INTRODUCTION

I am a current candidate for a dual Master's degree in Public Administration and Environmental Science (MPA/MSES) at Indiana University, and am seeking funding in the amount of $1,000 to conduct monitoring and review of restoration efforts in Cebolla Canyon, near Grants, New Mexico. This research will be part of a broader effort to assess successful wetland restoration techniques used by Bill Zeedyk and his partners, and to consolidate the monitoring findings and establish the erosion control and wetland establishment methods as Best Management Practices to be used in similar endeavors.

My research will consist of conducting geomorphology and vegetation monitoring of several reaches that have been the priority of targeted restoration projects conducted by the Rio Puerco Alliance, working in partnership with private contractors and governmental partners.

HISTORY

Cebolla Canyon is primarily within and protected by a congressionally designated Wilderness Area (Cebolla Wilderness) within the congressionally designated El Malpais National Conservation Area (EMNCA) near Grants, New Mexico. The project area has multiple designations including Wilderness Area, and National Conservation area. However, all of the project area is Bureau of Land Management Public Lands. Within the project area, Cebolla Spring and Cebollita Spring emerge from the ground and provide habitat and/or water to a variety of wildlife species including Bald Eagle (Haliaeetus *leucocephalus*), Mule Deer (Odocoileus *hemionus*), Elk (*Cervus canadensis)*, Mountain lion (Felis *concolor*), Bobcat (Lynx *rufus*), Abert's Squirrel (*Sciurus aberti*), two species of Wild Turkey (*Meleagris gallopavo intermedia, Meleagris gallopavo Merriami)* and reptiles such as the side-blotched lizard (*Uta stansburiana*).

The next nearest constant water source for wildlife is the Cebollita Spring, approximately 10 miles away. In addition, several ephemeral playas hold seasonal water but the nearest playa is about seven miles away. The valley was homesteaded in the early 1900s, and today, only ruins of the stone houses and hydrological modifications established by early settlers remain. The historic wetland of Cebolla Creek was drained and earthen dams constructed to retain water for agricultural use. These changes to the area's hydrology coupled with cattle grazing reduced the historic wetland to a fraction of its original size and inadvertently created a massive down-cut, incising the stream banks in some areas as deep as 50 feet.

Previously, water from the springs was impounded and used for irrigation almost exclusively. Former wetlands were drained and dams, irrigation ditches, and impoundments were constructed along Cebolla Creek to support agriculture. The irrigation systems and impoundments are no longer functional, but Cebolla Creek was displaced from its natural drainage, headcutting was occurring in the valley bottom, and the wetlands had not recovered. In one area, an abandoned diversion channel led from Cebolla Spring to a storage reservoir. Projects have been conducted to block that channel to re-connect groundwater flow from the Spring to the former wetland. In other areas, grade control structures have been built to raise the bed of the Spring where it was deliberately ditched and drained.

Due to the draining of the valley, the plant community composition had deteriorated to a monoculture of blue grama grass (*Bouteloua gracilis*) with rabbit brush (*Chrysothamnus nauseosus)* increasing in the valley bottom. This coupled with increasing encroachment of Piñon (*Pinus edulis*) and Juniper (*Juniperus scopulorum*) from the uplands had converted the vegetative composition of the valley to that of a warm season upland plant community instead of a wetland. Some re-vegetation with wetland species was implemented to jump start recovery in the areas treated by RPA and its partners.

Since 1994, the BLM has worked to reduce livestock use of the Cebolla Spring, promoting standing water, vegetation growth, and shade. In addition, since the fall of 2000 the Albuquerque Wildlife Federation has been organizing volunteer groups to work to construct restoration best management practice structures to spread water over the valley. These structures are re-wetting the meadow, widening the stream banks, and encouraging aggradation in the channel bottom to return this portion of the wilderness area to its natural condition of a perennial stream and a properly functioning wetland. The result has been two-fold: the creek gradient is flattened and water infiltration into the banks has increased, promoting an increase in emergent wetland plant species, which add to bank stability. Monitoring two years after project implementation has shown phenomenal results: the bed of the creek has gained 6 feet of sediment, the former channel through the wetland has disappeared, and water moves as sheet flow across the entire wetland surface. This raising of the bed has also raised the water table and encouraged the growth of wetland species. The saturated zone associated with the spring has expanded downstream along the first terrace adjacent to the creek. The saturated zone currently is over 40 acres. The wetlands area associated with the spring has the potential to double in size to over 80 acres. A long-term landscape-based approach to improving the ecological health of Cebolla Canyon and its associated wetlands is needed. I hope to incorporate this long-term planning into the remainder of my graduate studies, with further compilation of monitoring outcomes taking place in the summer of 2018.

TECHNIQUES

My research will focus on conducting monitoring and reporting of the outcome of restoration completed in Reaches 0 through 5. Results of initial rounds of monitoring in 2012 showed positive changes in response to the restoration treatments at Cebolla Creek. Reach 0 saw many changes in geomorphology and vegetation in response to the restoration. This restoration was performed during an extremely rainy season, and the start of the project was held back by both compliance issues and rain. **With another rainy season in summer 2012, the monitoring I will conduct 5 years later should show extraordinary results in wetland creation, wet-meadow expansion, and geomorphological changes.** Below is a table summarizing the structures whose effects we will be monitoring. Because every watershed is unique, it is difficult to assess these structures against controls (untreated watersheds); rather, we will be assessing the results of treatments as a time series study.

In the past and going forward, we will focus on the aggradation of sediment through the wetland. Over the last 5 years the original gully through the Cebolla Spring has filled in, and it has gained roughly 6 feet of additional sediment as the huge 10 square mile watershed just pours into the wetland, spreads out, loses stream power, and drops its sand. Surveying was done with a sub-meter GPS to take a 7000-foot longitudinal profile (taking many cross sections). Over the three-year project, a several foot gain in elevation was observed.

Treatment Type	Reaches this treatment can be found	Benefits	Methodology
Check dams: - one rock dam (low grade control structure built with a single layer of rock on the bed of the channel) - filter dam (porous rock used to raise and stabilize grade of incised stream) - media luna (sheet flow spreader made of rock to disperse channelized flow) - picket structure (picket and rock filter dam)	Reach 0 (10 structures); Reach 2 (8 structures); Reach 3 (16 structures); Reach 5 (3 structures); Reach 6A (25 structures); Reach 7B (6 structures), Reach 8 (18 structures); Reach 9 (38 structures);	Raise grade and trap sediment	
Road Drainage – divert captured stream flow from roadway to valley bottom	Reach 0	Restoration of wet meadow	
New Channel Construction (berm removal)	Reach 0	Reconnect active channel to historic channel; aggrade natural channel in valley bottom	
Flow control structures: - plug (move material from berm breaching to plug abandoned irrigation ditch) - plug and pond (plug existing downcut, redirect stream flow via shallow pond back	Reach 0 (3 structures); Reach 1 (1 structure); Reach 2 (5 structures);	Diversion of channels, wetland expansion	

into historic remnant channels on meadow surface) - Berm repair - Conveyance ditch removal (break ditch bank and fill with dredge material) - Burrito dam (sandbags) - Flow splitter (diverts flow greater than bankfull discharge)			
Drop structures - Cross vane (grade control structure composed of boulders) - Rock rundown (grade control to harden channel bottom) - Zuni bowl, small rock chute (headcut control composed of rock lined stepfalls and plunge pools) - Headcut control structure (rock lined step falls and plunge pools)	Reach 0 (1 structure); Reach 3 (3 structures); Reach 5 (1 structure); Reach 6A (3 structures); Reach 6B (7 structures); Reach 8 (1 structure)	Stabilizes actively eroding headcuts and prevents headcut migration	
Temporary Exclosure Fence (mini-exclosure)	Reach 0 (2); Reach 2 (3); Reach 4 (1); Reach 5 (1);	Catch/protect sediment, aggrade channel	
Upland drainage tx (highspot removal)	Reach 2 (1); Reach 5 (2)	Drain abandoned roads, excavate remnant soil	
Current deflector (post vane) – deflector structure consisting of an upstream pointing barb	Reach 7A (9)	Induced meandering; widen channel; initiate floodplain development	
Current deflector (baffle) – triangular deflector structure used to create lateral erosion of a streambank	Reach 7A (2)	Induced meandering; widen channel; initiate floodplain development	
Rock harvesting		Harvesting of rock from roadside that has already been disturbed from road construction and maintenance activities. Possible excavation of embedded materials	

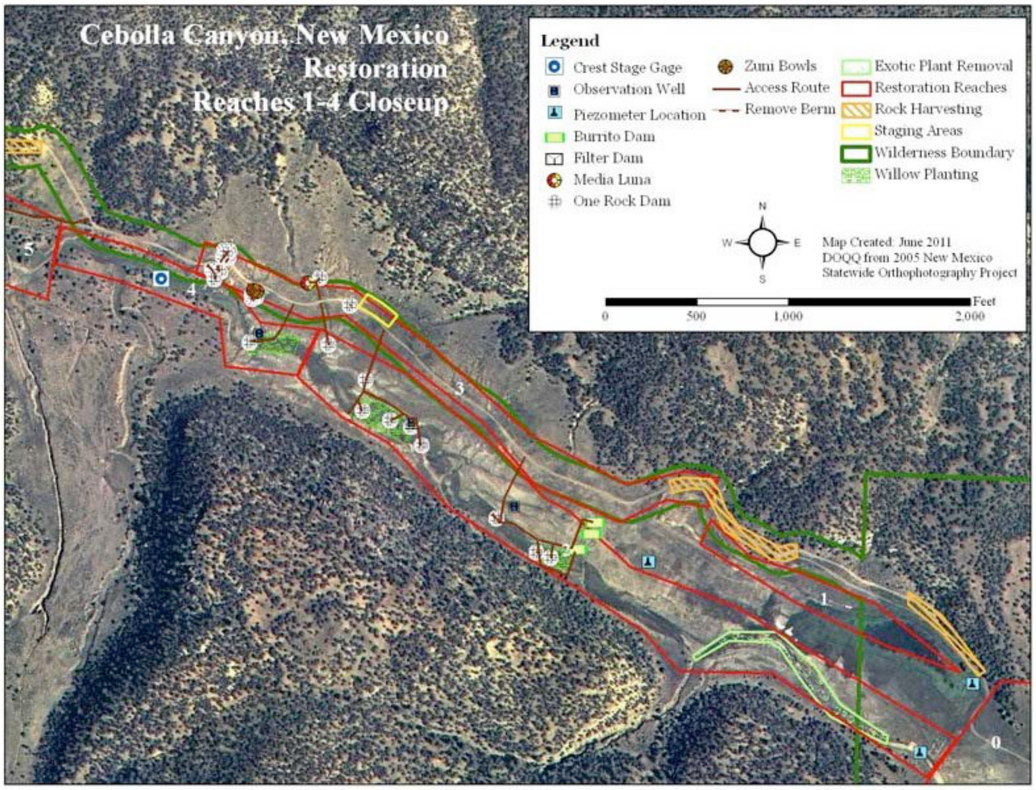
Vegetation

With yearly site visits, we have seen expansion of the wetland, expansion of wetland species downstream, aggradation of 4-6 feet on top of previous aggradation, and die-off of rabbitbrush (due to treatment and wetter conditions) and vegetation changes from grama grass to wet meadow. Downstream in Reach 2, There was a large decrease in Western Wheatgrass and an increase in Foxtail barley, results which may be related. Foxtail barley invades on saturated soils, and soon after, Western Wheatgrass dies out from too much water. We will be looking for vegetation changed aligned with the state-transition model compiled by Keystone Restoration Ecology:

1. Community becomes wetter through brief flood events from main channel or tributary channels. Extra water during growing season grows more vigorous vegetation and plant community changes to wet meadow (Western Wheatgrass) community
2. Area becomes inundated for a significant time, either by pooling in the channel of Cebolla Creek, or by expansion of Cebolla Spring wetland. Vegetation responds by becoming more hydric until it becomes a delineated wetland community with Foxtail Barley, Western Wheatgrass, and Polygonum smartweed.
3. Successional stage from early to late successional species. In the absence of disturbance and continual inundation, this stage proceeds.

4. This transition occurs when elk or cattle wallow in the spikerush and create large open pools (6 feet across). The open space allows for cattails to colonize the thick spikerush vegetation.
5. The spikerush (Elpa) can quickly change to bulrush if the seeds of bulrush get established, otherwise, the change proceeds more slowly through Juncus torreyii.
6. If the spikerush areas dry out seasonally, they can become colonized by Juncus balticus and Carex praegracilis. These areas are saturated, but have no surface moisture. This community is found along the edges of the Cebolla Spring area, between the spring and the channel, and not found (yet) to the west where the wetland is advancing

My goal is to document the ecological gains made through utilizing these restoration techniques by thoroughly monitoring the geomorphology and vegetation changes, establishing those techniques as cost-effective and low-tech strategies for wetland restoration in similar climates. **Seven years after initial treatment, we will have a unique opportunity to assess the success of a wetlands restoration project after considerable time has passed, allowing us to test the predictions of Keystone Restoration Ecology of the vegetation changes in the state-transition model, to monitor further changes in the already demonstrably improved geomorphology, and to compile suggestions for further work**. Ultimately, we hope to compile the techniques utilized over the course of this restoration for inclusion in the Best Management Practices recommended by the Natural Resources Conservation Service (NRCS). It will demonstrate and monitor innovative techniques to return land altered for agricultural use to its natural condition. This could provide the basis for other projects using similar techniques to return many acres of land hydrological modified for agricultural use to their original condition in New Mexico, which would have enormous benefits to the watersheds. These projects could provide habitat for diverse plant and animal species which are currently finding fewer hospitable locations; it would increase the amount of recharge into aquifers; it would stop erosion and improve water quality in area streams. Ultimately, these techniques would be sustainable, because they would return the land to its natural condition and would require no further modifications.


Cebolla Canyon, New Mexico
Restoration
Reaches 1-4 Closeup
Legend
Crest Stage Gage
Observation Well
Piezometer Location
Burrito Dam
Filter Dam
Media Luna
One Rock Dam
Zuni Bowls
Access Route
Remove Berm
Exotic Plant Removal
Restoration Reaches
Rock Harvesting
Staging Areas
Wilderness Boundary
Willow Planting
Map Created: June 2011
DOQQ from 2005 New Mexico
Statewide Orthophotography Project
Feet
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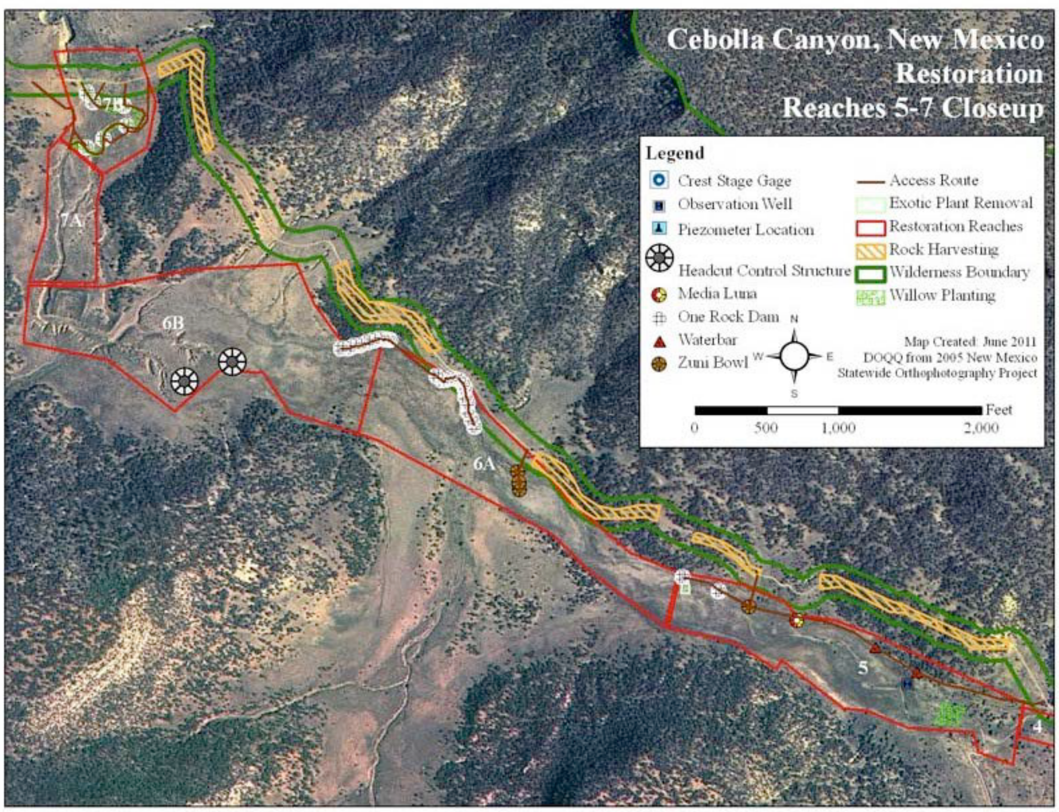
Cebolla Canyon, New Mexico
Restoration
Reaches 5-7 Closeup
Legend
Crest Stage Gage
Observation Well
Piezometer Location
Headcut Control Structure
Media Luna
One Rock Dam
Waterbar
Zuni Bowl
Access Route
Exotic Plant Removal
Restoration Reaches
Rock Harvesting
Wilderness Boundary
Willow Planting
Map Created: June 2011
DOQQ from 2005 New Mexico
Statewide Orthophotography Project
Feet
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