USA: Nevada: Restoration of Riparian Wet Meadows

Overview

The goal of this project was to restore riparian grass and sedge meadows currently dominated by Artemisia tridentata var. tridentata. The project sought to evaluate burning sites with low, intermediate, and high water tables; essentially, dry, intermediate, and wet sites. In order to define the alternative states and thresholds for these ecosystems, the project examined burning and water table effects on both abiotic variables and the establishment of grasses adapted to relatively high (Poa secunda ssp. juncifolia), intermediate (Leymus triticoides), or low (L. cinereus) water tables. Wet sites had lower soil temperatures and higher soil water contents than dry sites. Burning was found to increase soil temperatures on all sites. Undershrub microsites on control plots had the lowest temperatures, while former undershrub microsites on burn plots had the highest temperatures. Surface soil water was low on burn plots early in the growing season due to desiccation, but higher at deeper depths after active plant growth began. Emergence was generally greater on wet sites, but survival was microsite- and species-specific. Undershrub microsites on control plots facilitated emergence and first-year survival, but seedlings that survived initially harsh conditions on burn plots had similar numbers alive at the end. In general, favorable environments and establishment of species adapted to mesic conditions indicate that wet sites are an alterative state of the naturally occurring dry meadow ecosystem type, and can be restored to grass and sedge meadows. Harsh environments and lack of species establishment adapted to mesic conditions indicate that dry sites have crossed a threshold and may represent a new ecosystem type. Understory vegetation and seed banks on dry sites have been depleted, and restoration will require burning and reseeding with species adapted to more xeric conditions.

Project Details

Lead entity types:

- Academic, Training and Research

Adaptive management

Describe adaptive management processes and mid-course corrections taken to address unforeseen challenges and improve outcomes in each of the following categories:

State of Progress:

- Closed/completed, no further follow-up

Project Start:

1996-01-01

Project End:

1998-12-31

Global Regions:

- Northern America
- Americas
- World

Countries:

- United States of America

Ecosystem Functional Groups / Biomes:

- Savannas and grasslands biome

Extent of project:

- Other

Extent of restoration:

- Other

Degradations:

- Climate change

- Fragmentation
- Unsustainable grazing

Description:

Riparian corridors in the western US are severely degraded due to overgrazing by livestock, stream channel incision, and lowered water tables. One consequence of this initial degredation is the expansion and dominance of the shrub Artemisia tridentata var. tridentata, and the loss of what were once grass and sedge dominated meadows.

Planning and Review

Goals and Objectives

Was a baseline assessment conducted:

unsure

Was a reference model used:

RM5

were_goals_identified:

YES

Goals and objectives:

- Other

Goals Description::

The project addressed three questions: 1) How do soil water and temperature differ among water tables and in response to burning, and what are the effects of Artemisia?, 2) How is the establishment of plant species adapted to relatively high, intermediate, and low water tables affected by water table depth, burning, and Artemisia?, 3) Can the abiotic and establishment responses be used to identify alternative states and define restoration thresholds for these ecosystems?

Stakeholder Engagement

Were Stakeholders engaged?:

unsure

Description of Stakeholder Involvement:

Riparian meadows increase water storage, decrease sedimentation, and provide forage for both wildlife and livestock, their restoration is of considerable interest to land managers. The research was conducted on the Humboldt-Toiyabe National Forest, the largest national forest outside of Alaska, a 6.3 million acre forest stretching from California across northern Nevada.

Ecosystem Activities and Approaches

General Activities: Five Artemisia-dominated study sites were located within the Toiyabe Mountains in central Nevada in July 1996, representing a gradient of modification of the dry meadow ecosystem type. Selection was based on presence of species typical of the dry meadow and Artemisia/Leymus ecosystem types. The depth to the water table was determined from hand-augered wells. The project included two replicate high water table sites (water was at -153 to -267 cm), one intermediate water table site (-250 cm to -280 cm), and two low water table sites (greater than 300 cm). The wet and intermediate sites had higher cover of perennial graminoids and forbs, lower densities and volumes of Artemisia, and were more similar to the model dry meadow type than low water table sites. Common species included Carex douglassii, L. cinereus, L. triticoides, Poa secunda ssp. juncifolia, and Lupinus argenteus. A paired plot approach was used in which one plot at each site received the restoration treatment and the other served as a control (referred to as burn and control plots, respectively). Plots (740 sq m to 900 sq m) were fenced following treatment to exclude livestock and native ungulates. Treated plots were burned from the 19th to the 21st of October 1996 using a drip-torch to remove both woody and understory vegetation. All Artemisia was killed as a result of the burn. Rain gauges were located at each site to record growing season precipitation. Water table depth was measured monthly throughout the growing season in burn and control plots at each site with three or four wells installed in September 1996. Seedling establishment was examined for those grass species adapted to relatively wet, dry, and intermediate site conditions (Poa secunda ssp. juncifolia, Leymus cinereus, and L. triticoides, respectively) on both burn and control plots. Seeds of Poa were collected near the study sites in the summer prior to the burn. Seed fill was low and commercial seed was used for other species. Establishment quadrats (50 cm x 50 cm) were randomly located in both past and present undershrub and interspace microsites in burn and control plots. Quadrats were seeded in October 1996 following the burn with 100 filled seeds (1997 cohort) using a 50 cm x 50 cm grid with 100 evenly spaced holes. The small Poa seeds were placed 1 cm below the surface, while larger seeds of the two Leymus species placed 2 cm below the surface. Seeding was repeated one year later in October 1997 with four new locations using identical methods (1998 cohort). Seedling emergence and survival was censused every three weeks in 1997 and 1998 starting in April or May and continuing through July. During the summer dry period (Aug-Sept) survival was monitored monthly. Root sprouts and seelings of species that were not seeded were removed at each sampling date to reduce competition.

Project Outcomes

Eliminate existing threats to the ecosystem: Both water table depths and pre-treatment vegetation indicated that Artemisia dominated sites within these riparian corridors are generally at the lower end of the water table depths required to support the dry meadow ecosystem type. Weixelman et al. (1996) described the dry meadow ecological type in this region as having depths to saturation of-70 to -100 cm in June and July. Depth to water table reached these levels only in the spring and early summer of 1998 on the wet and intermediate sites. The relatively low water tables on the study sites are reflected in the persistence of Artemisia and rabbitbrush which cannot survive on sites that have high water tables or periods of prolonged soil saturation in the spring. For the water tables examined in this project, wet sites generally had more favorable environmental conditions (higher soil water and lower soil temperatures) than the dry sites. Soils on wet sites had lower percentages of coarse fragments (12% for the wet sites vs. 23% on the dry sites) and higher organic carbon than soils on dry sites. Coarser soils and lower organic carbon on dry sites undoubtedly resulted in lower water retention and capillary movement. Also, dry sites had higher Artemisia densities and volumes, but lower abundances of perennials in the understory than wet sites. In dry years, perennial understory species on wet sites may effectively deplete soil water in near surface soils relatively early in the growing season. Higher Artemisia densities coupled with lower soil water retention and water tables on dry sites may contribute to generally lower water contents throughout the soil profile. Burning had no measurable influence on water table depths on the small plots, but had significant effects on soil temperature and water. Generally higher soil temperatures following the burn was a function of eliminating the shade provided by burned vegetation, removing the insulating effect of litter, and altering the soil albedo. Initially lower soil water in surface soils was the result of snow removal, desiccation by wind, and increased soil temperatures resulting in higher evaporation. The increase in soil water at depths > 30 cm was probably a result of removing the deeper-rooted Artemisia. In areas sprayed with 2,4-D (2,4-Dichlorophenoxyacetic acid) to remove Artemisia tridentata ssp. vaseyana, soil water depletion during the growing season was reduced an average of 9% or 2.4 cm annually over a 20-yr period. Most of the difference occurred at deeper depths (- 0.9 to - 1.8 m), and the greatest difference (+33%) occurred the year after spraying when herbaceous biomass was low. Artemisia plants influenced soil temperature and water on control plots and had residual effects on burned plots. Reduced solar radiation coupled with higher humidity under Artemisia canopies explain the lower soil temperatures in undershrub microsites. Higher burn temperatures under shrubs and mortality of existing vegetation may explain both higher soil temperatures and soil water in burn undershrub microsites. Fire in under canopy locations is often hot enough to burn existing vegetation and litter, and result in darker and warmer soils. The abiotic conditions on the different sites had significant effects on seedling establishment. Like other semi-arid ecosystems, generally higher emergence and life spans on wet and intermediate sites can be related to higher soil water retention and availability. Higher vegetative regrowth, greater snow retention, and less extreme fluctuations in soil temperatures on wet and intermediate sites were probably also important. These results indicate that wet sites have the potential to support episodic establishment of species requiring mesic conditions, and to provide these species with adequate water once rooted. Burn plots generally had lower emergence than control plots, except during the second year on wet sites. Near surface soils on burn plots had lower soil water availability and higher but more variable soil temperatures, and the combined soil temperature and water requirements for germination may not have been met. Also, mortality of seedlings that did emergence was probably high. Seedlings that survived the initially harsh conditions on burn plots exhibited relatively high life spans and greater growth (although not measured). The increase in soil water after Artemisia removal is greatest in the first year after treatment, and this increase undoubtedly facilitates vegetative regrowth and seedling establishment. Individual Artemisia plants affected seedling establishment both before and after the burn. In semi-arid ecosystems, facilitation of seedling establishment by shrubs that modify the environment can depend upon the degree of stress resource levels and environmental conditions) experienced by seedlings. In this study, emergence was ighest in control undershrub microsites when other microsites had lower soil water availability or more extreme temperatures, e.g., spring and early summer 1997. Similarly, survival was highest in undershrub microsites when soil water availability was relatively high, e.g., 1998 when surface soil water rapidly declined. The interaction between seedling and shrub usually switches from facilitation to competition once the life stage changes from seedling to adult. In this study, seedlings in undershrub microsites were typically smaller than in other microsites. After the burn, harsher environmental conditions resulted in lower seedling emergence. But, lack of competition from Artemisia and herbaceous species resulted in life spans and numbers of surviving individuals that were similar to other microsites. Species differences in emergence and survival can be related to their affinities to sites with different water tables. Poa occurs with high constancy in the dry meadow ecosystem type and requires the highest water tables. It had almost no emergence in 1997, the dry year, but moderate emergence in 1998, the wet year. The species with intermediate water table requirements, L. triticoides, consistently had the highest emergence and survival on wet and intermediate sites. L. cinereus had the highest survival and life spans of the three species in the drier 1997, and it had the highest life spans on dry sites in 1998. Factors limiting recovery of the ecosystem: The abiotic and establishment responses can be used to identify alternative states and define restoration thresholds for Artemisia-dominated riparian corridors. Water table depths and shrub abundance indicated that the study sites were at the lower end of the water tables necessary to support dry meadow ecosystems. Despite this, wet sites had both higher soil water contents and lower soil temperatures than dry sites. Seedling emergence was higher on wet sites for all three species, and survival of species adapted to high and intermediate water tables, Poa and L. triticoides, was generally highest on wet sites followed by the intermediate site. In contrast, survival of the species adapted to more xeric conditions, L. cinereus, was clearly higher on dry sites. These results indicate that wet and intermediate sites represent an alternative state of the dry meadow ecosystem type, and have the potential to be restored to grass and sedge dominance. Due to relatively low water tables on these sites, maintaining grass and sedge dominance probably requires proper grazing and possibly periodic burning. Dry sites appear to have crossed a threshold as reflected by a lack of environmental conditions necessary for establishment of species adapted to dry meadows. They may represent a new site type with the potential to support the Artemisia/Leymus ecosystem type. The understory vegetation and seed banks on dry sites have been depleted, and restoration will require burning and reseeding with species adapted to more xeric conditions.

Monitoring and Data Sharing

Does the project have a defined monitoring plan?:

NO

Open Access URL:

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Long Term Management

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