

A Constructed Wet Meadow Model for Forested Lands in the Southwest

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Abstract—Improving primary roads in the Zuni Mountains of New Mexico must take into consideration the wet meadows and upland areas. This study looks at spring flow rates, erosion, channels and changes in plant cover and composition. The goal is to help planners design environmentally sensitive roadways for wet meadow areas.

Wet meadows occur naturally in the high elevations of the Zuni Mountains of New Mexico. These areas typically have higher diversities of plant and animal species than adjoining upland areas due to the availability of permanent or semi-permanent water sources. The low-lying nature of these areas has typically made them more suited for transportation routes and easier crossings than the immediate surroundings. Road and railway beds built in these areas often constrict and cut off the natural flow of water through these areas. Constriction and blockage of natural drainage ways can lead to incised channels and lowered water table levels. The vegetation in these areas typically changes from mesic to xeric in response to the decreased water availability.

The roads staff on Cibola National Forest in New Mexico are working to improve primary roads in the forest that have deteriorated and do not provide safe, year round access. In addition, they are obliterating abandoned roads and railroad grades originally built to remove timber from the forest. The design and construction practices used for new roads considers them as part of the ecosystem. In areas where the roads intersect drainages, structures are installed to permit water to pass beneath the road surface unobstructed. Structures used include multiple raised culverts spread across meadow crossings and French drains. Both types of structures limit the concentration of surface flows. Eroded channels and dewatered meadows as a result of improper road designs and construction practices can be observed along unimproved forest roads in the Zuni Mountains. The damage created by these inappropriate designs and practices can often be corrected and the areas rehabilitated.

Agua Fria meadow in the Zuni Mountains, 32-km southwest of Grants, New Mexico is a forest meadow that showed evidence of having been a wet meadow. Observations by

forest personnel designing improvements for Forest Road 49 through the meadow, suggested that the area could have been dewatered because of the location of old transportation routes and drainage structures. A plan was developed and implemented to rewet the meadow.

Before the road and meadow projects, Agua Fria was a broad meadow with a relatively straight, 2-3 m deep, entrenched channel running down one side, that quickly funneled runoff through the area from the upper watershed. Several abandoned railroad beds and Forest Road 49 crossed the meadow, perpendicular to the direction of water flow. The vegetation cover across the meadow was a mixture of xeric grasses, shrubs and forbs with a few large Ponderosa Pine and Juniper trees scattered throughout the area.

During the construction phase, the entrenched channel was back-filled in sections to prevent water from flowing in it. Beginning near the top of the meadow, a new highly sinuous channel, .6 m deep, was constructed down the center of the meadow. The channel was built to create a step-pool sequence type flow pattern. Straight channel sections form the steps and curved bank sections, reinforced with tree stumps serve as the pools. The beginning and end of each channel section is delimited by a rock weir structure that concentrates water flowing in the channel. Concentration of the flow in the channel keeps soils and other materials suspended in the runoff from settling to the bottom. The roadway across the meadow was built on top of an earthen berm elevated almost 2 meters at the high point. Sixteen culverts were installed through the berm, spaced across the active runoff section of the meadow to permit water to flow underneath the roadway with minimal obstruction. At the down stream end of the meadow, the new channel was merged with the old channel. Meadow areas disturbed during construction were tilled and planted with a mixture of native grass seed to encourage the quick establishment of vegetative cover to prevent soil erosion. The construction phase of the project was terminated in the fall of 1996.

The channel and roadway projects have been monitored since completion by regular visits to the site. Runoff has only been observed flowing in the channel during the spring while snow was melting on the upper watershed. Runoff can also be generated by large rainfall events. However, observations of the channel during the non-winter months have not demonstrated that rainfall has generated adequate runoff to promote continuous flow in the channel. Spring runoff in 1996 and 1997 rarely produced flows that exceeded the bank full stage of the new channel. Erosion and deposition in the channel was negligible in these years. Seed planted in the areas disturbed during construction germinated, but did not grow well.

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Spring runoff in 1998 began in March and flowed continuously until the end of May. Runoff exceeded the bank full stage along most reaches of the channel until early April after which regular flow measurements were continued. A channel flow rate at slightly below bank full capacity was measured and determined to be 34 cfs. We will attempt to estimate what the maximum flow rates could have been using high water marks noted upstream from the project area. The high runoff rates observed during the spring of 1998 correspond with the 23 percent higher than the average annual precipitation observed for this area. Runoff eroded and breached the channel in a number of locations, which was expected. However, in one channel section towards the lower end of the project, water that breached the channel was inadvertently diverted away from the new channel into the former channel. It was estimated that more than half of the above bank full flow was diverted at this point towards the old channel. The runoff flowed along an old road and then along the course of the old channel. Most of the old channel had been back filled from upstream to the lower end of the project, so the water actually flowed on top of the backfill. These overland flows created several long and deep head cuts and gullies from the lower junction of the old and new channels moving up the meadow.

Vegetation in the seeded and undisturbed areas grew tall and dense during the spring and summer of 1998. A vegetation survey will be conducted in October 1998 to compare plant cover and composition with pre-project conditions measured in the fall of 1994. The roadway was not affected in any way by the runoff across the meadow.

Forty-five piezometers were installed across Agua Fria meadow during September and October 1998 to monitor the depth and distribution of the water table. The drilling records will be used to determine the makeup of the subsurface soil layers. Forty 3-m deep wells were installed along 5 rows, uniformly spaced down the length of the meadow. The remaining five wells were installed one per row, to a depth of 10 m. During installation of the 10 m wells, freestanding water was encountered at 9 m below the soil surface. Bedrock was encountered in one well at 10 m. The soil profile in most wells consisted of thick clay layers divided by thin layers of sand and gravel.

The hydrologic conditions required to support a wet meadow currently do not exist in the Agua Fria meadow, based on our observations to date. We anticipate that the recently elevated channel will direct sufficient spring runoff onto the meadow surface and into the subsurface layers that a permanent to semi-permanent water supply is established that will support wet meadow plant species. In the meantime, our investigations are helping us understand how Agua Fria meadow and Forest Road 49 function and change in response to our interventions.

The results of our investigations will provide information to resource managers and roadway planners that can help them design environmentally sensitive roadways for wet meadow areas. In addition, our results will document the effectiveness of stream channel redirection as a method to rewet a dewatered forest meadow.