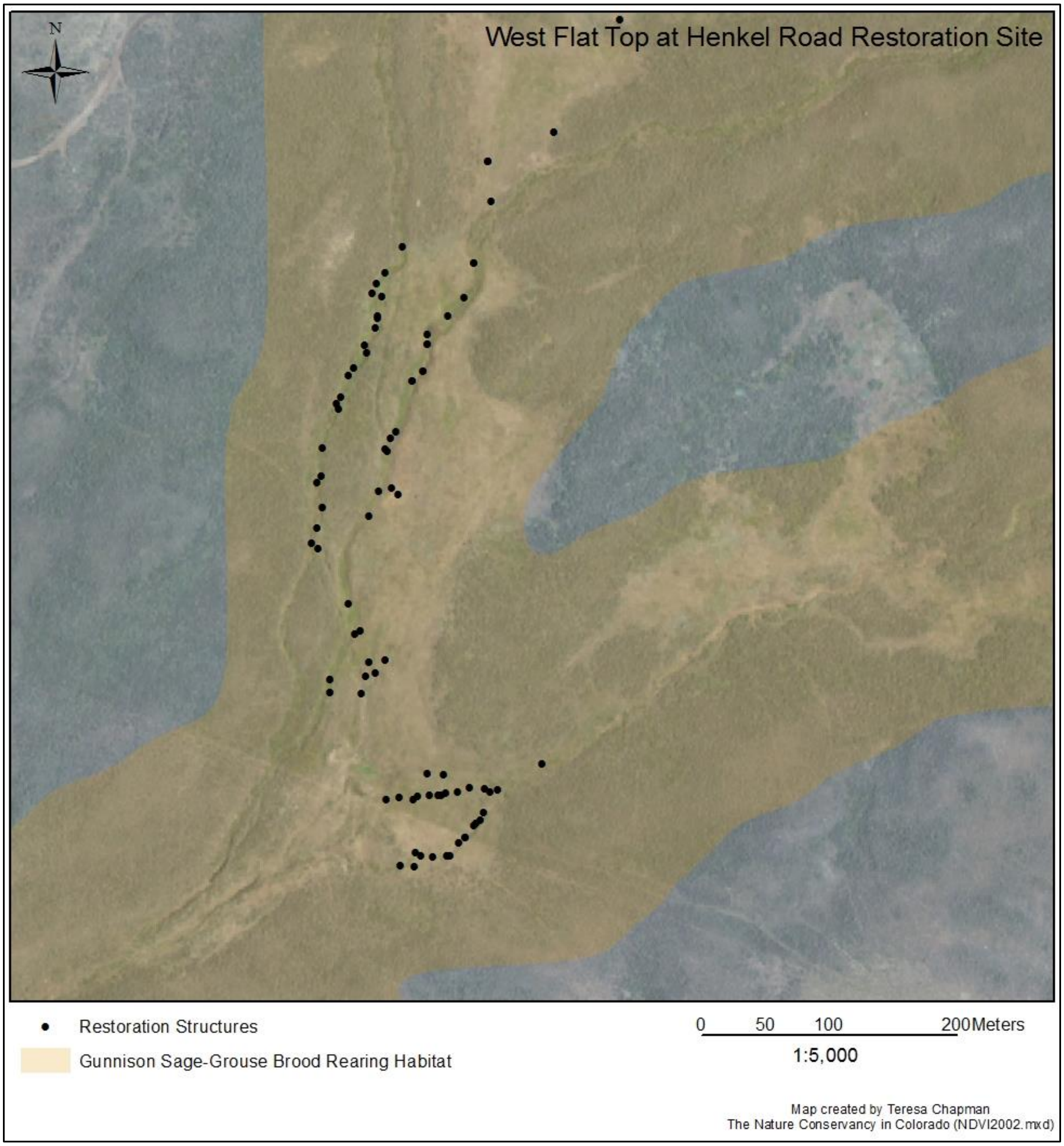


Figure 2. The Gunnison sage-grouse Brood rearing habitat at West Flat Top at Henkel Road restoration site.

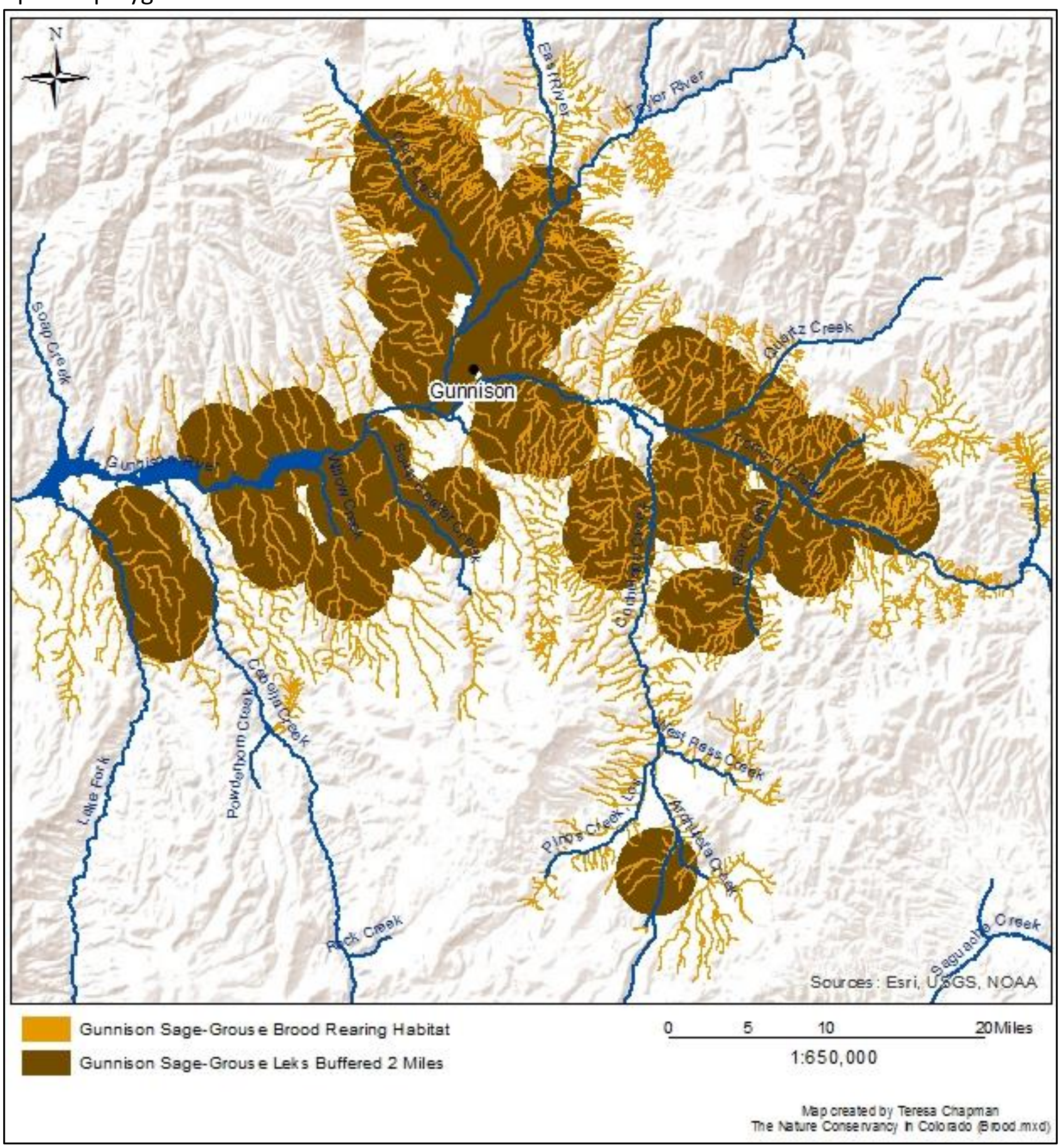


Criteria 2: Close proximity to lek locations (<= 2 miles)

Determine stream reaches within a specified distance of Gunnison sage-grouse leks (Figure 3).

a. Buffer known active Colorado Parks and Wildlife (CPW) lek locations to two miles.
b. Calculate areas of overlap between lek buffers.
c. Determine number of leks within two miles of a stream reach.

Figure 3. Stream reaches within 2 miles of an active Gunnison sage-grouse lek. There are 1,883 stream reaches within 2 miles of Gunnison sage-grouse leks, totaling 927 miles of perennial, intermittent, and ephemeral streams and approximately 5,540 acres of current riparian vegetation, as mapped by CPW riparian polygons.



Criteria 3: Restoration Potential Index (difference in greenness between a wet year and a dry year)

Determine Restoration Potential Index of stream reaches using a time series of a climate-related vegetation index (NDVI: Normalized Differenced Vegetation Index). NDVI is a proximate for productivity of vegetation. Very productive and green vegetation has higher NDVI values than drier, browner, less productive vegetation. The index directly gives the percentage of decreased riparian area between a drought and a wet year.

a. Obtain NDVI values from peak growing season and drought months (July and August) in a time series between 2000-2011 from USGS Landsat Climate data records (http://landsat.usgs.gov/CDR_ECV.php) to determine years with very high and very low NDVI values.
b. Remove water and clouds from all images. NDVI values range from -10000 to 10000 (scaled by .0001).
c. Determine the wettest and driest years between 2000-2012. The year 2002 was the driest and 2009 was the wettest (Figures 5-7).
d. Use the CPW Riparian polygons, the National Wetlands Inventory dataset, and the BLM Gunnison basin seeps and springs layer to calculate the mean NDVI values of riparian plants and spring fed systems during a wet year and estimate a threshold value for NDVI values in riparian areas. The mean of riparian vegetation had a NDVI value of approximately 4000.
e. Classify area of stream reaches above 4000 NDVI for the Landsat time series.
f. Calculate an index based on the difference in riparian area above the threshold 4000 NDVI in a wet year versus a dry year. Standardize the ratio by the area above 4000 NDVI in the wet year.

$$\text{Restoration Potential Index} = \frac{([\text{NDVI} >= 4000 \text{ wet year}] - [\text{NDVI} >= 4000 \text{ dry year}])}{[\text{NDVI} >= 4000 \text{ wet year}]} * 100$$

An area which lost half of the area above 4000 NDVI between 2009 and 2002 would have a value of 50 (or .5). A value of 100 indicates that the stream reach did not green up above the NDVI threshold of 4000 and therefore decreased the riparian vegetation by 100%. A score of zero indicates that the area never greened above the threshold and is too dry, lower elevation or very highly degraded (Figure 4).

<u>Interpretation of Restoration Potential Index values:</u>

0: very dry (due to either low elevation, steep/rocky topography, lack of consistent water source). Not prime areas for restoration.

1-60: very high elevations, or very wet high flowing creeks/springs (also possibly forested areas and/or errors in database). These areas are well-functioning riparian habitats in terms of maintaining green areas during drought. Not prime areas for restoration.

60-99: potentially spring fed system and maintained at least a small area of green riparian habitat during the 2002 drought. Areas where restoration efforts would likely show fast response because there is water moving in system during droughts.

100: area has ability to green up but did not hit threshold value in 2002. Areas where restoration efforts would likely show a slower response because there is less water moving through system during dry years.

We considered all streams with a Restoration Potential Index >= 60 as areas with potential for improvement with these restoration techniques. Streams with values greater than 60 have potential to add resilience to these systems through stream restoration.

Figure 4. NDVI values for 2009 (wet year) across the Gunnison Basin. Green areas on the map are above the 4000 value for NDVI indicating green riparian vegetation. Brown areas are very dry.

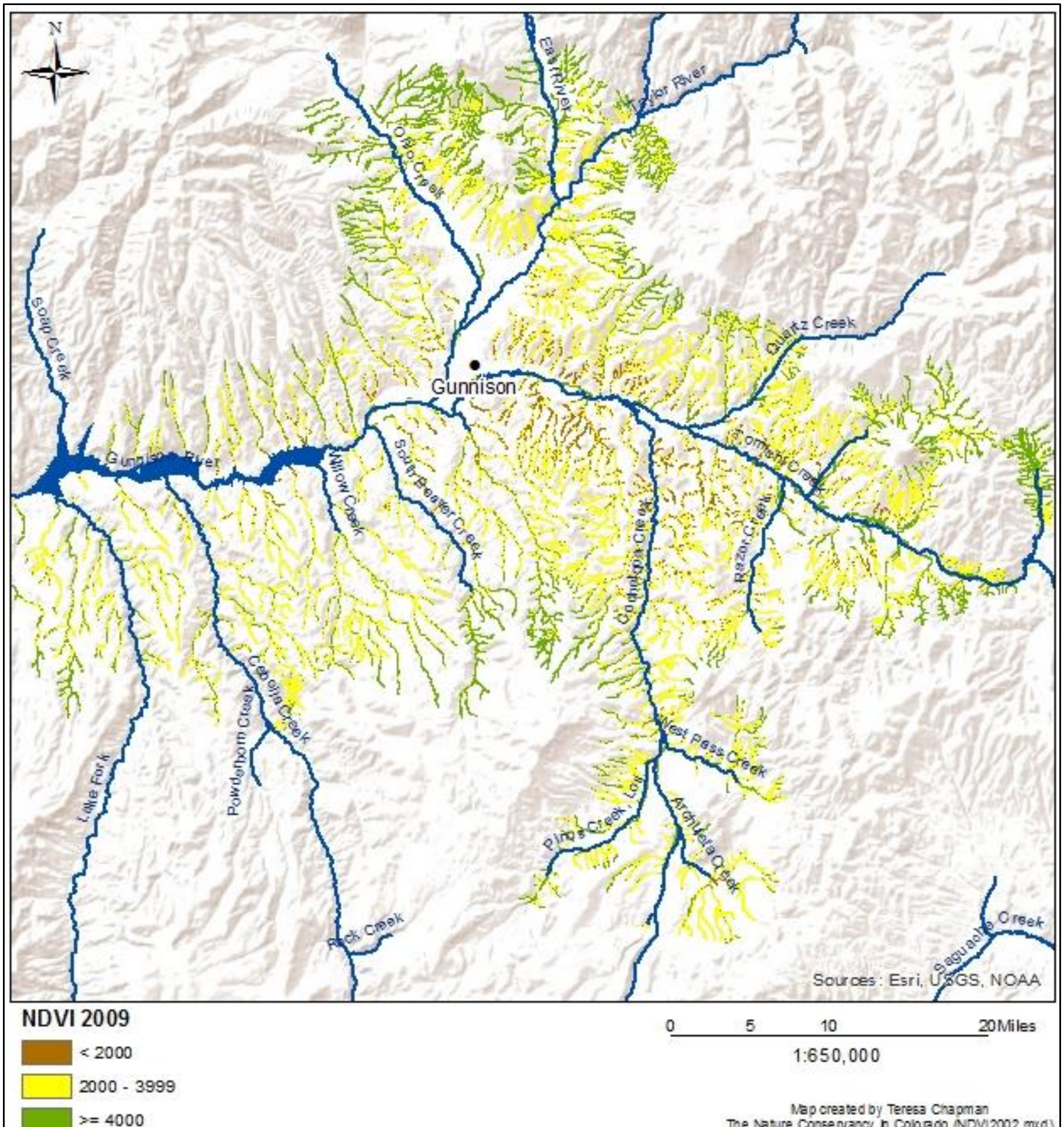


Figure 5. NDVI values for 2009 (wet year) at West Flat Top at Henkel Road restoration site. Many areas within the stream reach were above the NDVI threshold of 4000, indicating very green riparian vegetation.

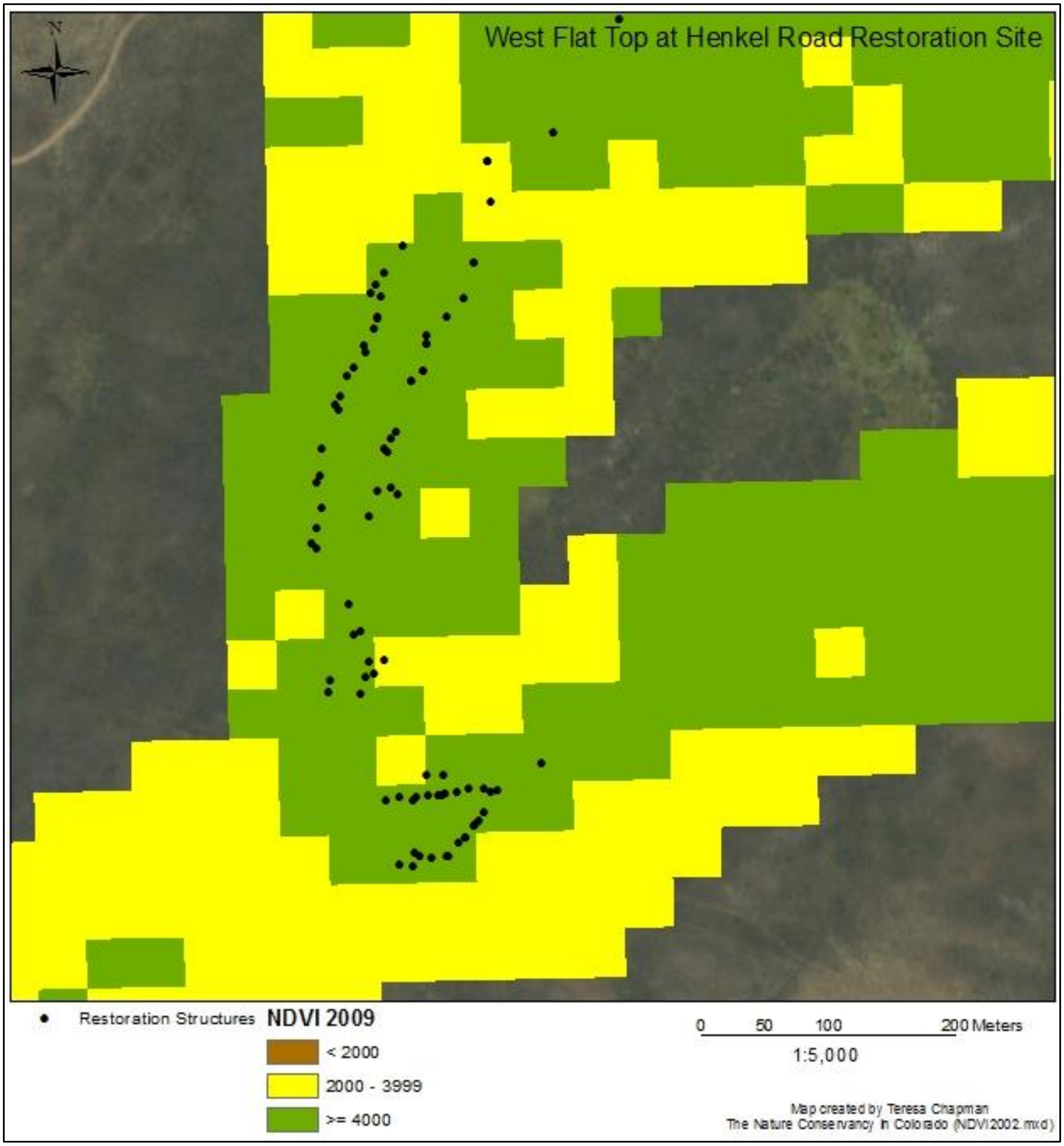


Figure 6. NDVI values for 2002 (drought year) across the Gunnison Basin. The area of vegetation that is less green, less productive, and less moist is shown in brown and covers a greater area compared to a wet year. Less vegetated area reached the NDVI threshold of 4000, shown in green below, during the drought of 2002, indicating the severity of the drought and the negative impact on riparian habitat.

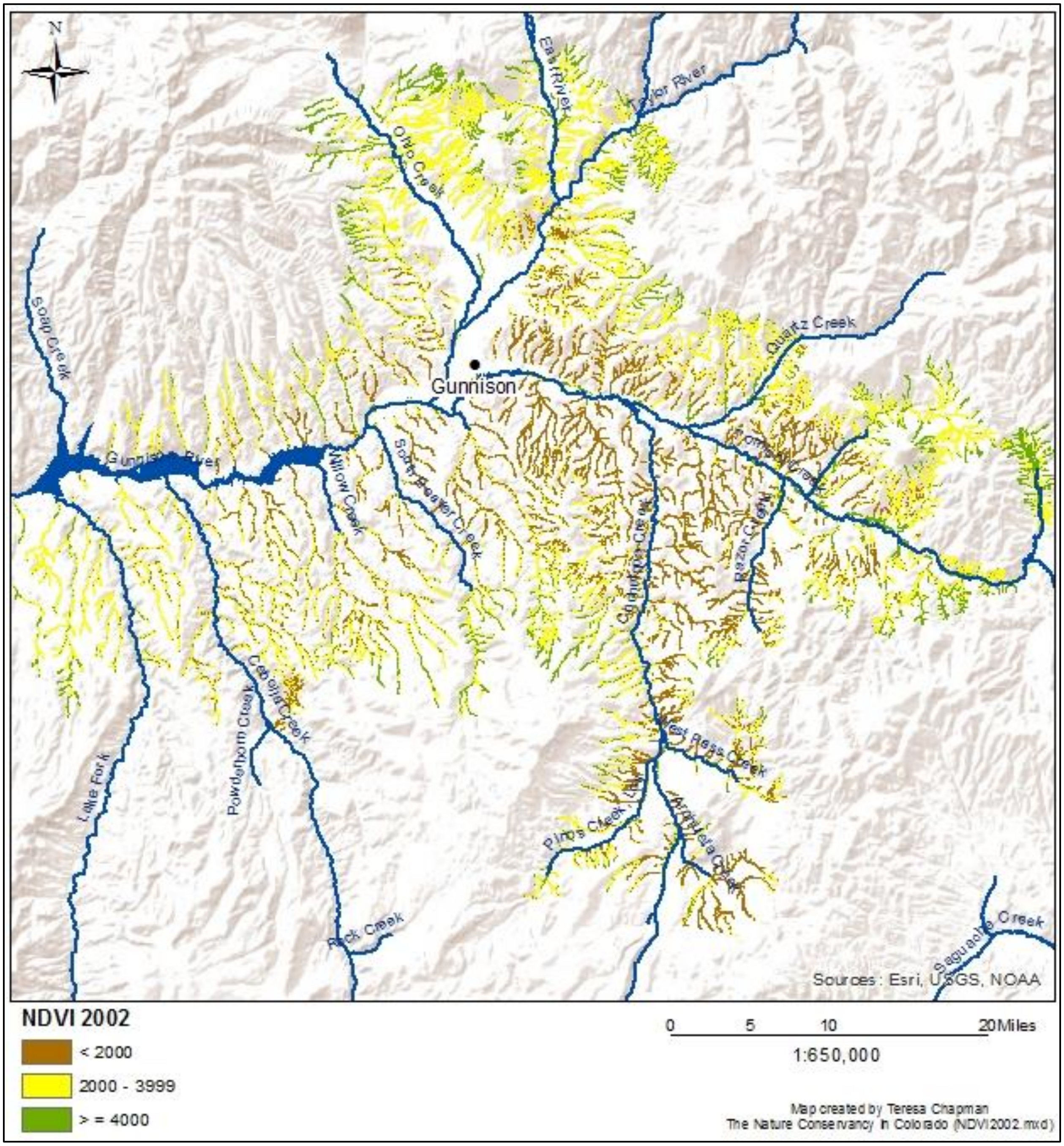


Figure 7. NDVI values for 2002 (drought year) at West Flat Top at Henkel Road restoration site. The stream reach did not have any riparian areas that crossed the NDVI threshold of 4000.

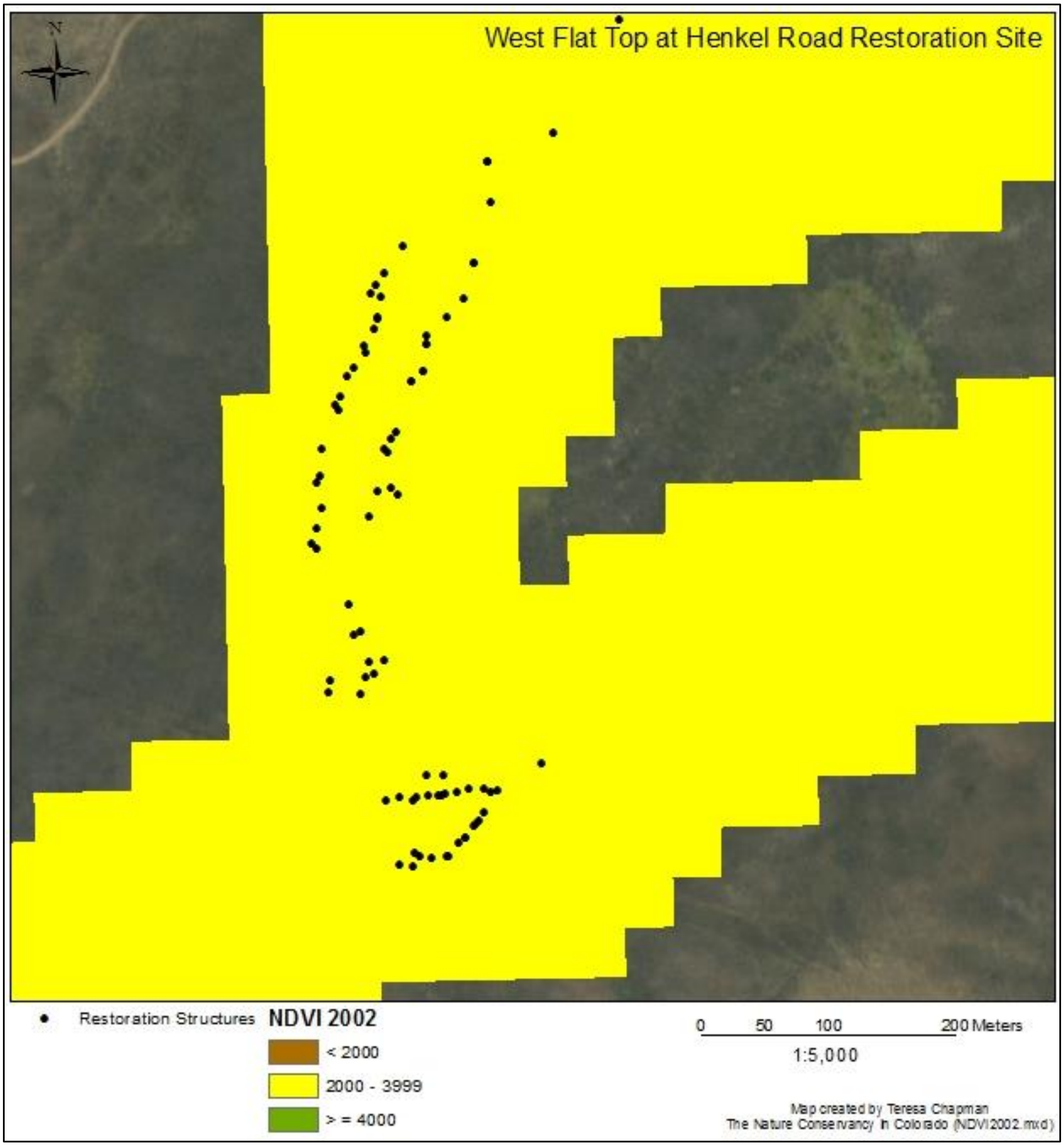
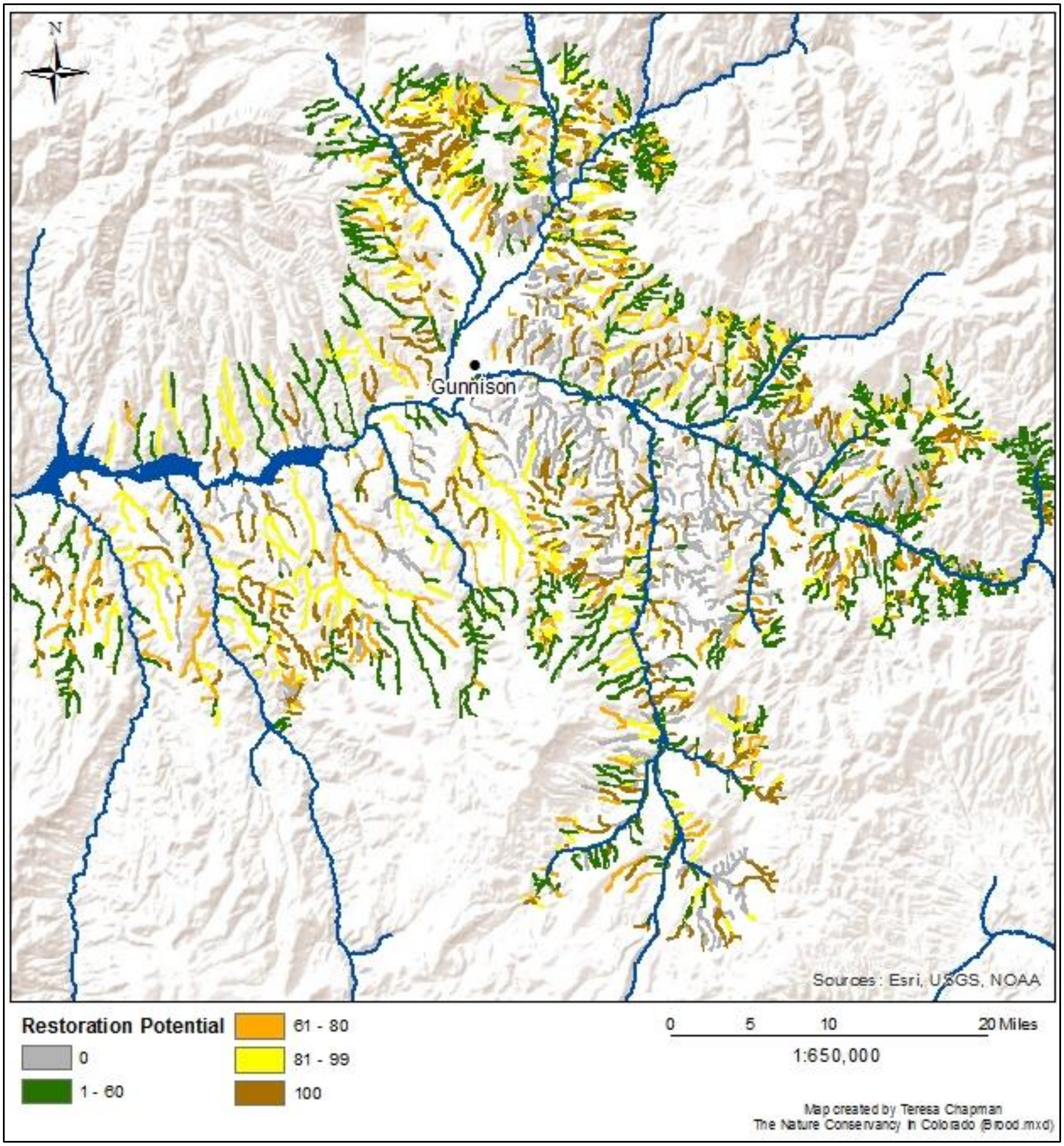


Figure 8. Restoration Potential Index across the Gunnison Basin stream reaches. The West Flat Top at Henkel Road restoration site scored 100 on the Restoration Potential Index since the stream reach did not have riparian area that greened up above NDVI 4000 in year 2002. Of the total stream reaches near leks, 847 streams measured with Restoration Potential Index above 60, meaning they lost 60-100% of very green riparian area during the drought and indicating they could benefit from current restoration treatments. These streams total 421 miles and approximately 1732 acres of current riparian vegetation.



Criteria 4: Riparian Condition Index (comparing the extent of the floodplain and the current extent of riparian vegetation).

a. Create a topographic floodplain for every stream reach by generating the cost of travelling from the stream centerline across a slope layer from a 10-m digital elevation model. This process creates a floodplain based on the slopes and natural topography and estimates the potential riparian area if the floodplain were connected to the stream (Figure 9).
b. Calculate the extent of current riparian vegetation within the floodplain by classifying 1 m aerial imagery with a supervised maximum likelihood classification algorithm in ArcGIS. We 2011 NAIP imagery with four bands, including near infrared. We estimated the accuracy of the classification with 700 randomly generated points. The total accuracy of the riparian class was 86% (Figure 10).
c. Generate the Riparian Condition Index by dividing current riparian extent by the total floodplain area (Figure 11).

$$\text{Riparian Condition Index} = \frac{\text{Current Riparian vegetation (m2)}}{\text{Total Floodplain (m2)}} * 100$$

We used a threshold between 1and 25 on the Riparian Condition Index to prioritize wetlands where we could significantly increase riparian acreage. Since we do not know how much of the modelled floodplain a well-functioning stream occupies, we placed the threshold for riparian vegetation extent to below 25% of the floodplain. We aim to determine an approximate value for restored streams from areas in our restored areas once they have responded fully to the treatments.

Figure 9. Topography based modeled floodplain at West Flat Top at Henkel Road restoration site.

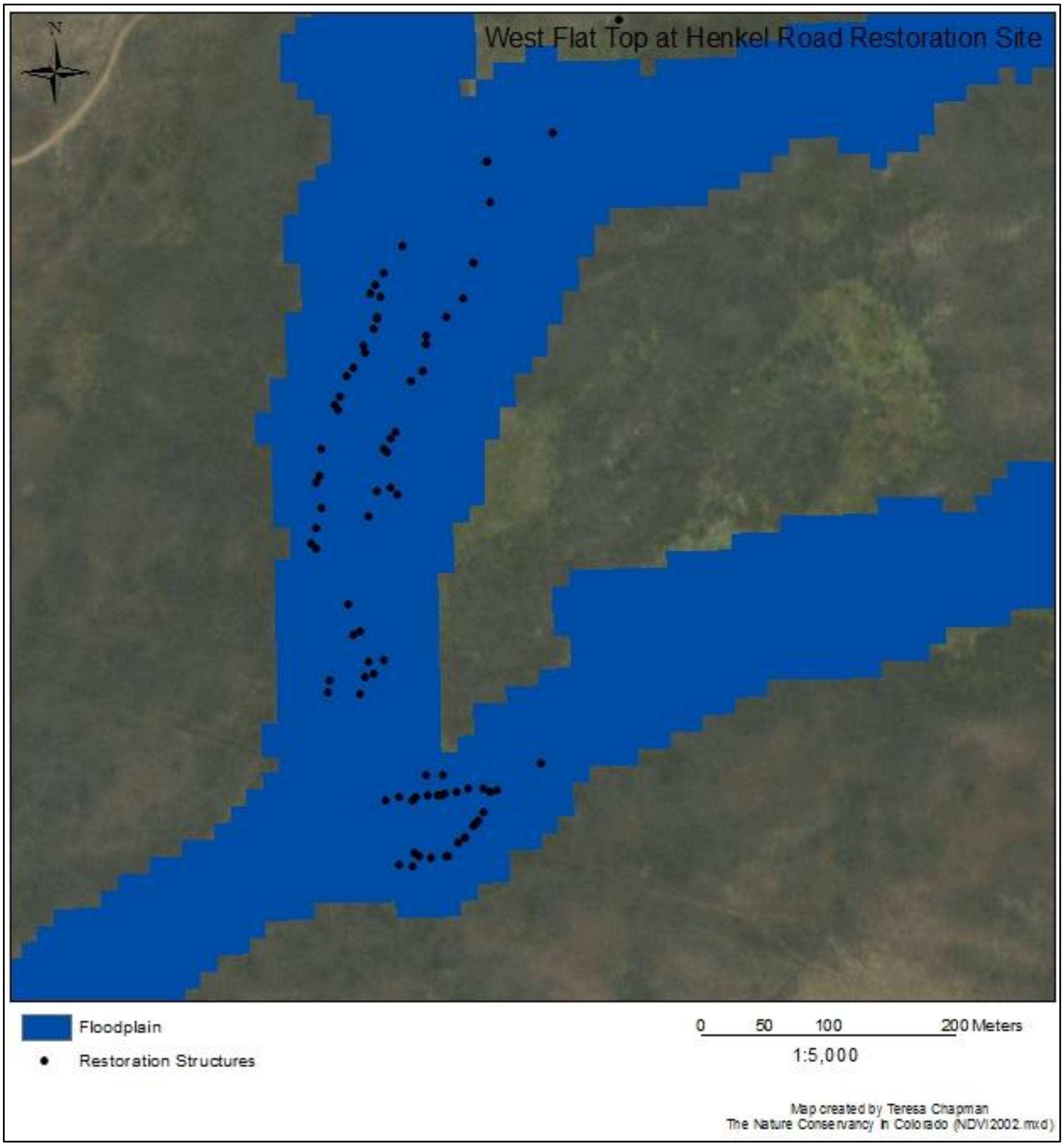


Figure 10. Extent of riparian vegetation in 2011 prior to restoration overlaid with topography based modeled floodplain at West Flat Top at Henkel Road restoration site. The ratio of 2011 riparian vegetation to the area of the floodplain creates the Riparian Condition Index and estimates the potential for expansion of the wetland.

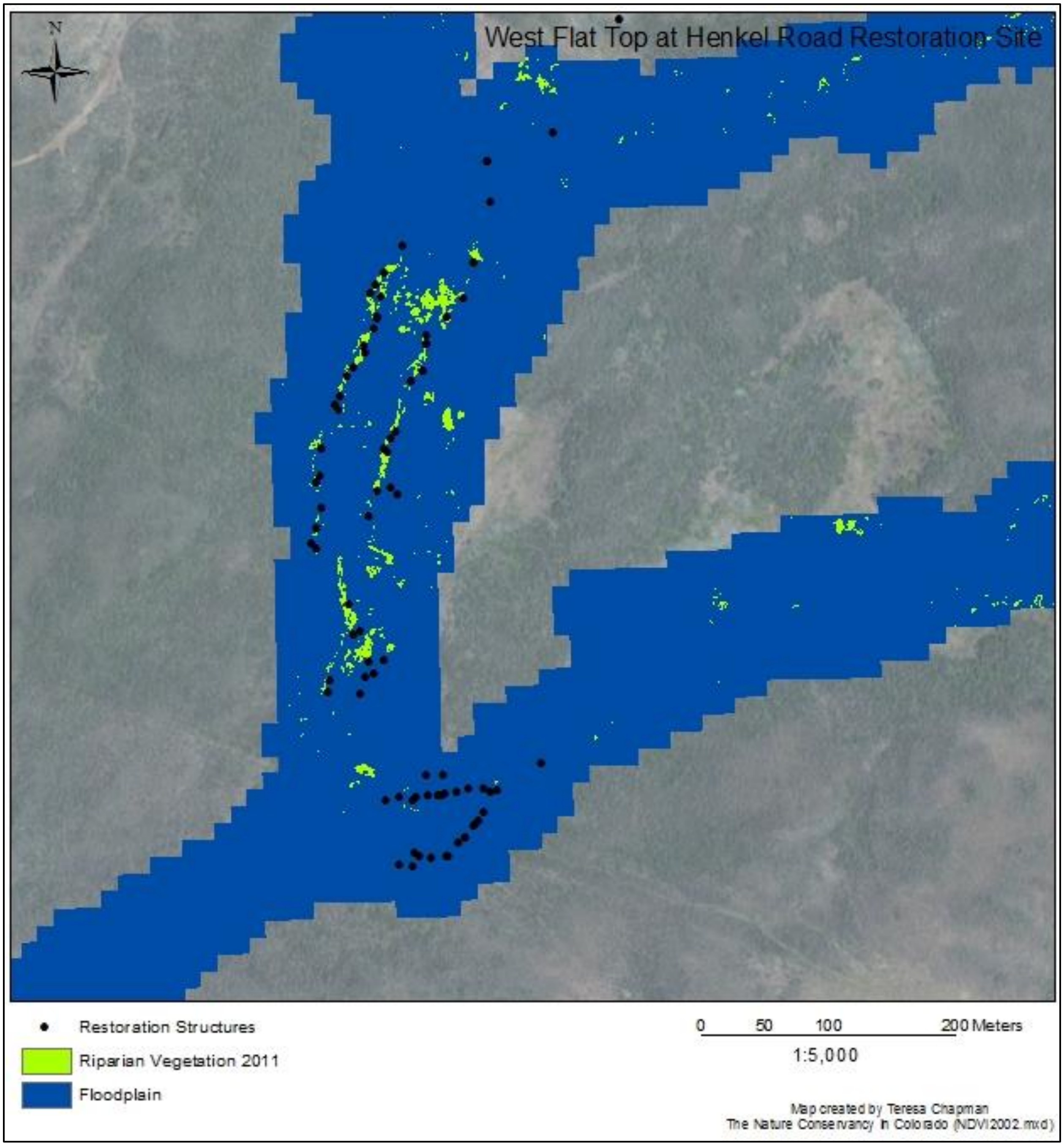


Figure 11. Riparian Condition Index at West Flat Top at Henkel Road restoration site. The site scored a 3 for this index, indicating that riparian vegetation in 2011 only occupied a small fraction of the potential floodplain and there is opportunity to expand the riparian vegetation here.

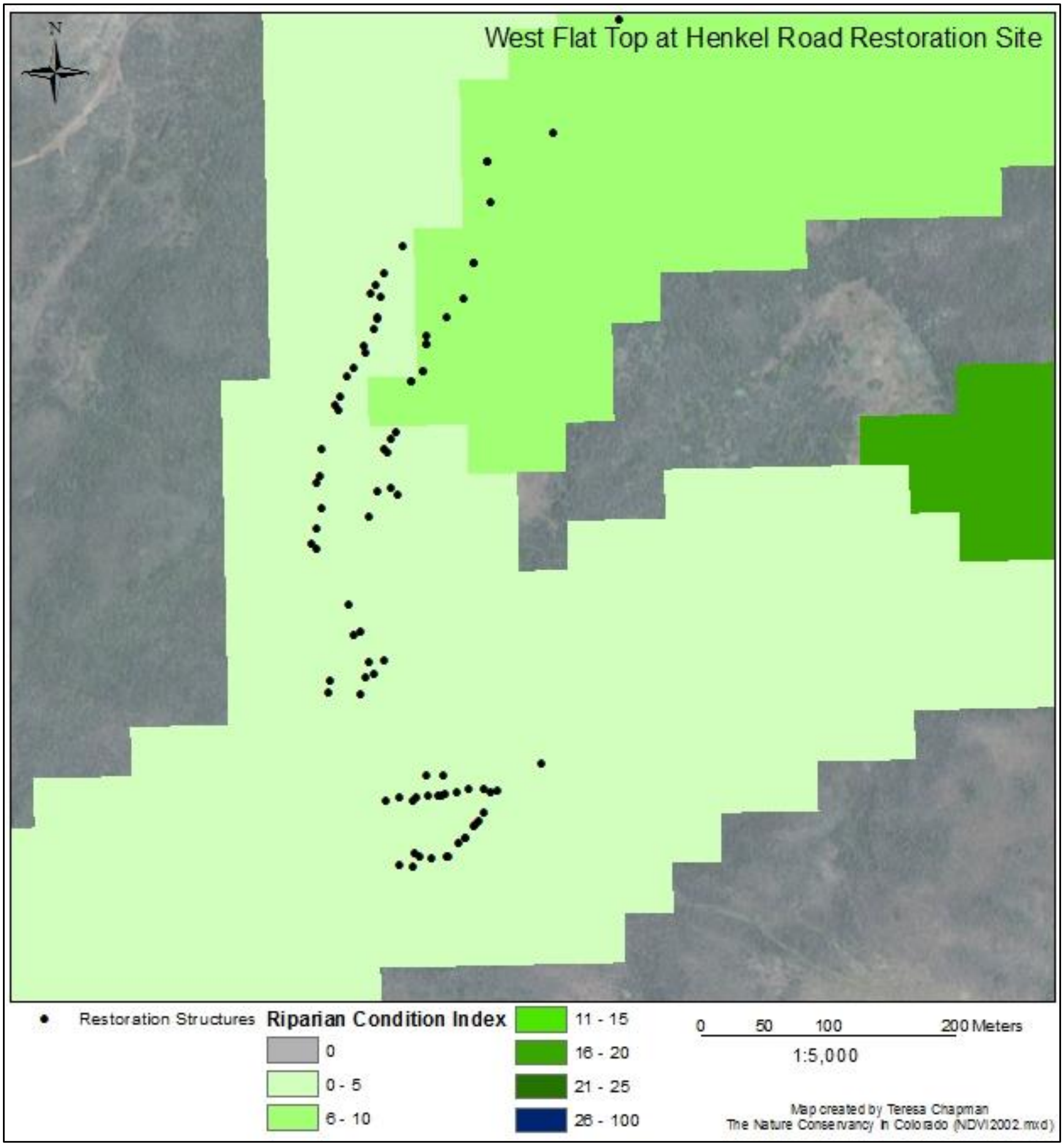
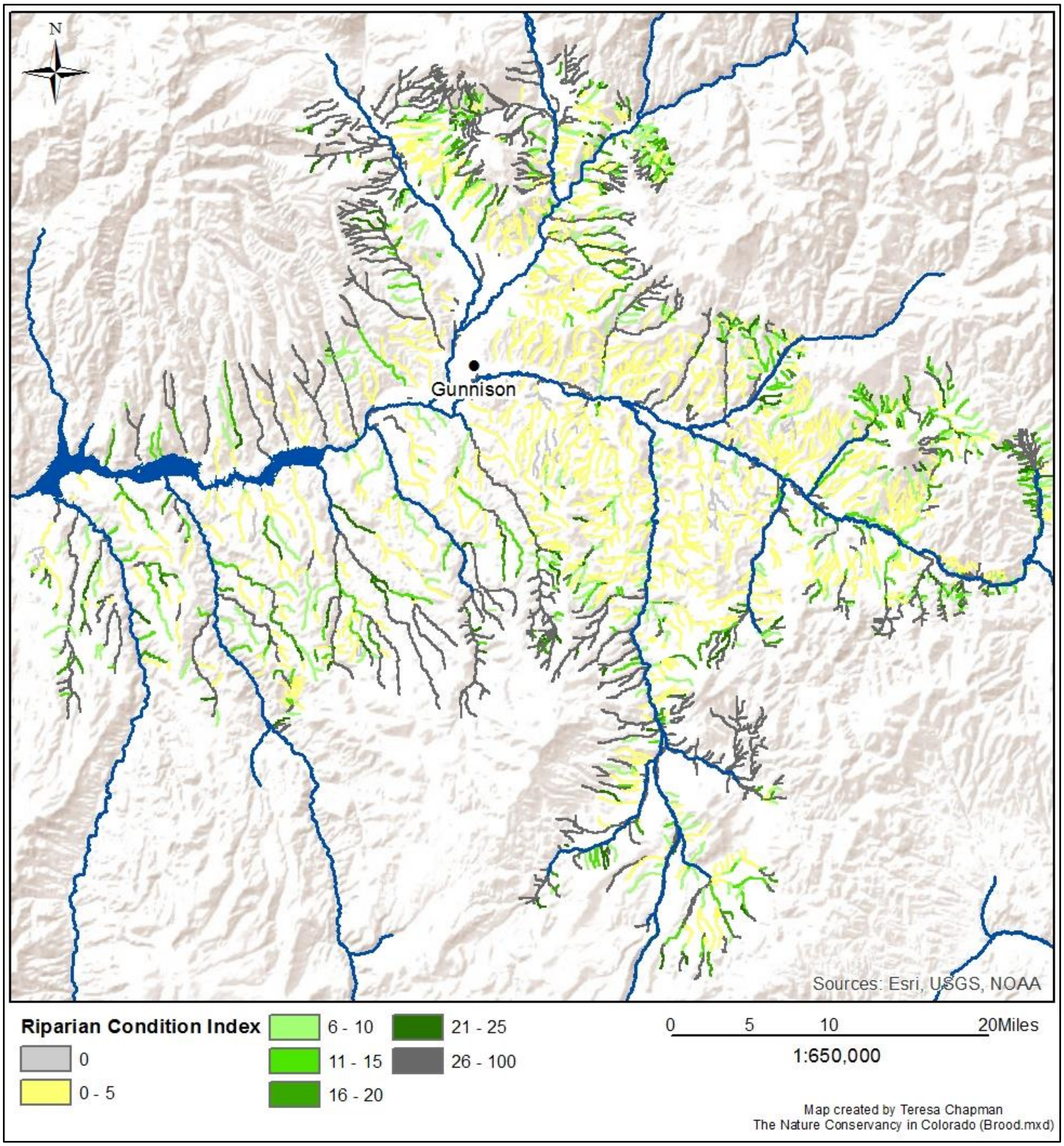


Figure 12. Riparian Condition Index across the Gunnison Basin. Within the streams that scored high for Restoration Potential Index and in close proximity to leks, we estimate that approximately 529 streams show promise to greatly improve the extent of riparian vegetation based on the Riparian Condition Index (scored between 1-25). We used a threshold between 1and 25 on the Riparian Condition Index to prioritize wetlands where we could significantly increase riparian acreage. These streams total 265 stream miles and 750 acres of current riparian vegetation.



Results

The results of these four criteria result in 529 high priority stream reaches within 32 sub-watersheds in the Gunnison Basin. These streams total 272 stream miles and 765 acres of current riparian vegetation. Not all the stream miles will require or be feasible to restoration (Figure 13). Field assessments will determine the number of stream miles within each stream reach that will need restoration. The area of riparian acreage is most likely a more appropriate metric for restoration need. To arrive at this result, we reduced the number of stream reaches at each of the four criteria.

There are 4,410 stream reaches in the Gunnison Basin that contain Gunnison sage-grouse brood rearing habitat.

There are 1,883 stream reaches within 2 miles of Gunnison sage-grouse leks, totaling 927 miles of perennial, intermittent, and ephemeral streams and approximately 5,540 acres of current riparian vegetation.

Of the total stream reaches near leks, 847 streams measured with Restoration Potential Index above 60, meaning they lost 60-100% of very green riparian area during the drought and indicating they could benefit from current restoration treatments. These streams total 421 miles and approximately 1732 acres of current riparian vegetation.

Within the streams that contained brood rearing habitat, were in close proximity to leks, and scored high for Restoration Potential Index, we estimate that approximately 529 streams show promise to greatly improve the extent of riparian vegetation based on the Riparian Condition Index scored between 1-25. Table 1 summarizes the stream priorities and their metrics within the sub-watersheds.

To put these values into perspective, between 2012 and 2015 the team installed 750 new structures across 32 stream reaches totaling 20 miles and treated 61 acres of riparian vegetation (Figure 14). The team did not work across every mile within those reaches. We prioritized areas within those reaches based on restoration need determined during field assessments.

We estimate that this riparian vegetation extent could potentially double with restoration treatments. Within this estimated stream mileage are smaller areas surrounding the existing riparian vegetation where the work is located. Stream miles are a very rough estimate of the work needed, since restoration happens intermittently between degraded areas.

Figure 13. Map of priority stream reaches identified by the GIS analysis within the Gunnison Basin. High Priority stream reaches are defined as: 1) intersecting brood rearing habitat, 2) within two miles of a lek, 3) with a Restoration Potential Index between 60 and 100 (indicating riparian areas that significantly dried during the drought but maintain greenness during wet years), and 4) with a Riparian Condition Index between 1 and 25 (indicating that the current riparian vegetation occupies a small percentage of the floodplain). Combining these metrics results in stream reaches with high potential to improve by our restoration techniques and to increase resilience to the impacts of climate change, including drought and monsoons.

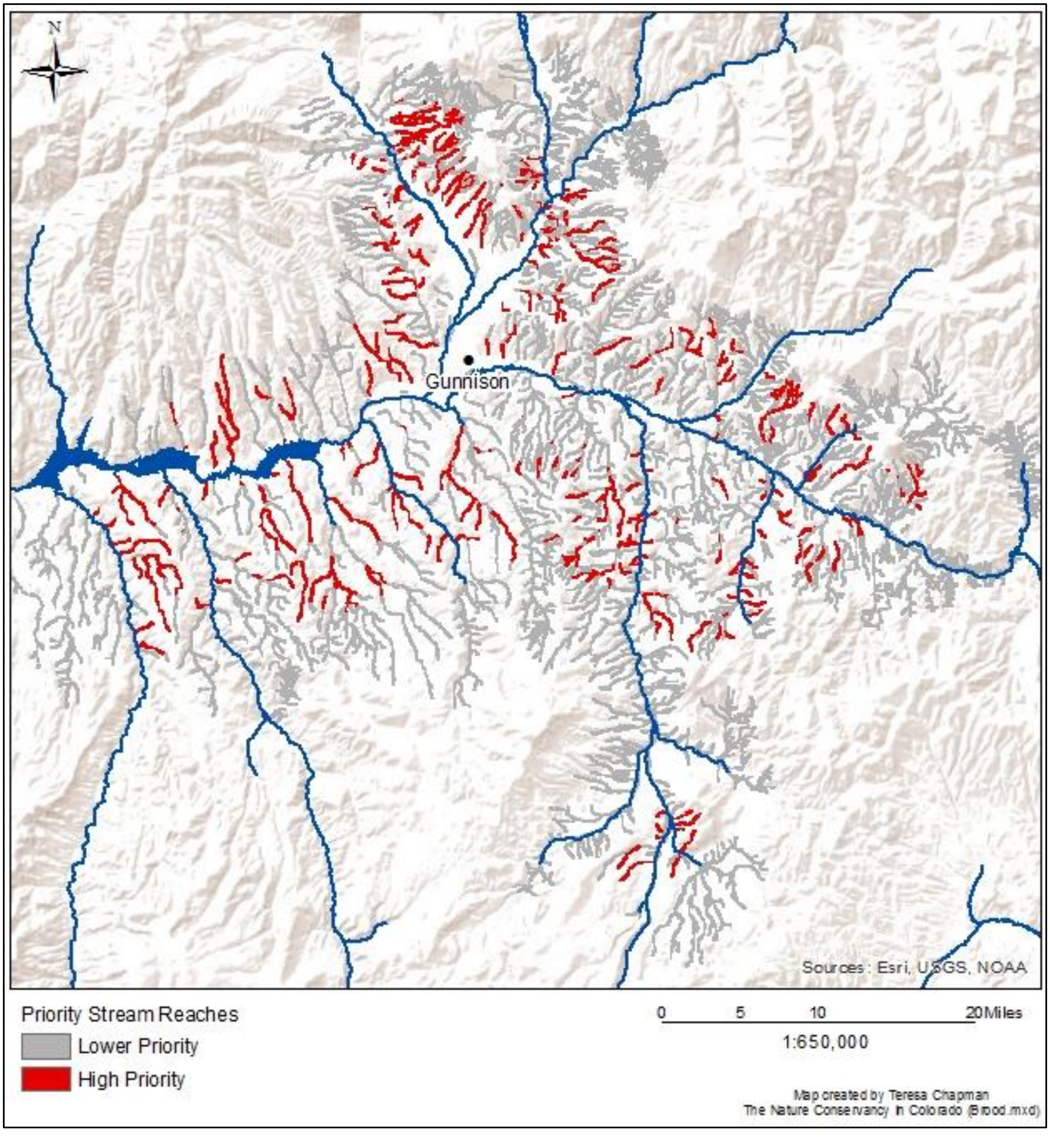


Figure 14. Map of priority stream reaches identified by the GIS analysis within the Gunnison Basin, Priority catchments where restoration structures were constructed and maintained between 2012 and 2016, and potential sites under current review for upcoming seasons.

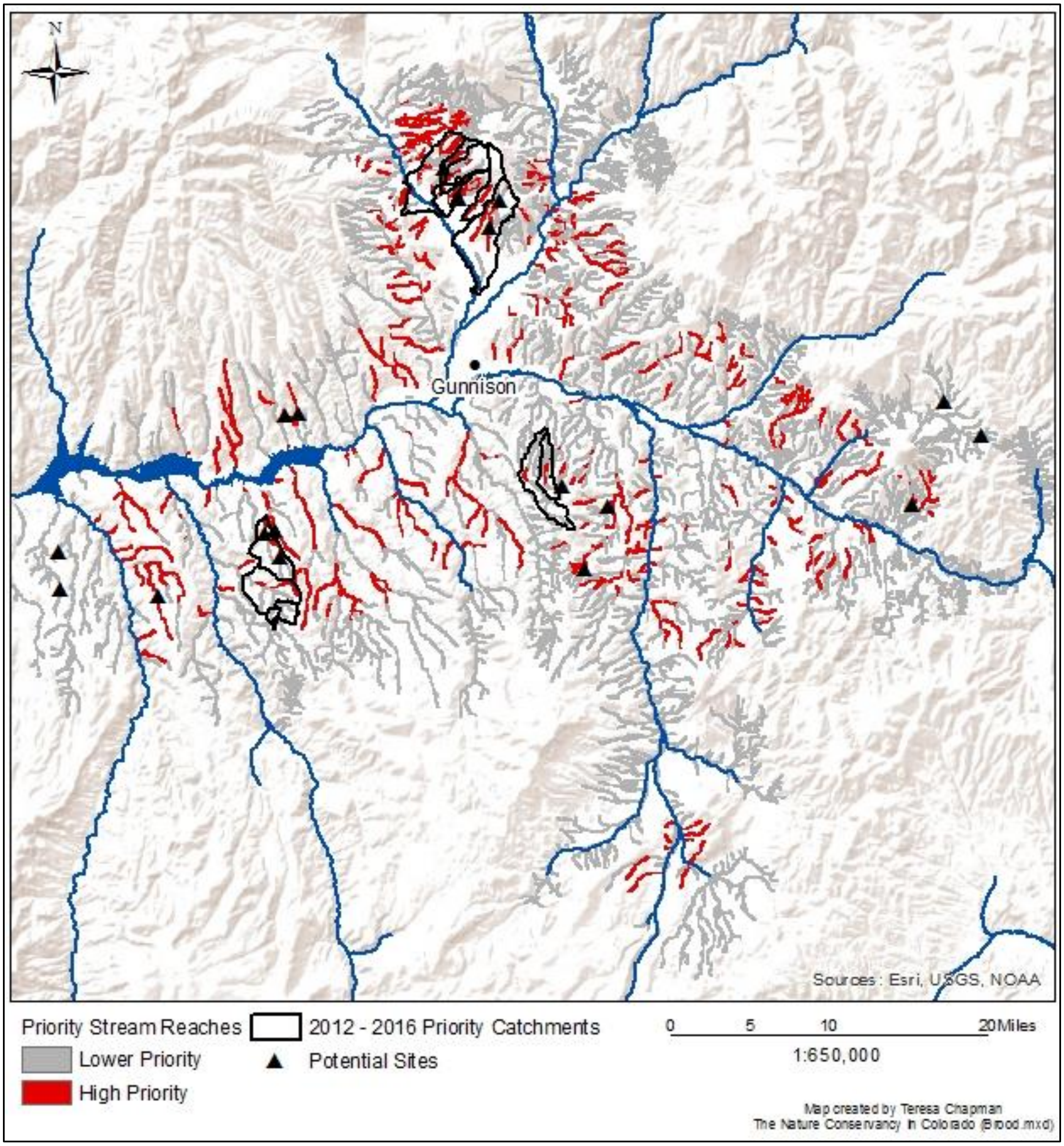


Table 1. Summary of Priority Stream Reaches in the Gunnison Basin by Sub-watershed. An estimated 765 acres of riparian habitat within 32 sub-watersheds would benefit from the restoration techniques. Shaded sub-watersheds contain priority sites treated during 2012-2016.

	Sub-watershed Name	Number of Priority Stream Reaches	Average Restoration Potential Index	Riparian Condition Index	Average Number of Leks within 2 Miles	Riparian Acres	Stream Miles
1	140200030506	5	85	17	1.0	10.7	3.4
2	Alder Creek	8	92	9	1.9	3.9	3.1
3	Alkali Creek	21	93	10	1.0	16.0	8.0
4	Antelope Creek	24	92	12	1.5	50.2	9.4
5	Archuleta Creek	8	87	14	1.0	11.0	3.7
6	Barret Creek-Tomichi Creek	33	87	14	1.1	50.2	19.0
7	Cabin Creek	1	98	0	1.0	1.3	0.9
8	Chance Gulch-Tomichi Creek	11	93	14	2.0	8.3	6.0
9	Goose Creek-Cebolla Creek	1	75	0	3.0	1.6	0.6
10	Headwaters Razor Creek	2	100	0	1.0	1.4	3.3
11	Headwaters Willow Creek	8	94	10	1.0	13.5	5.3
12	Hot Springs Creek	17	89	13	2.2	21.3	11.0
13	Long Gulch	30	95	10	2.5	30.9	13.1
14	Long Gulch-South Beaver Creek	11	88	13	1.8	21.3	7.3
15	Lower East River	11	90	13	1.3	7.5	4.6
16	Lower Ohio Creek	79	93	10	6.5	100.7	37.2
17	Lower Quartz Creek	6	91	15	1.5	8.3	2.4
18	Lower Taylor River	5	85	16	1.0	2.6	1.8
19	Middle Ohio Creek	29	99	2	4.4	24.8	17.1
20	Mill Creek	1	95	0	1.0	0.5	0.4
21	Outlet Cebolla Creek	7	83	16	1.0	13.1	3.9
22	Outlet Cochetopa Creek	37	92	12	1.6	32.0	14.2
23	Outlet Lake Fork	18	89	13	3.1	44.0	6.6
24	Outlet Razor Creek	19	90	13	1.4	46.8	7.7
25	Pine Creek Mesa-Blue Mesa Reservoir	9	94	7	1.3	16.9	3.4
26	Sewell Gulch-Tomichi Creek	11	95	10	1.6	7.6	5.6
27	Sheep Gulch-Gunnison River	52	87	14	2.3	48.5	28.4
28	Steers Gulch-Gunnison River	6	91	13	1.7	15.9	4.4
29	Stubbs Gulch	11	95	8	1.0	25.0	6.2
30	Sugar Creek-Willow Creek	10	86	11	1.3	46.7	6.0
31	Willow Creek-Blue Mesa Reservoir	23	96	5	2.1	61.4	13.0
32	Wood Gulch-Tomichi Creek	27	93	10	1.8	19.8	13.9

Once the GIS analyses were completed, the team filtered the resulting stream reaches by feasibility, land-ownership, and local knowledge, conducted rapid field assessments to verify restoration need, and revisited the sites to design specific restoration treatments. We consider the following criteria for feasibility and restoration need:

1. Landownership and willingness of landowners,
2. Status of NEPA process,
3. Accessibility (first cut),
4. Proximity to other sites to increase efficiencies,
5. Opportunities for scaling up more efficiently, and
6. Geographic representation across the basin.

We also conduct rapid field assessments to determine specific restoration needs and treatments. This assessment includes completion of a field form developed by CNHP which aims to evaluate:

1. Restoration potential problems, e.g., head cuts, compaction, roads, etc.,
2. Level of work needed,
3. Accessibility,
4. Potential for significantly increasing stream miles,
5. Importance for Gunnison sage-grouse,
6. Opportunity for increasing efficiency,
7. Adjacent sagebrush habitat condition, and
8. Overall rank and refine priorities

We also consider other factors to consider for determining where to work:

1. Upstream supply of sediment
2. Ease of access for delivery of materials
3. Complete repair and maintenance work started when needed Priority sites identified for pilot
4. No regrets sites
5. Potential for significantly expanding miles or acres
6. High potential for success
7. Opportunity to increase efficiency in scaling up
8. Opportunity to demonstrate a new tool, e.g., plug and pond
9. Importance for Gunnison sage-grouse
10. Willing landowner/land manager

Updated October 26, 2016. With input and review by Gay Austin, Andrew Breibart, Jonathan Coop, Betsy Neely, Shawn Conner, Chris Pague. Renee Rondeau, Nathan Seward, Mike Pelletier, Imtiaz Rangwala, and Meg White.

APPENDIX E. FINAL TOTAL PROJECT BUDGET.

	CPW Purchase Order			Leveraged Funds			Total Project Budget		
	Budget	Expenses	Balance	Budget	Expenses	Balance	Budget	Expenses	Balance
Personnel - Salary	$0.00	$0.00	$0.00	$19,884.29	$15,176.48	$4,707.81	$19,884.29	$15,176.48	$4,707.81
Personnel - Fringe	$0.00	$0.00	$0.00	$7,953.71	$6,222.36	$1,731.36	$7,953.71	$6,222.36	$1,731.36
Travel	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Supplies	$0.00	$0.00	$0.00	$20,000.00	$0.00	$20,000.00	$20,000.00	$0.00	$20,000.00
Contracts	$91,743.00	$91,742.20	$0.80	$38,912.00	$65,351.16	-$26,439.16	$130,655.00	$157,093.36	-$26,438.36
Construction	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Communications	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Occupancy	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Expenses	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
TOTAL DIRECT EXPENSES	*$91,743.00*	*$91,742.20*	*$0.80*	*$86,750.00*	*$86,750.00*	*$0.00*	*$178,493.00*	*$178,492.20*	*$0.80*
Indirect Expenses (9% for CPW/22.5% for TNC)	$8,256.00	$8,256.80	-$0.80	$18,912.00	$19,518.75	-$606.75	$27,168.00	$27,775.55	-$607.55
TOTAL EXPENSES	*$99,999.00*	*$99,999.00*	*$0.00*	*$105,662.00*	*$106,268.75*	*-$606.75*	*$205,661.00*	*$206,267.75*	*-$606.75*

Itemization of CPW Expenses

	CPW Purchase Order					
	Budget	Invoice #1	Invoice #2	Invoice #3	Invoice #4	Balance
Personnel - Salary	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Personnel - Fringe	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Travel	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Supplies	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Contracts	$91,743.00	$18,461.88	$29,920.33	$39,750.53	$3,609.46	$0.80
Construction	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Communications	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Occupancy	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Expenses	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
TOTAL DIRECT EXPENSES	*$91,743.00*	*$18,461.88*	*$29,920.33*	*$39,750.53*	*$3,609.46*	*$0.80*
Indirect Expenses (9% for CPW)	$8,256.00	$1,661.57	$2,692.83	$3,577.55	$324.85	$324.05
TOTAL EXPENSES	*$99,999.00*	*$20,123.45*	*$32,613.16*	*$43,328.08*	*$3,934.31*	*$0.00*