WERA-021: Revegetation and Stabilization of Deteriorated and Altered Lands

2006
Annual Research Reports

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COMMITTEE-WIDE RESEARCH PROJECTS

INTRODUCTION

Members of WERA-021 have been involved in several large-scale, region-wide interdisciplinary research projects. These projects are not formally led by WERA-021, but our interactions as a committee have clearly facilitated their development and will make it more likely to develop other region-wide research programs in the future. In this section we highlight the projects and the participating committee members. Details on the projects can be found in the individual unit reports in the following sections.

COMPLETED PROJECT

1. Integrated Restoration Strategies towards Weed Control on Western Rangelands

   WERA-021 Committee Members active in this project were:

   Jeanne Chambers, USFS, USDA Forest Service, Rocky Mountain Research Station, Reno, NV; **David Pyke**, USGS, Forest & Rangeland Ecosystem Science Center, Corvallis, OR; **Eugene W. Schupp**, Utah State University, Logan, UT

ONGOING PROJECT

1. A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome

   WERA-021 Committee Members active in this project were:

   Jeanne Chambers, USFS, USDA Forest Service, Rocky Mountain Research Station, Reno, NV; **David Pyke**, USGS, Forest & Rangeland Ecosystem Science Center, Corvallis, OR; **Fred Pierson**, Northwest Watershed Research Center, USDA ARS, Boise, ID; **Bruce Roundy**, Brigham Young University, Provo, UT; **Eugene W. Schupp**, Utah State University, Logan, UT

CALIFORNIA

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INTRODUCTION

This report summarizes restoration research in the Department of Botany and Plant Sciences, the Department of Environmental Sciences, and the Center for Conservation Biology, University of California, Riverside; and the USDA Forest Fire Laboratory, Riverside. The research is/was funded by The National Science Foundation, the Environmental Protection Agency, the National Park Service, the Fish and Wildlife Service, and the University of California Integrated Pest Management Program. Experiments are being carried out primarily in parks and conservation reserves in vegetation types that are threatened by development. This includes coastal sage scrub vegetation, oak savannas, and Mojave/Colorado Desert. These vegetation types are being lost to urbanization, air pollution, nitrogen deposition, and invasive species, and contain many threatened, endangered, and sensitive plant and animal species, and are the subject of many restoration and mitigation studies.

COMPLETED PROJECTS

1. Exotic weed control at the Shipley Ranch Reserve (E.B. Allen, M.F. Allen, UC Riverside, and Douglas Deutschman, San Diego State University)

   The Shipley Ranch Reserve is a habitat mitigation reserve that was purchased by the MWD in return for the land being flooded at the Diamond Valley Lake Reservoir. It was historically grazed, but the cattle were removed in about 1990 and the vegetation has been recovering since. However, a large fire in 1993 burned much of the ranch, and native species recovery has been slow. A second fire burned through part of the reserve in November 2003, and has provided an opportunity for observation of restoration success post-fire. Large areas are dominated by exotic annual grasses that were once native shrub- and forbland. Our objectives were to reduce the grass cover to allow native species to recolonize. We used three methods, a grass specific herbicide, sheep grazing, and dethatching of grass litter to promote native species establishment. The sheep grazed 1 ha plots for 48 hours in spring 1999, 2000, and 2001. The herbicide Fusilade was applied to 1-ha plots during the 1999 and 2000 spring seasons. Dethatching was done during October-November 1999 prior to the winter rainy and spring growing season. The dethatching treatment allowed the recolonization of many annual plants, including many exotics. Both grazing and Fusilade/dethatching decreased the abundance of exotic annual grasses as hoped, but grazing also decreased the native forbs. However, during the spring, 2005 field survey we learned that the effects of both grazing and herbicide were persistent 5 years after the last application of the treatment. The post-fire data from the 2004 field season showed a reduction in exotic grass but an increase in exotic forbs. In the 2006 field season there were no longer any differences between treatments and controls.

2. Restoration of Habitat for the Endangered Quino Checkerspot Butterfly (E.B. Allen, UC Riverside)

Abandoned farmland was purchased as part of the Western Riverside County Habitat Conservation Plan. This Plan includes some 130 sensitive, threatened and endangered species (plants, birds, herptiles, fish, insects). The farmland is destined to become habitat for some of these species, if it can be restored. A project funded by the US Fish and Wildlife Service was initiated in abandoned farmland in fall 2004 to restore habitat for the endangered Quino checkerspot butterfly, *Euphydryas editha quino*. The butterfly larvae feed almost exclusively on one plant species, *Plantago erecta*, while the adults use nectar from several shrubs of coastal sage scrub vegetation. The farmland is surrounded by remnants of this vegetation, but the soil was treated with sewage sludge, making restoration challenging. The site was burned in July, 2004 to control grasses, but following an unusual October rain, was again covered with exotic annual grasses. The site was disked in November to control grasses again, and several additional weed control methods were applied. These included grass-specific herbicide (Fusilade), mowing, and seed bank solarization using plastic. The plots were seeded in January, 2005. The solarized plots had the lowest density of exotic grasses and forbs and the highest establishment of native species. The Fusilade treatment was second best. The mowing and herbicide treatments were applied again in the 2006 growing season, and a new set of solarized plots were initiated and seeded. Results for 2006 were comparable to those from 2005, and a manuscript for publication is in preparation.

ONGOING PROJECT

1. Restoration of Mojave and Colorado Desert vegetation invaded by exotic annual grasses and forbs (E.B. Allen, UC Riverside)

Several species of exotic grasses (*Bromus rubens, Schismus barbatus*) and forbs (*Erodium cicutarium, Brassica tournefortii*) have invaded the Mojave and Colorado Desert and are especially abundant in areas of high anthropogenic nitrogen deposition. Several treatments were applied over two growing seasons (2005, 2006) to control the exotics and test response of the native vegetation. These include application of the grass-specific herbicide Fusilade, hand weeding of exotic forbs, and application of sugar to immobilize soil N. The latter treatment is done to reduce available soil N that appears to increase exotic species growth to the detriment of native species. Field and greenhouse studies are also underway to test the impacts of N fertilizer on native and exotic plant growth. The study showed that herbicide is very effective in controlling the grasses and allowing native forb growth, and hand weeding of exotic forbs in addition to grass control increases native forbs even more. The sugar treatments were effective in immobilizing soil N. Sugar reduced the growth of exotic grasses but also reduced the growth of native annual forbs. This suggests that native desert forbs have relatively high N requirements, and greenhouse studies are underway to test this hypothesis.

NEW PROJECT

1. Reestablishment of Creosote Bush Scrub Vegetation following Fire in the Colorado Desert **(**E.B. Allen, UC Riverside**,** Matt Brooks, USGS, Las Vegas

Fire in Creosote Bush Scrub (CBS) may become more common in the future as alien grass species continue to invade this habitat and alter fuel characteristics. The impacts of fire on CBS vegetation and post-fire successional processes are largely unknown, yet fire has become locally common in CBS since the 1970s. One area of particular concern is the Coachella Valley of the northwestern Colorado Desert. This is a major wildland/urban interface (WUI) area significantly impacted by atmospheric nitrogen deposition, concomitant fuel alterations from alien annual grasses, and ignition frequencies from human activities. CBS vegetation takes much longer than more temperate vegetation types to re-establishment after fire, and the majority of plant species are adapted to fire-free conditions. Alien species that invade this habitat and promote fire are also aggressive fire-followers and may cause type conversion of CBS into alien annual grassland when sites have a short fire return interval, similar to what has occurred in Great Basin shrublands. We hypothesize that the impact of fire on CBS is significant, long lasting, and promotes alien dominance. The purpose of this study is two-fold: 1) document the post-fire recovery of CBS in a fire chronosequence that represents burn ages from 2 to 33 years ago, including areas that have burned twice and three times; and 2) evaluate competition between alien grass and shrub seedlings in burned and unburned CBS. Field experiments will test the ability of alien grasses to compete with CBS shrub seedlings and prevent their establishment. The value of this study will be to discover the impact of fire on certain species, functional groups, and seedbanks, the impact of multiple burns on CBS related to the invasive-fire feedback cycle, and the impact of alien grass on shrub establishment. This knowledge is necessary in order to understand the fate of this vegetation type following fire and to develop effective post-fire restoration treatments. Another major goal of this proposal is to create a manual on fire, invasive species, and restoration of CBS for the Colorado Desert.

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COLORADO

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INTRODUCTION

This report summarizes reclamation, restoration and related research projects at Colorado State University during 2006. Research was conducted by the Department of Forest, Rangeland and Watershed Stewardship, the Department of Soil and Crop Sciences, the Department of Biology, the Department of Microbiology, the Department of Horticulture and Landscape Architecture, and the Center for Environmental Management of Military Lands with funding from the Colorado Agricultural Experiment Station, USDA, EPA, U.S. Army, and the Colorado Department of Public Health and Environment.

COMPLETED PROJECTS

1. Validation of Erosion Models Using Radioisotopes, JMRC Hohenfels, Germany (Steven Warren, Center for Environmental Management of Military Lands)

   This project began in 2005 and was completed in August 2006. Soil cores were collected from an uneroded area at the Hohenfels Training Area to develop a reference profile of ^{210}Pb and ^{137}Cs isotopes in the soil. Despite suspicions that the ^{137}Cs profiles would be distorted by fallout from the Chernobyl nuclear accident, the ^{137}Cs profiles were significantly more interpretable than the ^{210}Pb profiles. The USLE-2D and USPED erosion models were computed for the training area. The USLE-2D model was found to be inappropriate; the results of the USPED model were considerably more intuitive. Should funds come available, soil cores from the training area will be collected and compared to the ^{137}Cs profile as a spatially distributed estimate of soil erosion and sediment deposition. The results will then be compared to the model results to see which model is most appropriate for predicting spatially distributed soil erosion and sediment deposition

2. Cyanobacterial Inoculation for Soil Stabilization at the Yucca Mountain Nuclear Repository (Steven Warren, Center for Environmental Management of Military Lands and Paul Kugrens, Department of Biology).

   This project began in 2004. Cyanobacteria were collected at a nearby undisturbed area and propagated in the laboratory. Live cyanobacteria were immobilized in clay pellets and applied to the disturbed area. The hypothesis was that the pellets would be dissolved by incident rainfall and the live, but immobile, cyanobacteria would be transported into the soil pores where they would become established and help stabilize the soil. Regrettably, it was discovered that the pelletization process killed the cyanobacteria and the resulting pellets were sterile.

3. The effect of long-term composted biosolids and biosolids-alum water treatment residuals reapplications on native rangeland soils and vegetation (J.A. Ippolito, M.W. Paschke and K.A. Barbarick, Department of Forest, Rangeland and Watershed Stewardship and the Department of Soil and Crop Sciences at CSU)

   The goal of this project is to understand both the long-lasting environmental effects of a single composted biosolids application, a single biosolids-water treatment residual co-application, and the short-term impacts of a repeated application on soils and plant community dynamics in a rangeland ecosystem.

4. Cheatgrass control and community restoration in Rocky Mountain National Park (C.S. Brown and M.W. Paschke, Department of Bioagricultural Sciences and Pest Management and the Department of Forest, Rangeland and Watershed Stewardship)

   The objective of this project is to test strategies for selecting species for revegetation and restoration of cheatgrass (*Bromus tectorum*) infested sites after chemical control of the weed. In particular, we are investigating whether the facilitation, tolerance, or inhibition model of succession is supported by performance of seeded species mixtures that have been selected based on their roles in natural successional processes.

5. Integrated control of spotted knapweed: Utilizing spotted knapweed-resistant native plants to facilitate revegetation (M.W. Paschke, J.M. Vivanco, L.G. Perry, Department of Forest, Rangeland and Watershed Stewardship and the Department of Horticulture and Landscape Architecture at CSU, and R.M. Callaway Division of Biological Sciences, University of Montana)

   The objectives are to determine if plants that excrete high concentrations of organic acids into the rhizosphere can be used to detoxify spotted knapweed soils and allow for the subsequent establishment of native vegetation and, to identify additional species that produce high concentrations of organic acids.

ONGOING PROJECTS

1. Effects of Fire on Biological Soil Crusts and Their Subsequent Recovery (Steven Warren, Center for Environmental Management of Military Lands, CSU; Paul Kugrens, Biology Department, CSU; Larry St.Clair, Brigham Young University)

   This project which began in 2004, examines the effects of a prescribed burn in the pinyon-juniper ecosystem on the biological soil crusts. Pre- and immediate post-burn soil samples were collected to evaluate the effect of burning on the biological soil crust organisms. Soil samples will be collected again after one year.

2. Soil Erosion Survey for Camp Guernsey, Wyoming (Steven Warren and Tom Ruzycki, Colorado State University)

   The Unit Stream Power Erosion and Deposition (USPED) model will be used to predict the magnitude and spatial distribution of soil erosion and sediment deposition at Camp Guernsey, Wyoming. Resulting maps will be used to schedule training events away from sensitive areas and schedule land rehabilitation activities for areas exceeding acceptable levels of soil erosion.

3. Assessment of Livestock Grazing Impacts on Fine Fuels at the Makua Military Reservation (Steven Warren, Colorado State University)

   This project is a demonstration of the use of cattle and sheep to reduce the fine fuel loads at the training area in an effort to limit the frequency and intensity of wildfires that have the potential to sweep into nearby endangered species habitat.

4. Metal Toxicity Thresholds for Important Reclamation Species in the Western U.S. (Edward Redente, Mark Paschke, and Ken Barbarick, Department of Forest, Rangeland and Watershed Stewardship and the Department of Soil and Crop Sciences).

   This project began in June 1999. The objective is to establish heavy metal toxicity thresholds for approximately 35 plant species that are commonly used in reclamation work in western North America. The project involves large greenhouse screening studies and will eventually establish toxicity thresholds for a variety of grasses, forbs and shrubs for As, Cd, Cu, Mn, Pb, and Zn.

5. Integrated Control and Assessment of Knapweed and Cheatgrass on Department of Defense Installations (Mark Paschke and Edward Redente, Department of Forest, Rangeland and Watershed Stewardship; Don Klein, Department of Microbiology Colorado State University and Lincoln Smith, USAD-ARS, Albany, CA)

This project began in April 2000 and will end in 2007. The objective is to develop a strategy for the control, monitoring, and prediction of knapweed and cheatgrass infestations at Fort Carson in Colorado and Yakima Training Center in Washington.

6. Turning the tide on invasive exotic weeds: Utilizing the chemical weapons of native plants to combat exotic weeds on abandoned coal mines (M.W. Paschke, E.F. Redente, J.M. Vivanco and L.G. Perry, Department of Forest, Rangeland and Watershed Stewardship and the Department of Horticulture and Landscape Architecture)

   The objective is to determine if native allelopathic plants could be used to displace exotic invasive species. If so, then allelopathic seed mixes could be an effective tool for controlling exotic weeds in western coal mines.

7. Development of tools to integrate restoration activities in the National Park Service (M.W. Paschke, Department of Forest, Rangeland and Watershed Stewardship)

   The objective of this project is to bring current academic input into the process of land resource management and restoration within the National Park Service. This project facilitates the Natural Resource Program Center of the NPS, and specifically the Restoration Technical Advisory Group, to meet their stated goals to: 1) coordinate and enhance communication on natural resource restoration issues within the NRPC, Regions, and Parks; 2) provide Service wide consistency with respect to restoration; and 3) promote scientifically sound restoration practices within the NPS.

8. Allelochemical control of non-indigenous invasive plant species affecting military testing and training activities (J.M. Vivanco, M.W. Paschke, Department of Horticulture and Landscape Architecture and the Department of Forest, Rangeland and Watershed Stewardship at CSU, and R.M. Callaway, Division of Biological Sciences, University of Montana)

   The objective of this project is to utilize the chemical properties of allelopathic invasive weeds as an economical and safe way to control other exotic species, and in the process understand the invasive properties of these weeds in order to control their spread on military sites.

9. Establishing shrubs to achieve bond release on Colorado coal mines: A demonstration of methods (M.W. Paschke Department of Forest, Rangeland and Watershed Stewardship at CSU)
   The purpose of this project is to evaluate the long-term response of various shrub establishment techniques at three coal mine sites within mountain shrub habitats in northwestern Colorado. Research plots were established in the autumn of 2000 and monitored for four growing seasons (2001 – 2004). In the current project, we will

collect data on these plots in 2007 in order to evaluate these methods over a longer and more ecologically-meaningful time frame. This project will thus provide critical information regarding what is, or is not feasible for shrub establishment in these habitats. Increasing shrub establishment will result in improved wildlife habitat and long-term surface stabilization.

PLANNED OR POTENTIAL PROJECTS

1. Postfire application of biological soil crusts for soil stabilization, native species recovery, and suppression of invasive plants in the Sonoran Desert (Gerald J. Gottfried, U.S. Forest Service, Rocky Mountain Research Station; Steven D. Warren, Colorado State University; Patti Fenner, Tonto National Forest; Eddie Alford, Arizona State University; Marcia Narog, U.S. Forest Service, Pacific Southwest Research Station)

   This project will investigate new technologies to restore naturally occurring biological soil crusts following fire in the Sonoran Desert grasslands.

2. Ecological defense mechanisms of the dry tropical forest (Steven D. Warren, Colorado State University)

   This project will investigate native woody species from the dry tropical forest of Hawaii to determine which, if any, produce allelopathic chemicals that may deter the invasion of exotic grasses. Any species found to possess such qualities will be ideal candidates for restoration of the dry tropical forest ecosystem.

3. Mitigation of the grass/wildfire cycle in the dry tropical forest (Steven D. Warren, Colorado State University)

   This project will study the relative effectiveness of using bovids, ovids, camelids and equids or some combination to reduce the fine fuel load which contributes to wildfires in the dry tropical forest endangered species habitat of Hawaii. Breaking the grass/wildfire cycle is an essential precursor to dry tropical forest restoration.

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Meiman, P.J., E.F. Redente and M.W. Paschke. 2006. The role of the native soil community in the invasion ecology of spotted (Centaurea maculosa auct. non Lam.) and diffuse (C. diffusa Lam.) knapweed. Applied Soil Ecology 32:77-88.

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IDAHO

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INTRODUCTION

This report summarizes revegetation and restoration research conducted at the USDA-ARS Northwest Watershed Research Center in Boise, Idaho for 2006. The focus of the NWRC revegetation/disturbed land program is to characterize establishment requirements of native grass and shrub species; evaluate impacts of wild and prescribed fire on vegetation, invasive weeds, soil erosion, streamflow and water quality; and to optimize restoration strategies for disturbed rangeland in the Great Basin region of the western United States.

ONGOING PROJECTS

1. <u>Prescribed-Fire Research at the Reynolds Creek Experimental Watershed in Southwestern Idaho</u> (Stuart Hardegree, Fred Pierson, Pat Clark, Gerald Flerchinger, Mark Seyfried)

   The Northwest Watershed Research Center initiated a landscape-scale, prescribed-fire research program in 2001 at the Reynolds Creek Experimental Watershed (RCEW) in southwestern Idaho. This program is a cooperative effort with the private-land owners at RCEW, the Bureau of Land Management, Lower Snake River District and Owyhee Field Office, Idaho Department of Lands, and other ARS research locations in the sagebrush-steppe vegetation type. The objectives of this research program are to assess prescribed-fire impacts on vegetation, soil, and water resources, post-fire grazing management, weed response, and the efficacy of fire treatments for fuels management and juniper control. The second prescribed fire in this program was conducted in September 2004 at the Whiskey Hill research site in RCEW. NWRC continues to monitor vegetation recovery, hydrologic impacts and grazing animal behavior at both Whiskey Hill and the Breaks sites (burned in 2002). The Upper Sheep Creek sub-watershed at RCEW will be burned in 2007 and will include more detailed pre- and post-fire analysis of hydrology and runoff as it is a discrete watershed.

2. <u>Hydrologic Impacts of Western Juniper</u> (Stuart Hardegree, Fred Pierson, Pat Clark, Gerald Flerchinger, Mark Seyfried, Danny Marks, Tony Svejcar, Jon Bates)

Wildfire played an important role in the control of western juniper in the western United States prior to European settlement. NWRC continues to cooperate with the Eastern Oregon Agricultural Research Center in Burns, Oregon, and the Bureau of Land Management, Lower Snake River District, to establish a series of 4 research watersheds in southern Idaho to study the hydrologic impacts of juniper. In 2006, NWRC completed the construction of four weir structures and six complete meteorological stations in the South Mountain area of Owyhee County, Idaho. The basic experimental design will be to monitor meteorological inputs, runoff and water quality in each watershed (~150 acres). These watersheds will be monitored for vegetation attributes, infiltration, erosion, streamflow, snow distribution, grazing animal behavior and forage utilization for an initial calibration period of 5-8 years. After a period of watershed calibration, three of the watersheds will undergo mechanical eradication of juniper. All watersheds will be monitored for an additional 8-10 year period. Subsequent control of juniper on these watersheds will be maintained by use of prescribed fire. NWRC welcomes collaboration with other research programs and projects that could benefit from our long-term infrastructure at these sites.

3. Risk Assessment of Fuel Management Practices on Hillslope Erosion (Fred Pierson, Pete Robichaud, Ken Spaeth, Corey Moffet)

NWRC continued to cooperate with the Forest Service, Rocky Mountain Research Station in Moscow, Idaho to develop a web-based erosion risk management tool (ERMiT) for natural resource managers to use following wildfires, prescribed fires and areas treated with different fuel management practices. From 1999-2005 field experiments were conducted in Idaho, Washington, Nevada, Montana and Colorado to quantify the hydrologic impacts of fire and to test the efficiency of post-fire mitigation practices such as contour-felled logs, straw wattles, hand trenches, straw mulch, contour raking, and wood mulch for controlling soil erosion. A final version of ERMiT was released in 2006 and a journal article on the technical aspects and an ERMiT user's manual were submitted for publication.

4. Cooperative Model Development and Enhancements at NWRC: Rangeland Hydrology and Erosion Model (RHEM) (Fred Pierson, Ken Spaeth, Corey Moffet)

In 2005, a broad cooperative effort was initiated between the NWRC and ARS, Tucson, NRCS Grazinglands Team, Forest Service, Rocky Mountain Research Station and the Bureau of Land Management to develop a Rangeland Hydrology and Erosion Model (RHEM) based on SPUR and WEPP modeling technologies. Potential applications of RHEM include: evaluating the impacts of land management practices (grazing, fire, range improvements practices); developing hydrologic information for Ecological Site Descriptions; assisting in conservation planning, and evaluating the outcome and benefits of conservation practices. In 2006, model code for an event-based model was completed and a sensitivity analysis conducted

5. Dynamic evaluation of thermal response to potential field-variable temperature regimes (Pat Clark, Gerald Flerchinger, Stuart Hardegree, Tom Jones, Fred Pierson, Mark Seyfried, Adam Winstral)

The Northwest Watershed Research Center has previously developed and tested several models for estimating cumulative seed germination response to temperature and water stress. In the last annual report, we listed two studies that compared 8 alternative thermal models. These models have been further tested by comparing predicted and measured cumulative germination response to 104 different field-variable temperature scenarios. The most accurate predictive models are those with the fewest a priori assumptions about model shape (relationship between subpopulation, temperature and germination rate). We used the most accurate empirical model to evaluate 41 seedlot-accessions of big squirreltail (Elymus multisetus) and bottlebrush squirreltail (Elymus elymoides) under a 38-year microclimatic simulation. Evaluation of thermal response under realistic field-variable temperature scenarios gives a more ecologically relevant index of relative germination response than does a simple comparison of germination indices derived from median population characteristics.

Another aspect of this research is to continue to validate seedbed microclimatic models that are used in predicting temperature and moisture conditions in the seedbed. Previously, NWRC scientists calibrated the SHAW microclimatic model with seedbed temperature and moisture data at the Orchard Field Test Site in Ada County, Idaho. These simulations were previously used to develop historical seedbed microclimatic scenarios to evaluate potential seedlot performance. NWRC scientists improved the accuracy of these models by evaluating soil freezing effects on soil water dynamics at this field site.

6. Influence of rangeland vegetation on soil water movement to deep drainage. (Mark Seyfried)

The NWRC is exploring how different rangeland vegetation impact the amount and timing of water movement through the soil profile resulting in deep drainage (downward movement of water through the bottom of the root zone). The amount and spatial distribution of deep drainage and groundwater recharge affect water supply and quality in the rapidly growing, semiarid USA. We synthesized research from the fields of ecology and hydrology to address the issue of deep drainage in semiarid regions. We started with a recently developed hydrological model that accurately simulates soil-water potential and geochemical profiles measured in thick (>50 m), unconsolidated vadose zones. Model results indicated that, since the climate change that marked the onset of the Holocene period 10 to 15,000 years ago, there has been no deep drainage and that continuous, relatively low (< -1 MPa) soil-water potentials have been maintained at depths of 2–3 m. The scenario derived from these results proposes that the native, xeric shrub dominated plant communities that gained dominance during the Holocene, generated and maintained these conditions. We presented three lines of ecological evidence that support the scenario. First, that xeric shrubs have sufficiently deep rooting systems with low extraction limits to generate the modeled conditions. Second, the characteristic deep-rooted soil-plant systems store sufficient water to be effectively buffered against climatic fluctuations. And third, adaptations resulting in deep, low extraction limit rooting systems confer significant advantages to xeric shrubs in semiarid environments. We then considered conditions in semiarid regions in which the model scenario may not apply, leading to the expectation that portions of many semiarid watersheds supply some deep drainage. Further ecohydrologic research is required to elucidate critical climatic and edaphic thresholds, evaluate the role of important physiological processes (such as hydraulic redistribution), and evaluate the role of deep roots in terms of carbon costs and whole plant development.

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IDAHO

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INTRODUCTION

This report summarizes revegetation and restoration research conducted by members of the USDA Forest Service, Rocky Mountain Research Station, Shrubland Biology and Restoration Research Work Unit stationed in Boise, Idaho and their cooperators during calendar year 2006. Most research is encompassed within the collaborative Great Basin Native Plant Selection and Increase Project (GBNPSIP). This effort emphasizes development of native plant materials for the Great Basin and the technology required for their use. Additional research examined the ecology and fire response of rush skeletonweed (*Chondrilla juncea*) on the lower Snake River Plain. Research was partially funded by the USDI-BLM Great Basin Restoration Initiative (GBRI) and Native Plant Initiative and the National Fire Plan.

COMPLETED PROJECTS

1. Ecological characteristics of sites invaded by rush skeletonweed (*Chondrilla juncea*) on the Snake River Plain (Brian A. Mealor[1], Ann L. Hild[1], C. Lynn Kinter[2], Nancy L. Shaw[3]. [1]University of Wyoming, Department of Renewable Resources, Laramie, WY; [2]Idaho Department of Fish and Game, Boise, ID; [3]USDA, Forest Service, Rocky Mountain Research Station, Boise, ID)

   Rush skeletonweed (*Chondrilla juncea* L.) is an exotic, invasive, perennial plant in the western Snake River Plain and adjacent areas. First recorded in foothill and montane habitats in 1963, it spread to over 900,000 ha in less than 15 years. Significantly less expansion was noted in drier shrub steppe communities, but it has become more widespread there in recent years. Infestations have been most commonly observed on abandoned farmland, annual grasslands, roadsides and other disturbed areas, particularly on coarse or sandy soils. We document soil and vegetation characteristics of 33 sites invaded by rush skeletonweed, and describe relationships between ecological site characteristics and skeletonweed infestations. Vegetation on most sites was composed of big sagebrush (*Artemisia tridentata* Nutt.) or big sagebrush/bitterbrush (*Purshia tridentata* (Pursh) DC) communities. Nearly all sites surveyed showed signs of disturbance in the past. Rush skeletonweed density ranged from sparse individuals to over 87 stems m^{-2}. Stem density was positively correlated with canopy cover of cheatgrass (r = 0.435; p = 0.011) and medusahead (r = 0.414; p = 0.017) indicating skeletonweed's ability to act as a secondary invader into communities dominated by invasive annual grasses. Our results indicate that rush skeletonweed is capable of invading a broad range of habitats ranging from 795 m to over 1300 m on a variety of soil and vegetation types.

2. Post-fire Invasion Potential of Rush Skeletonweed (*Chondrilla juncea*) (C. Lynn Kinter[1], Brian A. Mealor[2], Nancy L. Shaw[3], and Ann L. Hild[2] ; [1]Idaho Department of Fish and Game, Boise, ID; [2] Department of Renewable Resources, University of Wyoming, Laramie, WY; [3]USDA FS, Rocky Mountain Research Station, Boise, ID)

North American sagebrush steppe communities have suffered transformation via entry of invasive annual grasses and subsequent increase in fire size and frequency. We examined the effects of wildfires and environmental conditions on the ability of rush skeletonweed (*Chondrilla juncea* L.), a perennial Eurasian composite, to invade degraded sagebrush steppe communities, largely dominated by cheatgrass (*Bromus tectorum* L.). Recruitment of rush skeletonweed from seed and root buds was investigated on 11 burned and unburned plot pairs on Idaho's Snake River Plain following summer 2003 wildfires. Emergence from soil seedbanks was similar on burned and unburned plots in 2003 and 2004 (p = 0.37). Soils from recently burned plots (p = 0.05) and sterilized field soil (p < 0.01) supported greater emergence than did unburned field soils when rush skeletonweed seeds were mixed into the soils in the laboratory. These decreases may indicate susceptibility of this exotic invasive to soil pathogens present in field soils. Seeds bags field planted in late October 2003 reached peak germination by mid-January 2004 during a wet period; 1 percent remained viable by August 2004. Seedling emergence from sown plots or the native seedbank and establishment of new rosettes from root sprouts in 2003-2005 indicate that seed germination of rush skeletonweed on the Snake River Plain may be facultative, occurring in fall or spring if soil moisture is adequate, although fall germinants may not survive. Stand development results primarily from root sprouting. Establishment from seed is episodic, but provides for dispersal, with increasing fire frequency and size expanding the areas of disturbance available for new invasions.

ONGOING PROJECTS

1. Great Basin Native Plant Selection and Increase Project (Nancy Shaw and Mike Pellant, USDA FS Rocky Mountain Research Station, Boise, ID and USDI BLM Idaho State Office, Boise, ID)

The use of native plants for rehabilitation after wildfires and restoration of disturbed wildlands is encouraged by various BLM programs, initiatives, and policies. The Great Basin Native Plant Selection and Increase Project, funded by the BLM through the FS Rocky Mountain Research Station covers selection of native plant materials, culture, seed increase, and use on degraded rangelands. Priorities are: 1) increase of native plant materials available for restoration; 2) development of seed technology and cultural practices required for agricultural seed production of native forbs and grasses; 3) management of shrub seed sources in wildland stands; 4) techniques for improving the diversity of introduced grass monocultures; 5) developing the knowledge, techniques, and equipment required for reestablishing diverse communities; and 6) technology transfer.

Collaborators include the USDI Bureau of Land Management, Great Basin Restoration Initiative, Boise, ID; USDA Forest Service, Shrub Sciences Laboratory, Provo, UT and Boise, ID; Utah Division of Wildlife Resources, Great Basin Research Center, Ephraim, UT; USDA Agricultural Research Service, Forage and Range Research Laboratory, Logan, UT; USDA Agricultural Research Service, Bee Biology and Systematics Laboratory, Logan, UT; Utah Crop Improvement Association, Logan, UT; Association of Official Seed Certifying Agencies, Moline, IL; USDA Natural Resources Conservation Service, Idaho, Utah, Nevada, the Aberdeen Plant Materials Center, Aberdeen, ID, and the Great Basin Plant Materials Center, Fallon, NV; Brigham Young University, Provo, UT; USDA Forest Service, National Seed Laboratory, Dry Branch, GA; Colorado State University Cooperative Extension, Tri-River Area, Grand Junction, CO; USDA Agricultural Research Service, Western Regional Plant Introduction Station, Pullman, WA; Oregon State University, Malheur Experiment Station, Ontario, OR; USDA FS Pacific Northwest Research Station, Corvallis, OR; Utah State University, Logan, UT; University of Nevada - Reno.

2. Breaking Dormancy in *Lomatium dissectum* Seeds (Melissa Scholten[1,2], Nancy L. Shaw[1], and Marcelo Serpe[2]; [1]USDA Forest Service, Rocky Mountain Research Station, Boise, ID; [2]Department of Biology, Boise State University, Boise, ID)

Lomatium dissectum (fernleaf biscuit root) is a perennial, herbaceous plant found in semiarid habitats of the Western United States. This species produces seeds that are initially dormant. The dormant seeds have underdeveloped embryos that are completely surrounded by the endosperm. We have conducted laboratory and field experiments to determine the conditions that induce embryo growth and break dormancy. The laboratory experiments indicated that warm moist conditions or a combination of dry after-ripening followed by warm-moist conditions do not induce embryo growth. In contrast, cold stratification promoted embryo growth. During 12-weeks of cold stratification the embryo grew from 1 to 7 mm, which is approximately the full size of the embryo. Most of the embryo growth occurred during the first 6 weeks of stratification. Cold stratification also promoted germination. However, after 12 weeks of cold stratification the percent germination was only 20 %. Seeds buried in the field and exposed to natural winter conditions showed similar trends. The embryos grew when soil temperatures ranged between 0 and 10°C. Winter temperatures also triggered germination; after 15 weeks in the field germination was about 35%. We are currently investigating the effect of longer stratification periods and oscillations in temperature on breaking dormancy.

3. Competitive Dynamics Among Crested Wheatgrass and Native Grasses and Forbs (J.M. Muscha[1], M.R. Haferkamp (retired)[1], N.L. Shaw[2], and L.T. Vermeire[1]. [1]USDA ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, MT; USDA FS Rocky Mountain Research Station, Boise, ID)

Extensive monocultures of exotic crested wheatgrass (*Agropyron* spp.) in the interior western United States replaced former wildlife habitat and in many cases are susceptible to or currently invaded by exotic annual grasses and forbs. Approaches are being examined for adding native species to improve diversity and structure of these stands. Residual wheatgrass may, however, interfere with establishment of natives. Our objective was to determine competitive interactions of native grass/forb mixtures with crested wheatgrass. Five species used in this study were the exotic grass *Agropyron sibiricum* (AGSI), 2 native forbs, *Achillea millefolium* (ACMI) and *Penstemon speciosus* (PESP), and 2 native grasses, *Elymus elymoides* (ELEL) and *Poa secunda* (POSE). Treatments were: 1) AGSI (1 plant); 2) AGSI (2); 3) AGSI (1), ELEL, ACMI, PESP; 4) AGSI (2), ELEL, ACMI, PESP; 5) ELEL, ACMI, PESP, 6) AGSI (1), POSE (2), ACMI, PESP; 7) AGCR (2), POSE (2), ACMI, PESP and 8) POSE (2), ACMI, PESP. Ten replicates of treatments were grown in a greenhouse for 5 months. Greatest aboveground biomass was produced by AGSI (2 plants) (39.1 g), AGSI (1), ELEL, ACMI, PESP (37.4 g), and AGSI (1) (34.9 g). AGSI biomass was smaller when grown with any of the native plant combinations (24.7 g) than when grown alone (37.0 g). Treatments with only native plants produced less biomass (20.5 g) than treatments including AGSI (29.3 g). Biomass was twice as great for ELEL and nearly 3 times as great for POSE when grown without AGSI. Forb biomass was generally reduced by 2 AGSI (5.4 g vs 1.4 for ACMI, 0.9 g vs 0.6 g for PESP). Although competitive effects appear reciprocal, the impact on natives underscores the need to provide good wheatgrass control prior to seeding these natives into Siberian wheatgrass monocultures.

PLANNED OR POTENTIAL PROJECTS

1. Equipment and Strategies to Enhance the Post-wildfire Establishment and Persistence of Great Basin Native Plants (Nancy L. Shaw[1], Robert D. Cox[1], Mike Pellant[2], David A. Pyke[3]. [1]USDA FS Rocky Mountain Research Station, Boise, ID; [2]USDI BLM Idaho State Office, Boise, ID; [3]USGS BRD, Corvallis, OR)

The cycle of annual weed invasion and wildfire has altered large expanses of western shrublands, disrupted ecosystem functioning, and increased wildfire size, intensity and frequency. These impacts are costly in terms of losses to native species and ecosystems, and also in risks to human life and property and wildfire-associated expenditures. Post-fire rehabilitation provides an opportunity to stabilize and revegetate at-risk shrublands. The proposed research addresses Manager's Request Task 3: Reestablishment of native vegetation after fires on arid lands. The USDI Bureau of Land Management treats more acres and expends more funds through the Emergency Stabilization and Rehabilitation Program (ES&R) than other agencies, and is required by Executive Orders and agency regulations to use native species where feasible. However, our ability to establish mixtures of grasses, forbs, and shrubs is limited. Our objectives are 1) Examine seeding techniques for Wyoming big sagebrush, 2) Test seeding technology for native species, particularly native forbs, 3) Compare the ability of a modified rangeland drill and an experimental minimum-till drill to plant native seeds of diverse size and shapes and to reduce surface disturbance, thereby conserving residual native species and biological soil crusts, while minimizing planting of annual grass seed, 4) Apply and examine use of USGS proposed ES&R monitoring protocols for gauging seeding success for both the short and long term, 5) Provide plantings for long-term examination of livestock grazing on diversity in native seedings. This research will provide both basic and applied results on native restoration species and technology for their use.

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MONTANA

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INTRODUCTION

This report summarizes revegetation and restoration research conducted in 2006 by the Department of Land Resources and Environmental Sciences at Montana State University.

COMPLETED PROJECTS

1. <u>Recreation Impacts on High Elevation Soil Biota and Soil Processes</u> (Brian Eckenrod and Catherine Zabinski, Land Resources and Environmental Sciences, Montana State University).

   Mountainous regions are some of the most heavily utilized recreation areas, and this increased pressure from human use has resulted in major ecological changes, ranging from soil compaction and decreased water infiltration to loss of habitat and vegetation loss. Soil animals and soil microbial communities facilitate the decomposition of organic matter, making nutrients available for subsequent plant and microbe uptake and are essential to the productivity, successful establishment and sustainability of restored systems. This project had three main objectives: 1) to compare soil biota structure and function in disturbed, adjacent undisturbed and restored high elevation sites; 2) to compare rates of decomposition and nitrogen mineralization on undisturbed, disturbed, and restored campsites; and 3) to characterize soil chemical and physical properties across both site types and locations. We sampled sites in the Gallatin and Bitterroot Mountains in western Montana, and North Cascades and Mount Rainier National Parks in Washington. Mycorrhizal infectivity potential was low across all sites, and did not differ with disturbance. Decomposition rates did not differ after 3, 12, or 24 months of field-incubation of standardized substrates. Total N was lower on disturbed sites, and N mineralization rates were higher. Soil enzyme activity was lower for one substrate on disturbed sites, and nearly significantly lower for 4 additional substrates. Substrate induced respiration was lower on disturbed sites for 6 of 26 substrates. Soil physiochemical and biological characteristics are affected by disturbance and location, but the nature of those effects vary between parameters, suggesting that ecosystem components are decoupled, responding individualistically to disturbance.

ONGOING PROJECTS

1. The Ecology of Plant-Fungal Symbioses in Extreme Environments (Catherine Zabinski and Ylva Lekberg, Land Resources and Environmental Sciences, Montana State University).

   The study of plant growth and the mycorrhizal symbiosis in extreme environments is relevant to understanding the potential for vegetation establishment on industrially-impacted sites. This research focuses on arbuscular mycorrhizae (AM) and plant growth on thermal soils Yellowstone National Park. These soils are characterized by acidic to basic chemistry, elevated rooting zone temperatures (up to 57^{o}C), low phosphorous levels, and potentially toxic concentrations of multiple elements. These sites are very old, and therefore the potential exists for plant and fungal adaptations to extreme environmental conditions. With morphological characteristics and molecular tools, and incollaboration with Dirk Redecker, University of Basel, we have identified 3 unique phylotypes of AM fungi in thermal areas, and are measuring both fungal and hyphal viability across temperature gradients. We have established single-species cultures of AM fungi from thermal areas, so we can test the hypothesis that fungi from high temperature soils are adapted to those conditions. This studies applies to restoration work by increasing our understanding of this symbiosis in extreme environments, which is of direct application to revegetation concerns on heavily disturbed sites.

2. Belowground Ecology of an Invasive Forb and Native Grasses, (Catherine Zabinski, Karla Sartor, Land Resources and Environmental Sciences, Montana State University, Bret Olson, Animal, Range and Natural Resources, Montana State University).

   Restoration of degraded rangelands includes revegetating areas with invasive species. We have an ongoing research project focused on belowground competition between the invasive forb, *Centaurea maculosa*, and two native grass species. In addition to measuring root interactions, and the role of mycorrhizae in affecting competitive ability, we are analyzing data from stable isotope application, to determine how plants take up and allocate C and N when growing in competition with other species.

3. Revegetation Post-Disturbance in Cheat grass-Invaded Great Basin Shrublands. (Hilary Parksinson and Catherine Zabinski, Land Resources and Environmental Sciences, Montana State University, and Nancy Shaw, USDA FS Rocky Mountain Research Station).

   As a spin-off from the USDA-RMRS initiative to develop forb plant materials for revegetation, we are investigating species combinations that will result in increased plant community diversity and reduced cheat grass invasion in revegetated areas post fire disturbance. We have completed one greenhouse study to compare the growth of 5 forbs when grown alone or with one of three grass species, including *Bromus tectorum* and two native grasses. We have also set up a field experiment to look at native forb establishment and growth when growing with different densities of *Bromus tectorum*. In addition to plant responses, we will be measuring soil water, to test the hypothesis that *B. tectorum* lowers early season soil moisture, resulting in decreased establishment and growth of native forbs. This work is focused on Great Basin plant communities.

4. Native Species Selection for Optimizing Constructed Wetland Function. Paul Hook, Intermountain Aquatics, Otto Stein, Department of Civil Engineering, Montana State University Carrie Taylor, and Catherine Zabinski, Land Resources and Environmental Sciences, Montana State University).

   Constructed wetlands are an important source of wastewater treatment, but in colder environments there utility maybe be seasonally-limited. Previous work done by Drs. Hook and Stein and associated graduate students, documented more efficient wastewater treatment in cold temperatures with certain plant species in constructed wetlands. We have an ongoing greenhouse experiment where we are testing water quality in constructed wetlands planted with one of 19 species. The wetlands are exposed to seasonal-appropriate temperatures ranging from 6 to 24, and water chemistry is monitored after wastewater is applied in batch treatments every 21 days. In addition, we are measuring oxygen production across roots systems of all 19 of the species, to quantify what we consider to be the most important mechanism by which plant species increase wetland treatment processes that are oxygen-dependent during winter months.

5. Using Reinforced Native Grass Sod for Biostrips, Bioswales, and Sediment Control (DC01), Xiamming Shi, Western Transportation Institute, Montana State University, Doug Dollhopf, Reclamation Research Unit and Land Resources and Environmental Sciences, Montana State University, Tracy Dougher, Plant Sciences, Montana State University, and Lisa Rew, Land Resources and Environmental Sciences, Montana State University.

   This study was funded by California Department of Transportation, with the main objective to develop native grass sod for six ecoregions of California to aid highway site stabilization. Control of storm water runoff and sediment loss from disturbed land adjacent to highways is a cause of concern in many areas, and the California highway system is no different. Efforts to establish native grass from seed on slopes and water conveyance features requires long establishment periods before a degree of effectiveness is attained. It is anticipated that the use of reinforced native grass sod will facilitate quick vegetation establishment and soil reinforcement, reduce the risk of non-native weeds and fire hazards, and thus reduce the use of herbicides. In addition, the native grass sod is expected to minimize the amount of maintenance and water treatment needed for the vegetation management. We have selected seven grass species native to each eco-region and are growing them in 5 and 7 species mixes in climate controlled mini-greenhouses.

6. Mycorrhizal Functioning Across Environmental Gradients. NCEAS (National Center for Ecological Analysis and Synthesis) Working Group.

   We are conducting a meta-analysis to determine how beneficial mycorrhizal colonization is for plants across a range of environmental conditions. We are also working on a manuscript for managers to present a broad overview of the conditions under which managers should consider application of mycorrhizal inoculation.

7. Soil and plant response to slash pile burning and restoration. Natalie Meyer, and Cathy Zabinski, Land Resources and Environmental Sciences, Montana State University, and Tom DeLuca, The Wilderness Society, Bozeman, MT.

   Slash pile burning is the most common method of fuels disposal following ponderosa pine restoration harvests, which are designed to reduce the risk of catastrophic fire and restore the historical structure and function of western forests. The impact of high-intensity, long-duration fire (pile burning) on soil chemistry, arbuscular mycorrhizal (AM) fungi, and plant community establishment is not well understood. The objectives of our study are: (1) to characterize the impact of slash pile burning on soil nutrient availability, microbial activity, and mycorrhizal infection; and (2) to contrast several techniques for restoration of soils impacted by pile burning. In May 2006, 45 slash piles were burned in a ponderosa pine stand in Florence, Montana. Soil NH_4^+ concentrations were elevated in the center of the slash pile scars, while NO_3^- and P levels were not significantly different in center versus edge versus outside of slash piles. In October 2006, scars were either seeded with native graminoids or left unseeded, and divided into subplots assigned to one of five treatments: control, scarification, addition of a local organic matter mulch, scarification and organic matter mulch addition, and scarification and composted biosolid addition. Soils will be monitored for NH_4^+, NO_3^-, microbial biomass-N, *in-situ* N mineralization, total C and N, available P, and mycorrhizal inoculum potential. Native and non-native plant percent cover, relative frequency, and density will be measured for each treatment. These studies on above- and belowground impacts of slash pile burning will enhance our understanding of soil response to high-intensity fire, increase our understanding of the role of AM fungi in recently restored ponderosa pine ecosystems, and allow us to evaluate the potential of restoration techniques in the suppression of noxious weeds.

PLANNED OR POTENTIAL PROJECTS

1. The potential for carbon movement between plants via mycorrhizal hyphal linkages.

2. Plant and soil process response to coal mine reclamation treatments, 20 years post treatment.

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NEW MEXICO

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INTRODUCTION

This report summarizes some of the ecological restoration/rehabilitation research and monitoring activities currently managed by the Environmental Protection Division at Los Alamos National Laboratory.

COMPLETED PROJECTS

None

ONGOING PROJECTS

1. Restoration of a Degraded Piñon-Juniper Woodland (Samuel Loftin, LANL: Brian Jacobs, Bandelier National Monument)

   In 1994, the Santa Fe National Forest, Bandelier National Monument, and the USDA Forest Service Rocky Mountain Research Station began a study in the Jemez Mountains of northwestern New Mexico to test the effects of a thinning treatment on degraded p-j woodland. The thinning treatment was being evaluated as a means to stabilize soils and restore herbaceous plant abundance. In April 1995, we removed all piñon under 8-inch diameter and all juniper from an area of approximately 25 acres. The slash left over from the treatment was scattered evenly across the site. Within two to three years following the thinning treatment, cover of herbaceous vegetation was approximately three times that of control and pre-thinning levels. Given the herbaceous plant response and the condition of the slash, we had planned to reintroduce a prescribed fire sometime between five and ten years after the thinning treatment.

   However, in May 2000, the Cerro Grande Fire burned through the study site. The fire came from the south and should have reached both treatments at approximately the same time. In the thinned area, the fire dropped to the ground and fingered its way across roughly half of the site, meeting many of the objectives of a prescribed fire, killing small trees but having little long-term effect on herbaceous plants. In fact, although herbaceous plant cover was reduced by about half immediately following the fire, there was no significant difference between pre-fire cover and cover after two growing seasons. In contrast, the unthinned area was burned to the ground. Tree mortality was close to 100%, and much of the herbaceous vegetation was killed. After two growing seasons, the vegetation on the unthinned site was dominated by weedy species and seeded grasses. Clearly, the thinning treatment reduced the severity of the fire and the time needed for subsequent recovery of herbaceous vegetation.

We have made a number of notable observations from the site since the Cerro Grande Fire. Although the fire did not kill most of the mature piñon in the thinned area outright, many of the trees that had surface fires around their base died within a year. Apparently, these mature trees are very susceptible to even low intensity wildfire, something that must be accounted for when planning prescribed burns as a restoration tool. In addition, the entire region suffered a widespread outbreak of bark beetle, which has subsequently killed off all the remaining mature piñon within the study site boundaries. It might be expected that trees in the thinned area would be healthier than trees in unthinned areas, which would give them an advantage in resisting bark beetle infestation. However, the combination of severe drought conditions and overwhelming bark beetle populations overcame any advantage from the thinning treatments.

This project is ongoing but due to time and budget restraints we have not been able to monitor the site for the past two seasons (2005 and 2006).

2. <u>Burned Area Emergency Rehab Treatments at LANL</u> (Samuel Loftin, LANL)

The Cerro Grande Fire of May 2000 burned around 7,400 acres, (3,000 ha) of forest and woodland on Los Alamos National Laboratory in NW New Mexico. Approximately 1,800 acres (728 ha) of high and moderate burn areas were treated to reduce the risk of soil erosion and downstream flooding. Treatments included combinations of aerial seeding, aerial hydromulch, truck hydromulch, hand seeding and mulching, straw wattles, contour felling, and raking.

Response to these treatments has been monitored to assure adequate recovery of burned areas. Understory vegetation response has been sporadic due to inconsistent precipitation and overall drought conditions. We had relatively good response from seeded and non-seeded species in 2001 (>45% veg cover). However that number had dropped to around 25% veg cover by the end of 2005. Total cover (veg and litter) cover has remained relatively constant at around 60%. Despite the current cycle of alternating wet and dry years, effective cover in the thinned areas has been adequate and there is little evidence of soil degradation.

CURRENT PUBLICATION AND PAPERS

Buckley, K.J., J.C. Walterscheid, S.R. Loftin, and G.A. Kuyumjian. 2006. Results of Five Years of Monitoring Post-Fire Rehabilitation Activities at Los Alamos National Laboratory. LA-UR-06-0904. Los Alamos National Laboratory, Los Alamos, NM.

OREGON

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INTRODUCTION

Oregon State University, Dept. of Rangeland Ecology and Management are involved in a number of research projects related to revegetation and stabilization of deteriorated and altered lands. Research projects encompass both upland and riparian ecosystems and involve a wide range of issues including mapping invasion patterns of weeds, weed control with goats and bioherbicides, restoration of degraded winterfat range and impacts of western juniper on watershed function. All projects are ongoing thus publications are not presented.

CURRENT RESEARCH OF RESIDENT FACULTY

DR. MIKE BORMAN (Range Ecology and Restoration)

Goat grazing as a tool for controlling Himalayan blackberry.
Ongoing.

DR. JOHN BUCKHOUSE (Watershed and Riparian Management)

Twin Watershed Response to Juniper Overstory Reduction.
Ongoing.

DR. DOUGLAS JOHNSON (Landscape Ecology and Range Restoration)

Ecology and restoration of southwestern Oregon foothill rangelands.
Ongoing.

DR. WILLIAM KRUEGER (Plant/Animal Relations and Riparian Ecology)

State-and-transition modeling: nutrient changes within dry forest systems with canopy closure.
Ongoing.

DR. TAMZEN STRINGHAM (Rangeland & Riparian Ecology)

Research Projects with Graduate Students

1. Pat Shaver PhD candidate

Soil Moisture and Vegetation Responses to Juniper Removal on Sandy Soils in Central New Mexico

This project focuses on the long-term (20+ years) effects of soil moisture and vegetation response to the removal of One-seed juniper through herbicide application. Data will be used to increase our understanding of the impact of juniper on ecosystem processes and to further our ability to predict response to encroachment and/or treatment of juniper. State-and-transition models will be developed as a method for describing ecosystem change to land managers. Ongoing.

2. Casey Matney PhD candidate

Rehabilitation of winterfat rangelands: understanding the role of soil change

Dynamic soil properties are elements of the soil ecosystem that change with management and/or natural disturbance. Understanding the relationship between changes in soil structure and water capture and infiltration will further our knowledge concerning winterfat viability and seedling establishment. Ongoing.

3.. Mark Estes M.S. student

Nutritional value of native forages and restoration of a northern Great Basin valley using winterfat (*Eurotia lanata)* and squirreltail (*Sitanion hystrix*.).

Winterfat and squirreltail were broadcast seeded into four different seedbed preparations to determine if seedbed preparation increased the likelihood of seedling establishment and survival. The most successful seedbed preparation method for winterfat was the till treatment whereas squirreltail showed no preference between seedbeds. Ongoing.

5. Sarah Quistberg M.S. student

Riparian revegetation techniques for a reconstructed meadow channel

Two native sedge species *Carex nebrascensis* (Nebraska sedge) and *Carex utriculata* (beaked sedge) were planted as plugs into two geomorphic surfaces (depositional and erosional) within a reconstructed channel in northeast Oregon. In addition, within the erosional surface subplots with and without Canadian thistle were planted to determine the impact of this weed on sedge plug survival. Ongoing.

6. Ryan Leary M.S. student

Winterfat biomass production and seed viability with and without five years of rest from winter grazing.

Twenty one-half hectare exclosures were installed within three different winter grazed pastures in the Catlow Basin of southeastern Oregon in 2001. The viability and reproductive capabilities of winterfat, the dominant shrub within this ecosystem, is being compared between exclosures and grazed paired plots to determine whether or not five years of rest has been beneficial or not. Ongoing.

EASTERN OREGON STATE UNIVERSITY FACULTY

DR. LARRY LARSON (Weed Ecology)

Eastern Oregon rangeland research on the knapweed complex, perennial pepperweed, whitetop, and sulfur cinquefoil. Ongoing.

DR. MICHAEL MCINNIS

Restoration and maintenance of native plant diversity on deteriorated rangelands of the Great Basin and Columbia Plateau in a changing climate. Ongoing.

Invasive Plants Program for the Blue Mountain Demonstration Area (USDA Forest Service PNW Station)

OREGON / WASHINGTON / IDAHO

David A. Pyke
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Corvallis Research Group
3200 SW Jefferson Way
Corvallis, OR 97331

and

Cindy Salo
USGS Forest & Rangeland Ecosystem Science Center
Snake River Field Station
970 Lusk Street
Boise, ID 83706

INTRODUCTION

This report summarizes the revegetation and restoration research being conducted or contracted by the USGS, Forest & Rangeland Ecosystem Science Center (FRESC) for the period of January 1, 2006 to December 31, 2006. Research reported in this document was funded by USGS, the Bureau of Land Management, or by funds obtained through external granting agencies.

COMPLETED PROJECTS

1. Coordinated Intermountain Restoration Project (David A. Pyke and Cindy Salo, USGS, Forest & Rangeland Ecosystem Science Center, and Mike Pellant, Bureau of Land Management, Idaho State Office, Boise ID).

   An MS thesis was completed this year associated with this project. The greenhouse study examined the response of cheatgrass yields to applications of hydroseeding tackifiers (psyllium, plantago extracts and polyacrylimide) with and without sucrose. Cheatgrass biomass was negatively correlated with soil microbial N. The tackifiers did not reduce cheatgrass biomass by themselves, but psyllium increased soil microbial N.

2. Integrated Restoration Strategies towards Weed Control on Western Rangelands (Robert Nowak, Department of Environmental and Resource Science, University of Nevada – Reno and 11 other investigators including David A. Pyke, USGS, Forest & Rangeland Ecosystem Science Center).

We took the lead on analyzing the secondary weed and the microbial responses. Cheatgrass did not enhance the establishment of medusahead or squarose knapweed. A diverse mixture of native species (Wyoming big sagebrush, bluebunch wheatgrass, squirreltail, Sandbergs bluegrass, western yarrow and scarlet globemallow) established seedlings equally well as Vavilov Siberian wheatgrass. Applications of sucrose reduced the variation in the microbial community. Changes in microbial communities across the Great Basin are strongly influenced by changes in pH.

ONGOING PROJECTS

1. VegSpec. (Phil Smith, Natural Resources Conservation Service, Information Technology Center, Fort Collins, CO; John Patterson, NRCS, Lincoln, NE; James Henson, NRCS, Baton Rouge, LA; Steven Warren, Cntr. for Ecol. Mgmt. of Military Lands, Colo. State Univ., Ft. Collins, CO; David Pyke, USGS, Forest and Rangeland Ecosystem Science Center, Corvallis, OR)

   Current developments include a DVD/Quicktime movie that will provide a demonstration on how to use VegSpec. Also updates on the internal workings of the program.

2. Interactions of Cattle Grazing and Climate Change on Semi-arid Ecosystem Function (David Clausnitzer, David A. Pyke, Jayne Belnap, Tim Graham, USGS, Forest & Rangeland Ecosystem Science Center, and Robert Sanford, Denver University).

   Analysis of this project is still ongoing. We are using concentrating our efforts in using a structural equation modeling. The initial analyses are showing changes in physical soil parameters associated with livestock grazing intensity as measured by distance from water. We began testing the Century model using our data from the Great Basin and Colorado Plateau shrub grasslands. Modifications to the model are being conducted to allow it to operate correctly in these ecosystems.

3. Coordinated Intermountain Restoration Project (David A. Pyke and Cindy Salo, USGS, Forest & Rangeland Ecosystem Science Center, and Mike Pellant, Bureau of Land Management, Idaho State Office, Boise ID).

   We have on ongoing project under this program that began this year. One study is examining the dose responses of cheatgrass and medusahead yield to a range of sucrose applications to the soil in a site in Oregon and one in Idaho. We have initiated a study of seed bank longevity for Wyoming and mountain big sagebrush seeds.

4. Standardized Federal Emergency Stabilization and Rehabilitation Monitoring Protocols (David A. Pyke and Troy A. Wirth, USGS, Forest & Rangeland Ecosystem Science Center)

   Land management agencies with the USDA and USDI recognize the need for a common monitoring protocol within and among agencies. This specifically addresses the issue raised by a GAO report that the agencies cannot evaluate the effectiveness of Emergency Stabilization and Rehabilitation (ESR) treatments at meeting ESR program goals. We are testing a series of common monitoring procedures for their effectiveness in providing quantitative monitoring data using a standard procedure across the western US. We are also creating a standard database for data entry, retrieval and reporting.

5. Fire and Fire Surrogate Treatments for Restoration of Wyoming Big Sagebrush Communities (Cindy Salo, USGS, Forest & Rangeland Ecosystem Science Center, and Kelly Hogan, FWS, Hart Mt. National Antelope Refuge, Plush, OR).

   We are testing the prediction that fire surrogate treatments have the potential to decrease Wyoming big sagebrush densities and to allow native understory grasses and forbs to increase with lower risk of invasion by cheatgrass than with prescribed fire or wildfire. We collected pretreatment data in 2004 and 2005, then applied chemical (Tebuthiron) treatments in fall, 2005.

6. Fuels Management Treatments and Habitat for Greater Sage-Grouse (David A. Pyke and Cindy Salo, USGS, Forest & Rangeland Ecosystem Science Center).

   We are evaluating changes in vegetation after Dept. of the Interior fuels management treatments carried out at sites in Idaho, Nevada, Oregon, and Wyoming between 1997 and 2004, and comparing these changes with habitat needs of Greater Sage-Grouse. We collected field data in 2005 for evaluating changes in vegetation structure and cover and in abundance and diversity of food sources for sage-grouse (sagebrush, forbs, and ground-dwelling insects) at two spatial scales: fine-scale quantitative data to characterize patches (1 ha) and medium-scale qualitative data to determine the extent of different patch types across each fuels management treatment site and untreated comparison area. We collected an additional year's data in 2006.

7. Fire and fire surrogate treatments on sagebrush ecosystems (J. McIver, USFS PNW Res. Stn. and multiple investigators including USGS)

   This project will investigate the impacts of fire and fire surrogate treatments on ecosystem processes in mountain big sagebrush and Wyoming big sagebrush communities in the Great Basin. We have selected two sites on Hart Mountain National Antelope Refuge. On each site, we will collected baseline vegetation and soils data this year prior to applying a prescribed fire, herbicide (SPIKE 20P) and mechanical mowing of sagebrush to reduce fuels. Treatments are scheduled for fall 2007. We have located two additional sites in eastern Washington. One on Bureau of Reclamation lands near Saddle Mountain (N of Tri-Cities) and one on Nature Conservancy land in Moses Coulee.

CURRENT PUBLICATIONS AND PAPERS

Perkins, Lora B. 2006. Hydromulch tackifier and sucrose effects on microbial nitrogen and *Bromus tectorum* biomass. M.S. thesis. Oregon State University, Corvallis OR

UTAH

BRIGHAM YOUNG UNIVERSITY and U. S. FOREST SERVICE SHRUB SCIENCES LABORATORY

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INTRODUCTION

This report summarizes revegetation and restoration-related research conducted by faculty and scientists of Brigham Young University, the U.S. Forest Service Shrub Sciences Laboratory, and their cooperators for the year of 2006. Projects range from basic studies of physiology, ecology, and genetics to applied revegetation trials and weed control procedures.

COMPLETED PROJECTS

1. Effects of chaining on fire rehabilitation success in the Henry Mountains, Utah (Cristina Juran, Bruce Roundy, 275 WIDB Brigham Young University, provo, UT 84602, Jim Davis, Utah Division Wildlife Resources, Provo, Utah).

   Chaining increased establishment of aerial-broadcast native and introduced grasses on some fire rehabilitation sites. Aerial-seeded grasses and forbs established adequately without chaining on many sites. Successful establishment on these >1900 m elevation sites was associated with favorable spring precipitation after seeding and unusually high precipitation the second year after seeding.

2. Effects of disturbance on soil water availability in sagebrush steppe (Alison Whittaker, Utah Division of Wildlife Resources, Bruce Roundy, Brigham Young University 275 WIDB, Provo, UT 84602, Jeanne Chambers, Rocky Mountain Research Station, 920 Valley Road, Reno, Nevada 89512.)

   Time of available soil water increased with annual precipitation and site elevation. Time of surface soil water availability (1-3 cm) was increased by 12 days on a wetter year compared to a drier year, but was not affected by fire or perennial herbaceous species removal. Time of subsurface soil water availability (13-15 and 28-30 cm) was increased by 4-7 days by disturbance and was less affected by annual precipitation.

3. Effects of cheatgrass and browsing on big sagebrush growth and seed production (Jim Davis, Utah Division of Wildlife Resources, Daniel Eddington, and Bruce A. Roundy, Brigham Young University, 275 WIDB, Brigham Young University, Provo, UT 84602)

The effects of Plateau herbicide on reduction of cheatgrass on 7 big sagebrush communities are being studied. Plateau decreased cheatgrass cover, increased soil water availability, and increased sagebrush seed stalk length and annual leader growth. However, the herbicide also decreased the number of sagebrush flowering stalks resulting in fewer sagebrush seedlings the second year after treatment.

ONGOING PROJECTS

1. Ecology and Restoration of a Mojave Desert site (E. Durant McArthur, Stewart Sanderson, U.S. Forest Service Shrub Lab, Provo, UT 84401, and Bob Douglas, Dixie Field Office, Bureau of Land Management, St. George, UT).

   Monitoring is continuing to determine if and when annual plant dominance will shift to seeded perennial dominance. A new program for clustering associated species is being developed using a Mojave Desert plant community as a demonstration.

2. Ecology and Restoration of Cheatgrass Dominated Sites (Nancy Shaw, U.S. Forest Service Rocky Mountain Station, 316 E. Myrtle, Boise, Idaho 83702 and Scott Jensen, U.S. Forest Service Shrub Lab, Provo, UT 84401, and Mike Pellant, Bureau of Land Management, Boise, Idaho 83706.

   This project involves a number of studies designed to protect or restore sagebrush rangelands in southern Idaho and central Utah threatened by cheatgrass invasion or dominance. To encourage use of native grasses in revegetation, studies are progressing on rearing techniques to increase efficiency of native seed production. Large- scale seed production is being developed for forbs which hold promise for revegetation in the Great Basin.

3. Regeneration Biology of Shadscale (Susan Meyer and David Nelson, U.S. Forest Service Shrub Lab, Provo, UT 84401).

   Seedling disease studies are underway. A thermal time model has been successful in predicting changes in the chill response of afterripened seed. Publications are being prepared.

4. Regeneration Biology of Blackbrush (Susan Meyer and Burton Pendleton, and Janine Auger., U.S. Forest Service Shrub Lab, Provo, UT 84401).

   Data on home ranges and caching behavior of rodents are being collected. Size-age relationships are being developed to model blackbrush migration in relation to climate change.

5. Ecological Genetics of the Cheatgrass Head Smut Pathosystem (Susan Meyer and David Nelson, U.S. Forest Service Shrub Lab, Provo, UT 84401).

   Smut more effectively infects fall than winter-germinated cheatgrass. Ongoing studies are examining use of a bunt disease and a soil-borne fungus that attacks cheatgrass seeds in the soil during the winter.

6. Germination and Propagation of Native Forbs (Susan Meyer, U.S. Forest Service Shrub Lab, Provo, UT 84401).

   Requirements for germination are currently being tested for ecotypes of native forbs, including tall forb species.

7. Increasing Diversity of Mountain Big Sagebrush Stands (E.Durant McArthur, Stewart Sanderson, U.S. Forest Service Shrub Lab, Provo, UT 84401, Bruce Webb, Brigham Young University, Provo, UT 84602**,** Barbara Wachocki, and Mohammed Sandossi, Weber State University, Ogden, UT).

   Effects of tebuthiuron rates and season of application are being monitored on control and treated plots. Tebuthiuron thinned sagebrush stands , but did not increase understory diversity as much as was expected.

8. Fire history of Great Basin ponderosa pine communities (Stan Kitchen, U.S. Forest Service Shrub Lab, Provo, UT 84401).

   Historical fire regimes in two eastern Great Basin fire-sheds are being analyzed to determine regional patterns and local effects.

9. Native Plant Community Resistance to Weed Invasion (Phil S. Allen and Bruce A. Roundy, Brigham Young University, Provo, UT 84602; and Susan Meyer, U.S. Forest Service Shrub Sciences Lab, Provo, UT 84601).

   Low and high densities of 2 native grasses, 2 native shrubs, and 4 native forbs have been established in various combinations. Resource availability and weed resistance are being measured. Shrub and grass communities reduced, but did not eliminate weed population.

10. Establishment of Reserve Pastures for Camelids on the Bolivian Altiplano (Val Jo Anderson and Bruce A. Roundy, Benson Institute and Brigham Young University, Provo, UT 84602).

A variety of introduced grasses and shrubs have been seeded or transplanted at 3 sites in the Altiplano. Llama forage preference was measured in 2004. Llamas preferred timothy and orchard grass over other grasses and did not browse shrubs. Seed production of the adapted, introduced species at 3 elevation site has been limited. This project will focus on collecting and testing native grasses to improve forage production in the future.

11. Native seed production (Val Jo Anderson, Robert Johnson, Bruce A. Roundy, and various other cooperators at Brigham Young University, Provo, UT 84602, in cooperation with Scott Jensen, U.S. Forest Service Shrub Sciences Lab, Provo, UT 84601, and Jason Vernon, Utah Division of Wildlife Resources, Ephraim, UT 84627).

Effects of rearing practices on production of native forbs, grasses, and shrubs are being investigated at the Brigham Young University Farm, Spanish Fork, Utah. Seed production of globemallow species responded best to cultural practices such as row spacing and mulch applications. Methods of increasing native stand shrub seed production are being studied on 2 field sites. Reducing competition increased numbers of reproductive spurs of bitterbrush in wildland stands. Insects were also found to reduce native wildland forb seed production by 40%.

12. Effects of vegetation changes on bee diversity (Val Jo Anderson and Robert Johnson, 275 WIDB, Brigham Young University, Provo, UT 84602).

Bee diversity is being sampled to determine effects of vegetation conversion from sagebrush/juniper plant communities to cheatgrass or crested wheatgrass on 4 sites. Bee diversity may affect pollination and reproductive success of rare plants.

13. Increasing diversity of crested wheatgrass stands (Bruce A. Roundy and Val Jo Anderson, Brigham Young University, Provo, UT 84602).

Herbicidal and mechanical partial and full control of wheatgrass are being compared in relation to success of sown native species and weed invasion on 2 sites in Utah. Cooperators in Idaho have installed similar experiments. Both herbicidal and mechanical treatments have produced partial and near-complete control of crested wheatgrass, but seedbanks still contain many crested wheatgrass and weed seeds. Two-way discing best controlled crested wheatgrass, but many crested wheatgrass seedlings emerged in spring 2006. Seeded native grasses also emerged well, as did flax, but seeded shrubs and other forbs had low emergence, even though precipitation and soil water availability support high emergence. First and second-year responses to treatments will be measured spring 2007.

14. A regional experiment to evaluate effects of fire and fire surrogate treatments in the sagebrush biome (Jim McIver, Forestry and Range Sciences Lab, La Grande, OR

97850, and 19 others including Bruce A. Roundy, Brigham Young University, Provo, UT 84602).

A 5 year study of vegetation thresholds after fire and mechanical disturbance to restore function in sagebrush communities at risk from weed and woodland invasion has begun. This large project is funded by the Joint Fire Sciences Program and will measure vegetation, wildlife, insect, soil and hydrologic responses to disturbance on multiple sites in different ecological provinces. Pre-treatment vegetation and soil sampling was conducted summer 2006. Mechanical and fire treatments will be installed in fall 2006 and 2007.

15. Hydrothermal modeling of seed germination and root growth (Bruce A. Roundy Brigham Young University, Provo, UT 84602).

BYU undergraduate student mentoring funds and native seed funds are being used to support students testing seed germination rate and seminal root growth rates in relation to heat accumulation (degree hours or days). Using soil water potential as a threshold switch, we are determining whether germination and seedling growth predictions from our models match germination in seed bags, seed germination in small plots, and seedling survival data from 2 field sites. So far, our germination model correctly predicted fall 2005 and spring 2006 seed bag germination for most species.

CURRENT PUBLICATIONS AND PAPERS

Bain, N. B., S. E. Meyer, and P. S. Allen. 2006. A hydrothermal after-ripening time model for seed dormancy loss in *Bromus tectorum* L. Seed Science Research 16: 17-28.

Bedunah, D. J., E. D. McArthur, and M. Fernandez-Gimenez. 2006. Preface, p. iii-iv in Rangelands of Central Asia: proceedings of the conference on transformations, issues, and future challenges. USDA Forest Service, Rocky Mountain Research Station Proceedings RMRS-P39, Fort Collins, CO.

Bedunah, D. J., E. D. McArthur, and M. Fernandez-Gimenez (compilers). 2006. Rangelands of Central Asia: proceedings of the conference on transformations, issues, and future challenges. USDA Forest Service, Rocky Mountain Research Station Proceedings RMRS-P39, Fort Collins, CO. 127p.

Eddington, Daniel B. 2006. Effects of cheatgrass control on Wyoming big sagebrush in southeastern Utah. MS thesis, Brigham Young University, Provo, Utah. 30 p.

Fugal, Rachel. 2006. Evaluation of forage production, camelid acceptability, and nutrition of grasses and shrubs introduced for dry season supplementation on the Bolivian Altiplano**.** MS thesis, Brigham Young University, Provo, Utah.

Kitchen, S. G. 2006. Release of Maple Grove germplasm Lewis flax. Certified Seed Gleanings 25 (1): 2.

McArthur, E. D. and S. C. Sanderson. 2006. Salicaceae. p. 444 in K. Marhold IAPT/IOPB chromosome data 1. Taxon 55: 443-445.

Meyer, S. E., D. Quinney, and J. Weaver. 2006. A stochastic population model for *Lepidium papilliferum* (Brassicaceae), a rare desert ephemeral with a persistent seed bank. American Journal of Botany 93: 237-248.

Ramakrishnan, A. P., S. E. Meyer, D. J. Fairbanks, and C. E. Coleman. 2006. Ecological significance of microsatellite variation in western North American populations of *Bromus tectorum*. Plant Species Biology 21: 61-73.

Sanderson, S. C., J. E. Ott, E. D. McArthur, and K. T. Harper. 2006. RCLUS, a new program for clustering associated species: a demonstration using a Mojave Desert plant community dataset. Western North American Naturalist 66: 285-297.

Thompson, T. W., B. A. Roundy, E. D. McArthur, B. D. Jessop, B. Waldron, and J. N. Davis. 2006. Fire rehabilitation using native and introduced species: a landscape trial. Rangeland Ecology and Management 59: 237-248.

White, E. P., P. B. Adler, W. K. Lauenroth, R. A. Gill, D. Greenbereg, D. M. Kaufman, A. Rassweiler, J. A. Rusak, M. D. Smith, J. R. Steinbeck, R. B. Waide, and J. Yao. 2006. A comparison of the species-time relationship across ecosystems and taxonomic groups. Oikos 112: 185-195.

Whittaker, Alison. 2006. The effect of herbaceous species removal, fire, and cheatgrass (*Bromus tectorum*) on soil water availability in sagebrush steppe. MS thesis, Brigham Young University, Provo, Utah. 31 p.

UTAH

UTAH STATE UNIVERSITY

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INTRODUCTION

This report summarizes research activities related to revegetation and stabilization of deteriorated and altered lands at Utah State University for the calendar year 2006.

COMPLETED PROJECTS

1. Integrated Restoration Strategies Towards Weed Control on Western Rangelands (**Robert Nowak {overall project PI}** & Hudson Glimp, University of Nevada, Reno; Paul Doescher & John Tanaka, Oregon State University; **Eugene W. Schupp {Utah State University PI**} & Chris Call, Utah State University; Jeanne Chambers & Robin Tausch, USFS Rocky Mountain Research Laboratory; Dave Pyke, USGS Forest & Rangeland Ecosystem Science Center; Bob Blank & Tom Jones, USDA ARS; Mike Pellant, USDI BLM Idaho State Office; and Dan Ogle and Loren St. John, USDA Natural Resources Conservation Service). Funded by USDA CSREES IFAFS.

   Our overall goal was to provide a scientific foundation for developing management strategies for control of cheatgrass and other weeds in the Great Basin and for restoration of infested lands to productive native rangelands. This project is completed in that funding ended in September 2006. Nonetheless, data collection on Experiment 3 (see below) will continue with other support and the intention is to resample Experiments 1 and 2 in the future, depending on funding availability.

   This study was based on three experiments:

   Experiment 1: Screen 25 accessions of restoration material for competitiveness against cheatgrass.

   Objective: Identify suitable material for a transition stage in restoration from cheatgrass-infested range to diverse native range, and to evaluate generality of results across the Basin.

   Experiment 2: Investigate whether competitive interactions between cheatgrass and native perennials vary with nitrogen availability, perennial diversity, and with presence or absence of secondary weeds.

Objectives: Determine the role of nitrogen availability in competition
between cheatgrass and perennials; determine if a carefully selected set of perennial species is more competitive than individual species; determine if responses change with varying densities of perennials and cheatgrass (not in Utah); determine if the presence of secondary perennial weeds alter the interactions between cheatgrass and perennials.

Experiment 3: Investigate a series of potential restoration strategies at a larger scale, including prescribed fire, selected species mixtures, etc. This experiment will also be used for economic analyses, environmental education, and extension.

Objectives: Determine the effectiveness and the economic viability of a variety of potential restoration techniques; provide environmental education opportunities for the general public to help them understand rangelands, the threats they face, and restoration potential; provide outreach to public landowners and State and Federal land managers on restoration strategies.

Experiment 1 and 2 were conducted at two sites in each of four States (Utah, Nevada, Idaho, and Oregon), one relatively drier and one relatively wetter. This allows cross-Basin comparisons. Experiment 3, because of its size, was only conducted in a single site north of Reno, Nevada.

Experiment 1 involved sowing at all eight sites the same 21 available accessions of potential restoration materials. The remaining 4 accessions vary slightly among sites, depending on local interest. Seedings were done with and without cheatgrass competition. This experiment was drill-seeded in Fall 2003 and replicate plots were seeded in Fall 2004. Two year results for the both seedings are completed and data analysis is in progress.

Experiment 2 involved at all eight sites the core factorial experiment of: 9 perennial treatments (6 species of native perennials as monocultures, the 6 natives as a mixture, crested wheatgrass as monoculture, and no perennials) x 2 nitrogen treatments (with or without mobilization) x 2 cheatgrass treatments (with or without cheatgrass). One of the Utah sites also includes 2 secondary weed treatments (with or without squarrose knapweed, a weed already present at that site) crossed with the treatment combinations in the perennial mixture treatment. This experiment was sown in Fall 2003 and Fall 2004. Two year results for the both seedings are completed and data analysis is in progress.

Experiment 3 was initiated in 2005. The plot is north of Reno, NV. A single years sampling has been completed. More sampling is necessary before data analysis begins.

ONGOING PROJECTS

1. Role of seed predation in restoration of cheatgrass-infested rangelands (Steven Ostoja and Eugene W. Schupp, Utah State University, and William Longland, ARS Reno, NV). Funded by USDA CSREES IFAFS.

   This research builds on the overall completed restoration project (1) above and involves a series of five experimental studies addressing the impacts of seed-eating ants and rodents on seeds of desirable species and weeds in a restoration context. The core of the project deals with the net effect of rodents on desirable seeded species through their predation and seed caching roles. Field and laboratory experiments are mostly complete, data analysis largely completed, and the writing of a dissertation is in process.

2. Nutrient interactions and competition between exotic weeds and native grasses (Jeff Burnham and Eugene W. Schupp, Utah State University) Funded by USDA CSREES IFAFS.

   This research project is also an outgrowth of the larger completed restoration project above (1) and involves two experiments on the effects of nutrients on three-way interactions among bluebunch wheatgrass, cheatgrass, and squarrose knapweed during establishment. A field experiment addresses the effects of ratios of nitrogen and phosphorous while a green house experiment more thoroughly explores a range of nitrogen availabilities. The field experiment is completed and analyses are in progress; the green house experiment is presently being conducted.

3. A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome (J.D. McIver, Oregon State University; M. Brunson, Utah State University; S. Bunting, University of Idaho; J. Chambers, USFS; C. D'Antonio, University of California Santa Barbara; P. Doescher, Oregon State University; S. Knick, USGS FRESC; R. Miller, Oregon State University; M. Pellant, BLM; F. Pierson, USDA ARS; D. Pyke, USGS FRESC; K. Rollins, University of Nevada Reno; B. Roundy, Brigham Young University; **E.W. Schupp, Utah State University**; R. Tausch, USFS; D. Turner, USFS; M. Wisdom, USFS) Funded by Joint Fire Sciences Program.

   This region-wide project, known as SageSTEP (Sagebrush Steppe Treatment Evaluation Project) was funded in Summer 2005 and is now being implemented. We are designing experiments to evaluate the effects of fire and fire surrogate treatments on vegetation and fuel responses on sagebrush communities of the Great Basin with the ultimate goal of developing strategies for restoring this endangered ecosystem. Our experiments will: 1) provide managers with guidelines for restoring communities that is relevant across the 100+ million acres of the sagebrush biome; 2) be relevant to the temporal and spatial scales at which managers operate; and 3) reduce management risk and uncertainty of catastrophic wildfire to the greatest degree possible. Although there are numerous integrated objectives, the core objective is to quantify ecological thresholds, through the application of alternative treatments over a wide array of conditions. Specific objectives we will address include:

(1) Identify and quantify the abiotic and biotic thresholds that determine sustainability, or "recoverability" of big sagebrush plant communities in sagebrush-steppe and sagebrush semi-desert environments, specifically related to threats posed by cheatgrass and pinyon-juniper invasion.

(2) Assess the ecological effects of fire and fire surrogates on big sagebrush communities at risk of crossing a threshold of conversion to cheatgrass or pinyon-juniper, beyond which restoration may be difficult or logistically infeasible.

(3) Document how fuel loads change across vegetation treatments and ecological sites in relation to the objectives above.

(4) Elucidate the ecological, social, and economic trade-offs and treatment effects of no action, applying only fire and fire surrogate treatments, and restoration treatments in these sagebrush communities.

(5) Provide insight and guidance regarding use of our results for effective multi-species and multi-scale planning as part of ecosystem management of sagebrush communities in the Great Basin.

Utah State University is responsible for implementing and monitoring a series of sagebrush plots threatened with invasion by cheatgrass in the eastern Great Basin and Snake River Plain. In summer 2006 we obtained pretreatment data on a set of replicate plots in Rush Valley, Utah (Onaqui), and a second set of plots in the Owyhee Desert, northeastern Nevada (Owyhee). A third site in southeastern Idaho (Roberts) will be sampled this summer. We are presently seeking one additional site. Treatments for this part of the study are: (1) control, (2) relatively cool late-summer burn, (3) herbicide at a rate to kill approximately 50% of the sagebrush and (4) rotary mowing at a blade height to kill approximately 50% of the sagebrush. In addition, subplots will be treated with pre-emergent herbicide to the extent allowed by BLM rules. Onaqui treatments were applied in Fall 2006; the first post-treatment resampling for this site will be in summer 2007. Treatments for Owyhee and Roberts are scheduled to be applied in Fall 2007.

4. <u>Mycorrhizae and fire rehabilitation</u> (Dara Scherpenisse and Eugene W. Schupp, Utah State University) Funded by Joint Fire Sciences Program.

Building on the Joint Fire Sciences project above (3) we are investigating the role of mychorrizae in sagebrush restoration in two greenhouse experiments. Experiment 1 addresses the response of *Pseudoregeneria spicatum* (late seral perennial grass), *Elymus elymoides* (early seral perennial grass), and *B. tectorum* (annual weedy grass) to mycorrhizal symbiosis. The experiment will vary water availability and phosphorous concentration. Experiment 2 will build on experiment 1 by investigating: (1) the effects of mychorrizae on competition among the three species above and (2) whether commercially available mychorrizae function differently than mychorrizae cultured from a local sagebrush stand. Experiment 1 has been completed and samples are being processed. The culturing of local mychorrizae is in progress for initiating Experiment 2 in late Spring.

5. Seed banks and sagebrush restoration (Kristen Pekas and Eugene W. Schupp, Utah State University) Funded by Joint Fire Sciences Program.

We also are conducting a study as part of the Joint Fire Sciences project above (3) to investigate (i) the relationship between existing vegetation and the seed bank and (ii) the contribution of the seed bank to post-treatment vegetation responses. This study is being conducted at the Onaqui SageSTEP site. Pretreatment soil seed bank samples were collected in late summer 2006, shortly before treatments were applied. Subplots in the control and burn treatment plots were resampled immediately after the fire. All subplots will be resampled again in late summer 2007 after dispersal of most species has occurred. We have begun germinating samples in the greenhouse to quantify the germinable seed bank.

6. Effects of vegetation treatments on granivorous rodent communities (Stephen M. Ostoja and Eugene W. Schupp, Utah State University) Funded by Joint Fire Sciences Program.

Once again building on the Joint Fire Sciences project above (3) we are monitoring the granivorous rodent communities at the Onaqui SageSTEP site in the control, fire, and mowing treatment plots using Sherman live trap grids. Trapping was done before and immediately after treatments were applied; trapping will continue periodically over the next several years.

7. Cheatgrass and vegetation treatment effects on seed foraging by Western harvester ants (Scott Newbold and Eugene W. Schupp, Utah State University) Funded by Joint Fire Sciences Program.

Yet again building on the Joint Fire Sciences project above (3) we are investigating the effects of cheatgrass abundance and of burning and mowing on the selection, consumption, and dispersal of desirable perennial seeds by harvester ants. Research was begun at the Onaqui SageSTEP site in summer 2006. Research will begin at Owyhee and Roberts in summer 2007.

8. Effect of Vegetation Manipulation on Watershed Processes and Function (Ron Ryel, Jim Long, Fred Baker, and Helga van Miegroet, Utah State University) Funded by Natural Resources Conservation Service.

Conversion of quaking aspen (*Populus tremuloides*) forests to conifer-dominated communities is widespread in much of the Intermountain West. It is estimated that in Utah there has been a 50% decline in aspen-dominated stands in the last 50 years. Resource value loss associated with these changes include water yield, grazing potential, wildlife habitat, species diversity, water quality through increased sediment transport. While the regeneration ecology of aspen is well understood, there is much that we do not know concerning implementation of ecologically and economically sound and socially acceptable treatments. In cooperation with Deseret LLC, we are evaluating a broad range of potential aspen regeneration methods. The fundamental objective is the development of a diversity of effective strategies for regenerating aspen communities where they are currently being displaced by conifers. Treatments will include prescribed burning, timber harvest and biological treatment. In addition to evaluating regeneration potential of various treatments, we must also monitor response to herbivory, understory development, invasive weed encroachment, conifer regeneration, livestock forage value, wildlife habitat value and use, changes in soil biogeochemistry, sediment transport, and hillslope stability. Pretreatment data are now being collected.

PLANNED OR POTENTIAL PROJECTS

1. Effects of plant spatial patterns on ecosystem processes in a restoration context (Andrew Rayburn and Eugene W. Schupp, Utah State University) Funded by Joint Fire Sciences Program.

   Once again building on the Joint Fire Sciences project above (3) we are designing a series of experiments to investigate the effects of spatial structuring of individuals and populations at various spatial scales on ecosystem processes. These studies are in the early stages of development.

CURRENT PUBLICATIONS AND PAPERS

Allcock K., R. Nowak, B. Blank, T. Jones, T. Monaco, P. Doescher, T. Tanaka, D. Ogle, L. St. John, M. Pellant, D. Pyke, V. Satyal, J. Tanaka, E.W. Schupp and C. Call. 2006. Integrating weed management and restoration on western rangelands. *Ecological Restoration* 24:199-200.

WYOMING

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INTRODUCTION

This report summarizes the revegetation and stabilization of disturbed land research activities conducted during 2006 at the University of Wyoming and emphasizes activities of the Department of Renewable Resources and the Restoration Ecology program. The projects listed below were funded by federal and state agencies as well as private industry including the Abandoned Coal Mine Land Research Program (ACMLRP) and the Agricultural Experiment Station Competitive Grant Program at the University of Wyoming. The ACMLRP support is administered by the Land Quality Division of the Wyoming Department of Environmental Quality from funds returned to Wyoming from the Office of Surface Mining of the U.S. Department of Interior.

COMPLETED PROJECTS

1. Simulated Weathering of Saline and Sodic Minesoils from Northwestern New Mexico and Northeastern Arizona (B.D. Musslewhite, BHP-Billiton San Juan Coal Company, P.O. Box 561, Waterflow, NM 87421; T.H. Brown, Poudre Valley Environmental Sciences, Inc., 4419 View Point Court, Fort Collins, CO 80526; G.W. Wendt, Peabody Western Coal Company, P.O. Box 650, Kayenta, AZ 86033; C.R. Johnston, Western Research Institute, 365 N. 9th St., Laramie, WY 82072)

   The effects of weathering on alkaline minesoil (root-zone material) chemistry are poorly documented in the literature. Study of the important relationship between electrical conductivity (EC) and sodium adsorption ratio (SAR) have largely been focused on agricultural and rangeland soils. Chemical and physical properties of minesoils are unique and quite different from natural soils formed over hundreds of years through pedogenic processes. These differences largely occur because relatively unweathered overburden is exposed during mining processes and subsequently used as a lower root-zone medium (minesoil) during soil reconstruction. Some of these materials are classified as sodic and therefore are considered unsuitable rooting media for establishment of native vegetation. Weatherable minerals (e.g., pyrite, calcite, gypsum, and other geologic substrates) present in minesoils can effectively remediate or mitigate an elevated SAR condition by maintaining EC levels in the soil solution to promote clay particle stability and by providing sources of exchangeable calcium and magnesium. Coversoil (i.e., topsoil) enhances remediation through physical and chemical buffering between sodic root-zone material and the reconstructed soil surface. A laboratory column study was used to evaluate weathering potential of ten minesoil materials from three mining operations in the northwestern New Mexico and northeastern Arizona. Columns were prepared with 15 cm of coversoil over 30 cm of minesoil and subjected to simulated precipitation. Chemical evaluations of weathered materials indicated significant reductions in EC and SAR and overall improvement of minesoil quality. Drainage waters from the three coversoils suggest these materials behave as a chemical buffer above the underlying sodic materials. Coversoils provide a source of calcium and other electrolytes that promote physical stability and enhance remediation of sodic minesoil materials.

2. Salinity and Sodicity Interactions of Weathered Minesoils in the Four Corners Region (B.D. Musslewhite, BHP-Billiton San Juan Coal Company, P.O. Box 561, Waterflow, NM 87421; J.R. Vinson, New Mexico Mining and Minerals Division, 1220 South St. Francis Dr., Santa Fe, NM 87505; C.R. Johnston, Western Research Institute, 365 N. 9th St., Laramie, WY 82072; T.H. Brown, Poudre Valley Environmental Sciences, Inc., 4419 View Point Court, Fort Collins, CO 80526; G.W. Wendt, Peabody Western Coal Company, P.O. Box 650, Kayenta, AZ 86033; G.F. Vance, Dept. of Renewable Resources, University of Wyoming, Laramie, WY 82071-2000)

   Relationships between electrical conductivity (EC) and sodium adsorption ratio (SAR) changes over time in reconstructed soils at surface coal mining operations are insufficiently documented in the literature. Some minesoils (i.e., rootzone material) are classified as saline, sodic, or saline-sodic and have been considered unsuitable for revegetation. Weatherable minerals (e.g., pyrite, calcite, gypsum, and silicates) are commonly present in alkaline minesoils that can mitigate elevated SAR levels by maintaining or increasing electrolytes in the soil and provide sources of exchangeable calcium and magnesium. Coversoil (i.e., topsoil) enhances mitigation by providing soluble cations to drainage water percolating into minesoils. Weathering characteristics of minesoils and rooting patterns of key reclamation species were evaluated at sites from three surface coal mines in northwestern New Mexico and northeastern Arizona. Unweathered minesoils were grouped into 11 classifications based on EC and SAR. Comparison of saturated paste extracts from unweathered and weathered (6 to 14 years after reclamation) minesoils show significant ($p < 0.05$) reductions in SAR levels and increased EC. Weathering increased the apparent stability of saline and sodic minesoils thereby reducing risks of aggregate slaking and clay particle dispersion. Root density of fourwing saltbush (Atriplex canescens), alkali sacaton (Sporobolus airoides), and Russian wildrye (Psathyrostachys junceus) were generally unaffected by increasing minesoil EC and SAR levels. Saline and sodic minesoils can be successfully reclaimed when covered with topsoil and seeded with salt tolerant plant species.

3. Soil Physical Property Impacts from Land Application with Saline-sodic Coalbed Methane Water (L.A. King and G.F. Vance, Department of Renewable Resources, University of Wyoming, Laramie, WY 82072; G.K. Ganjegunte, Texas A&M Agricultural Research and Extension Center, El Paso, TX 79927)

   Development of coalbed methane (CBM) reserves in the Powder River Basin (PRB) of Wyoming and Montana is also extracting large volumes of co-production water. Water volumes are anticipated to exceed 162,000 ha-m in the PRB by 2020, requiring development of suitable water handling strategies. Land application with sprinkler irrigation is a common water management method. This study examined impacts to soil physical properties after one to four seasons of land application with saline (electrical conductivities (EC) between 1.6 and 4.8 dS m-1) and sodic (sodium adsorption ratios (SAR) between 17 and 56 mmol1/2 L-1/2) CBM water. Treated (irrigated) and representative control (non-irrigated) areas from six study sites were directly compared during the 2003 and 2004 field seasons. Soil types, plant communities and management strategies were variable across study sites although fine-textured soils pre-dominate. A companion study (King et al., 2007) showed significantly increased soil EC and SAR in surface horizons of study site treated areas. These increases were associated with significant reductions in surface infiltration rates ($p \leq 0.10$) on treated areas at all study sites. Three treated areas averaged ≤ 0.4 cm hr-1. Darcy flux rates were evaluated as indicators of impact to water flow patterns within soil profiles. Treated (vs. control) area Darcy flux rates were significantly reduced for 27 of 30 samples at depths to 120 cm. Our findings reflect degraded soil physical properties and diminished rates of soil water movement following saline-sodic CBM water applications. Concern is indicated for effectiveness of current sodium and soluble salt management and treatment strategies and for successful reclamation mitigation efforts after CBM water applications cease.

4. Soil Chemical Property Impacts from Land Application with Saline-sodic Coalbed Natural Gas Water (L.A. King and G.F. Vance, Department of Renewable Resources, University of Wyoming, Laramie, WY 82072; G.K. Ganjegunte, Texas A&M Agricultural Research and Extension Center, El Paso, TX 79927)

   Development of coalbed natural gas (CBNG) reserves in the Powder River Basin (PRB) of Wyoming and Montana is driven by national energy demands. Wyoming's PRB has over 13,000 CBNG producing wells with more than 50,000 projected. Large volumes of CBNG co-production water associated with CBNG extraction will exceed 162,000 hectare-meter (ha-m) in the PRB by 2020, requiring water handling strategies. Land application with sprinkler irrigation systems is a common water management method. Impacts were examined to various soil chemical properties from one to four seasons of land application with saline (electrical conductivities (EC) between 1.6 and 4.8 dS m-1) and sodic (sodium adsorption ratios (SAR) between 17 and 56 mmol1/2 L-1/2) CBNG water. Treated (irrigated) and representative control (non-irrigated) areas were established at six study sites and sampled during the 2003 and 2004 field seasons. Soil types, plant communities and management strategies were variable across study sites. Treated and representative control area data were compared. Soil texture, pH, EC, SAR and exchangeable sodium percentage (ESP) were measured at various soil depth intervals to 120 cm. Multiple year applications of CBNG water produced consistent trends of significantly increased soil EC, SAR and ESP values at variable depths down to 120 cm. Consistent trends of reduced pH values on treated (vs. control) areas were also determined. Less dramatic alterations to soil chemical properties were measured on a coarse-textured site. These findings indicate concern for effective Na^+ and soluble salt leaching success with current management and treatment strategies.

5. Using native grasses to competed with Russian Knapweed invasions (S. Tyrer, A.L. Hild, L. Munn and B. Mealor, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071)

   The establishment and growth of native species in soils where Russian knapweed (*Acroptilon repens* (L.) DC.) has been removed is unclear, making revegetation of areas where this weed has been controlled difficult. In a greenhouse study, we examined emergence and growth of two native forbs, *Gaillardia aristata* Pursh. and *Dalea purpurea* Vent. and two native shrubs, *Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young and *Krascheninnikovia lanata* (Pursh) A.D.J. Meeuse & Smit. Soils used in this experiment were obtained from within Russian knapweed invasions and adjacent non-invaded areas near Greybull and Riverton, Wyoming, and Greeley, Colorado. Because prior studies suggest zinc (Zn) accumulations within Russian knapweed invasions may negatively affect native species, plants grown in invaded and non-invaded soils in the greenhouse study were analyzed to ascertain whether more Zn accumulated in species grown in soils from invaded areas than non-invaded areas. To clarify whether Russian knapweed alters soil properties we also examined soil physical and chemical properties of invaded and non-invaded areas at each site. All species germinated and established in soils from Russian knapweed invasions. We suggest in areas where Russian knapweed has been removed, the soil properties should not limit the emergence and establishment of native non-graminoid species. This project concludes in 2006 and publications are in progress.

6. Structure and Function of Microbial Communities in Mine-Impacted and Pristine Environments: A Comparative Study. (E. McClain, P.D. Stahl, C.S. Chandler, P.S. Colberg. Department of Biology, Ft. Belknap College, Harlem, MT and Departments of Renewable Resources and Zoology and Physiology, University of Wyoming, Laramie, WY 82071. 2004-2006, Renewal.)

   This projec t was designed to provide an assessment of the impacts of mining activities on soil microbes at the Zortman-Landusky mine site, which is adjacent to the southern boundary of the Fort Belknap Indian Reservation. Soil samples collected from the mine site will be compared to soil samples collected from nearby non-impacted areas. Samples from ech site will be analyzed to determine: 1. Microbial community composition, 2. Microbial biomass, 3. Degree and extent of nutrient cycling, 4. Potential for bacterial sulfate reduction. By investigating these four parameters, researchers will be able to assess the impacts of mining activities on soil microbes ability to to perform important ecosystem functions related to nutrient cycling. Data will also be used to assess effectiveness of current mine reclamation efforts in restoring soil health at the mine site. Knowledge gained from this study will help tribal leaders, stste regulators and reclamation engineers identify effective strategies for restoring the Zortman-Landusky mine site and protect human health and natural resources downstream.

ONGOING PROJECTS

1. Changes in Soil Physical and Chemical Properties of a Cropland Irrigated with Cbng Produced Water (C.R. Johnston and G.F. Vance, Department of Renewable Resources, 1000 E. University Ave., University of Wyoming, Laramie, WY 82071-2000; Song Jin, Western Research Institute, 365 N. 9th Street, Laramie, WY 82072.

   Significant quantities of water are being discharged as a by-product of coalbed natural gas (CBNG) development in the Powder River Basin (PRB). Elevated salinity and sodicity in CBNG produced water has become a major concern, particularly with regard to its use or disposal. If used for irrigation, elevated salinity and/or sodicity in CBNG produced water may adversely affect soil physical properties such as structure, infiltration, permeability, and aeration. Soil chemical properties impacted by CBNG produced water used for irrigation include changes in nutrient supply, modification of the soil exchange complex with dispersion, and pH effects. Elevated salinity may also affect plant uptake of water and nutrients that are essential for photosynthesis and optimal plant growth. A sodic soil has been shown to maintain good soil structure if the salinity level is maintained above the threshold electrolyte concentration (TEC). In this study, cropland that was irrigated with Piney Creek and CBNG waters were sampled one and three years after application to evaluate changes in soil physical and chemical properties. Treated CBNG water received either gypsum, sulfur burner or both, and soils treatments included gypsum, elemental sulfur, or both. Changes in pH, electrical conductivity (EC), sodium adsorption ratio (SAR), and sulfate concentrations were determined at the beginning of the study, one year after water application and two years following water application. Changes in soil physical and chemical properties were monitored using a split plot experiment. In addition, single ring infiltration experiments were conducted to determine if infiltration rates were influenced by water type, and water and soil treatments.

2. Carbon Sequestration in Reclaimed Coal Mine Lands of Wyoming (G.K. Ganjegunte, Department of Soil and Crop Sciences, Texas Agricultural Experiment Station, The Texas A&M University System, 1380 A&M Circle, El Paso, TX 79927; P.D. Stahl and G.F. Vance, Department of Renewable Resources, P O Box 3354, University of Wyoming, Laramie, WY 82071-3354

   Wyoming is the leading producer of coal in the U.S. Coal mining activities have resulted in depletion of soil organic carbon (SOC) due to greater oxidation rates of the disturbed materials. Low SOC content of reclaimed mine lands presents a great opportunity to sequester CO2 through revegetation. This research evaluated the rates and mechanisms of SOC accumulation in reclaimed coal mines of Wyoming. Soil samples were collected (0-30 cm) from mines that had been reclaimed for 6 to 20 years with cool-season-grasses (CS) and shrubs (SH). Soil samples were also collected from topsoil stockpiles that have been stored for 3 months and 16 years. Samples were analyzed for organic C using an elementar CNS analyzer with lignin concentrations in soil samples evaluated using the alkaline CuO oxidation method followed by HPLC quantification. Results of the study indicated that SOC content of reclaimed soils increased with time. In cool season grass sites, SOC content (0-30 cm depth) increased with time from 25 Mg ha-1 in 3 months old topsoil stockpile to 33 Mg ha-1 in 20 yrs old sites. Shrub sites showed the opposite trend of declining SOC content in reclaimed sites with time, which ranged from 31 Mg ha-1 in 6 year old shrub site to 23 Mg ha-1 in 16 year old shrub site. The SOC contents of control sites (unmined areas) were greater than that of reclaimed sites (47 vs 48 Mg ha-1 for CS and SH sites, respectively). Lignin contents of SOC in reclaimed sites were significantly greater than that of control, indicating there has been an accumulation of recalcitrant organic C compounds in reclaimed sites. Results of our study indicated there was greater C sequestration potential of reclaimed mine lands and that the biochemical mechanism can be the major C stabilization process in reclaimed mine lands of Wyoming.

3. Innovative Technology Development to Maximize Beneficial Use of Produced Water from Coal Bed Natural Gas Operations in the Powder River Basin, Wyoming (G.F. Vance, R.C. Surdam and G.K. Ganjegunte, Department of Renewable Resources,

University of Wyoming, Laramie, WY 82071-3354 and Wyoming State Geological Survey, Laramie, WY 82073)

Wyoming has experienced rapid growth in the development of coal bed natural gas (CBNG), particularly in the Powder River Basin (PRB). Exploration and production is expected to increase not only in the PRB, but also in other areas of Wyoming. A contentious issue associated with CBNG production is what to do with all the produced water that must be removed in order for coal seams to degas. The primary concern with CBNG produced waters is the amount and influence sodium (Na+) (as defined by the sodium adsorption ratio (SAR)) has on soils, vegetation, wildlife and livestock in different environments, e.g., streams, agricultural lands, rangelands, and other PRB ecosystems. We are proposing research that will examine the use of calcium (Ca2+)-rich zeolitic materials as Na+ exchangers. Reduction in the amount of Na+ and a lowering of SAR will result in CBNG produced waters that can be beneficially used by the industry, land owners, and for downstream users. Proposed research will involve the completion of three (3) tasks including: 1) determination of cation exchange capacity (CEC), exchangeable cations, and volumetrics of selected zeolites (i.e., clinoptilolite) deposits; 2) evaluation of the potential for cation exchange reactions between CBNG produced water and natural clinoptilolite-rich deposits to reduce CBNG water SAR's; and 3) design of an economic, viable water treatment scenario based on cation exchange between natural clinoptilolite and CBNG produced waters.

4. <u>Potential Utilization of Natural Zeolites for Treating Coalbed Methane Natural Gas (Cbng) Produced Waters: Batch and Column Studies</u> (G.F. Vance and H. Zhao, Department of Renewable Resources, 1000 E. University Ave., University of Wyoming, Laramie, WY 82071-2000; M.A. Urynowicz, Department of Civil & Architectural Engineering, University of Wyoming; G.K. Ganjegunte, Texas Agricultural Experiment Station, Texas A&M University, 1380 A&M Circle, El Paso, TX 79927; R.W. Gregory, Wyoming State Geological Survey, P.O. Box 1347, Laramie, WY 82073

Fast development of the coalbed natural gas (CBNG) industry in many parts of the western U.S. has resulted in the co-production of saline-sodic waters, hereafter referred to as CBNG water. Management of CBNG water is a major environmental challenge because of its quantity and quality. In this study, the potential utilization of calcium Ca2+)-rich natural zeolites were examined for removal of sodium (Na+) from CBNG waters. Zeolite samples examined were from the St. Cloud zeolite mine in Winston, NM and the Bear River zeolite mine in Preston, ID. The zeolite materials were used in studies on sorption/desorption kinetics, adsorption isotherms and column experiments. Synthetic CBNG waters were prepared that simulated the water chemistry of CBNG waters and used in the various studies described herein. Results indicated that Langmuir model fit well the adsorption data. The maximum adsorption capacities from the adsorption isotherms for ST-Zeolite and BR-Zeolite are 9.6 and 12.3 (mg/g), respectively, only accounting for approximately 38% and 43% of their measured CEC values. Column study indicated that a ton (1000 kg) of ST-zeolite and BR-zeolite can be used to treat 16,000 to 60,000 liters of CBNG water, respectively by lowering the sodium adsorption ratio (SAR, mmol½ L-½) from 30 to an acceptable level of 10. Zeolite technology appears to be a cost-effective water treatment technology for maximizing the beneficial use of poor-quality CBNG water.

5. Biological Responses to Land Application with Saline-Sodic Coalbed Natural Gas Co-Produced Waters (L.A. King, G.F. Vance and A.H. Hild, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-2000; E. Pendall, Department of Botany, University of Wyoming, Laramie, WY 82071; G.K. Ganjegunte, Texas Agricultural Experiment Station, Texas A&M University, 1380 A&M Circle, El Paso, TX 79927)

Large coalbed natural gas (CBNG) reserves are being aggressively developed in the Powder River Basin (PRB) of Montana and Wyoming. About 20,000 CBNG wells are either drilled or permitted with > 50,000 future wells projected. Significant volumes of saline-sodic co-produced water are associated with CBNG extraction and are anticipated to exceed 366,000 ha m in the PRB over the next 15 years. Managing these volumes will require development of suitable water handling strategies (e.g., land application using conventional sprinkler irrigation systems). This study examined responses of native grassland vegetation communities after up to 5 years of land applications with saline (EC = 1.8 to 4.0 dS/m) and sodic (SAR =15 to 38) CBNG co-produced water (CBNG water). Treated (irrigated) areas and representative control (non-irrigated) areas were established at two study sites in 2003 with three additional sites added for the 2004-2005 field seasons. Because soil and plant types, water application rates, and water/soil treatment strategies were variable across study sites, parameters measured from each treated area were compared directly to those from representative control areas. On these study sites, multiple year applications of CBNG water produced consistent trends of increased EC and SAR in the upper 30 cm of soil profiles. Land applications of CBNG water had limited impact on AM fungi infection rates of selected perennial grass species, with only one of four species (western wheatgrass) indicating significantly (P=0.05) reduced infectivity and on only one treated area (vs. control). CBNG water applications significantly increased aboveground biomass production and aerial cover of both perennial grasses and total vegetation on treated areas (vs. control areas) on most sites in most years. Comparisons between non-perennial grass production on treated and control areas varied by site and year; however, non-perennial grass cover was significantly greater on control areas (vs. treated) on three of five sites in both 2004 and 2005. Treated area (vs. control area) species richness comparisons indicated no consistent response to CBNG water applications. Diversity as measured by evenness from aerial cover data, however, was greater on all control areas (vs. treated) at all sites but one in both 2004 and 2005. Evenness measured from frequency data was greater on control areas (vs. treated) on three of five sites in both years. Both Shannon's and Simpson's diversity indices from aerial cover data were greater on control areas (vs. treated) on all sites in 2005. Results using frequency data were mixed. Direct gradient analyses using canonical correspondence analysis (CCA) were utilized to evaluate study site and native plant species impacts related to SAR, EC, pH, % clay, and bulk density in the upper 30 cm of soil profiles. Investigating tolerances of native plant species to modified soil conditions created by land applications of saline-sodic CBNG water will help provide essential information needed to enhance vegetation diversity and reclamation potential of treated sites.

6. Recovery of Belowground Ecosystem Components Under Different Plant Communities on Reclaimed Coal Mine Lands (P.D. Stahl, L.J. Ingram, S.V. Huzubazar and C. J.

Bilbrough, Department of Renewable Resources and Department of Statistics, University of Wyoming, Laramie, WY 82071 and Land Quality Division, Department of Environmental Quality, Cheyenne, WY)

The ultimate goal of mineland reclamation is reestablishment of a productive, healthy, and sustainable ecosystem suitable for postmining land use. All ecosystems are composed of a producer component and a decomposer component and these subsystems are obligately dependent upon one another. Any approach to better understanding or better evaluation of ecosystem functioning, especially nutrient cycling, requires serious consideration of both aboveground and belowground ecosystem components. Although a combined aboveground–belowground approach is crucial to an understanding of ecosystem-level processes, most ecological work has been traditionally conducted without much explicit consideration of the belowground component . This is also true of our understanding of reclaimed ecosystems on coal mine lands. We propose to examine recovery of belowground ecosystem components (nutrient cycling, microbial community structure, and soil structure) under different plant communities found on reclaimed coal mine lands. Our study will include plant communities considered to be of good quality and of lower quality as well as communities having already been bond released. This approach has been chosen to ascertain whether there are differences in recovery of belowground ecosystem structure and function under these disparate communities. Examination of statistical relationships between plant community characteristics and belowground ecosystem components to will be conducted to determine if the plant community characteristics accurately reflect recovery of belowground structure and function.

7. Mechanisms for stabilization and accumulation of organic carbon in reclaimed mineland soils (P.D. Stahl, G.F. Vance and S.V. Huzubazar, Department of Renewable Resources and Department of Statistics, University of Wyoming, Laramie, WY 82071)

One of the major environmental controversies of our time is in regard to the rapidly rising concentration of CO_2 in the earth's atmosphere and whether or not this is causing global climate change. Regardless of its impact on the earth's climate, there is a growing movement in the United States and the rest of the world to lower the concentration of CO_2 in the atmosphere. In the United States, the most widely accepted strategy for reducing levels of CO_2 in the atmosphere is sequester (or remove) C from the atmosphere and store it in soil as SOC (the major component of SOM) where it has beneficial effects on soil properties and land sustainability.. There appears to be a particularly large potential to increase C storage as SOM in disturbed and reclaimed soils including reclaimed soils on surface coal mine lands in Wyoming. In fact, our previous studies of SOM dynamics and C cycling in reclaimed mine land soils in our state indicate that these soils are accumulating C at a rapid rate.

The overall objective of the research described in this proposal is to determine the specific mechanisms by which SOC (as the major constituent of SOM) is accumulating in reclaimed soils in surface coal mine lands in Wyoming. This objective will be accomplished by testing four hypotheses we have developed based on data collected in our previous studies of SOM dynamics in reclaimed mine soils and studies of SOM dynamics in intensively managed agricultural soils in the literature.

In addition to providing important benefits to the Wyoming coal mining industry, the mining industry in general, and potentially to global environmental quality, this proposed research will provide significants benefits to the University of Wyoming. Just as Wyoming is the nation's leading producer of coal, continued research on this topic as described in this proposal will cement the University of Wyoming's reputation as a national leader in the field of land reclamation research.

8. <u>Influence of plant community structure and topsoil handling method on soil structural development and microbial community recovery in reclaimed soil.</u> P.D. Stahl, L.J. Ingram, and A.F. Wick. Department of Renewable Resources, University of Wyoming, Laramie, WY 82071. 2006-2007.

   The overall objective of this research is to determine the influence of topsoil handling practice and plant community type on soil structure development and microbial community recovery (including recovery of mycorrhizal fungi) on surface mine reclamation sites. Soil physical structure and microbial communities are critical aspects of soil quality and sustainability. Soil structure (the size and arrangement of particles and pores) largely dictates soil function by influencing water infiltration rates and storage capacity, aeration, erosion resistance and nutrient cycling processes. Soil microorganisms drive nutrient cycling processes and thus contribute directly to plant community productivity.. Soil microorganisms, including mycorrhizal fungi, also contribute to soil function in number of other ways including development and stabilization of soil structure. Land management practices (i.e., mining, tillage, fertilization, vegetation type or crop species, etc.) are known to have significant impacts on soil structural properties and microbial communities. Stockpiling of topsoil, especially for long periods of time (>10 yrs) is known to have adverse impacts on the physical, chemical and biotic properties of soil. In comparison, the impacts of the direct placement (or direct hauling) of topsoil removed from a site about to be mined to an area to be reclaimed are much less adverse. Disturbance of soil associated with direct placement also has negative impacts such as degradation of soil structure and alteration of microbial communities; the extent of these effects is not well known.

   We are examining microbial community recovery (including that of arbuscular mycorrhizal fungi) and soil structure development in soils on a number of different aged sites (a chronosequence) reclaimed using stockpiled topsoil and compare it to that of similarly aged sites with the same vegetation seeded into a directly placed soil. We will also analyze microbial community recovery and soil structure development in soils on a number of different aged sites reclaimed using the same topsoil management strategy but revegetated with either cool season grasses or sagebrush and cool season grasses.

8. <u>Native grass competition with Canada Thistle on military installations.</u> (A. Hild, T. Collier, and B. A. Mealor. University of Wyoming Department of Renewable Resources and The Nature Conservancy Wyoming).

   Canada thistle (*Cirsium arvense*) is a conlony-forming exotic pereenial that is listed as a noxious weed in 43 states. Vegetative lateral spread from an extensive root system coupled with prolific seed production makes this species highly invasive in restoration plantings of native grasses. Using a combiation of biocontrol agents and competitive native grasses we examine the potiential for combined competition and herbivory for successful revevegetation. Future research will examine the impacts of cool versus warm-season species on *C. arvense* in field revegatation plantings. Beneficial results can alter the methodology for sustained control of C. arvense in revegetation efforts by using synergistic combinations of control, revegetation and insect herbivory.

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WESTERN UNITED STATES

USDA – NATURAL RESOURCES CONSERVATION SERVICE

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INTRODUCTION

Five reports on revegetation and stabilization of deteriorated lands projects were submitted from the NRCS Plant Materials Program and are presented below as submitted:

- 1 from Colorado
- 3 from Idaho
- 3 from Montana
- 1 from Nevada

COLORADO

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INTRODUCTION

Upper Colorado Environmental Plant Center (UCEPC) is a non-profit corporation organized by two Rio Blanco County, Colorado, Conservation Districts. It is operated with technical assistance from the USDA Natural Resources Conservation Service (NRCS) as well as assistance from other federal and state agencies, and the private sector. UCEPC is situated on a 269 acre site near Meeker, Colorado. The plant center's service area is the Upper Colorado River Basin. The region is mountainous with high plateaus, open parks, mesas, and river valleys.

UCEPC has the following high priority areas identified in its long-range plan:

1. High altitude and disturbed lands revegetation
2. Vegetative treatment to improve water quality
3. Increased productivity and conservation of rangeland, pasture, and woodland resources
4. Wildlife habitat enhancement
5. Xeriscape and horticulture uses of native plant materials

HIGHLIGHTS

<u>The plant center had no new plant releases in 2006.</u>

<u>In 2005, the plant center released two plants:</u>

1. Pueblo Germplasm Bottlebrush Squirreltail Selected Class Release.
   This release, along with Wapiti germplasm, will represent the only releases of ssp. *brevifolius* from single sources. Pueblo was collected in 1976 in the wet mountains southwest of Pueblo, Colorado. It is intended for use on oil shale, coal and mined land, and transmission corridors as well as for erosion control on cropland and rangeland.

2. Wapiti Germplasm Bottlebrush Squirreltail Selected Class Release.
   Wapiti was collected in 1981 near Buford, Colorado. Its intended use is the same as the Pueblo source.

In 2006, only one seed production planting, listed below, was established at the plant center:

1. 'Luna' Pubescent wheatgrass 1.3 ac

In 2006, the following four seed production plantings which were planted in 2005 were reseeded.

Plant Center Materials

1. 'Timp' Utah sweetvetch 1.0 ac (spaced planting)
2. Wapiti Squirreltail 1.0 ac

Bureau of Land Management Materials

3. Utah sweetvetch 1.0 ac (spaced planting)

National Parks

4. Blue grama (Great Sand Dunes) 1.0 ac

The following new studies were initiated at the plant center in 2006.

1. Junegrass Seeding Study (The study started in 2005, but due to poor germination was reseeded in 2006.) This study should help determine the best planting times and methods for establishing prairie Junegrass.

2. Direct Seeding of Native Shrubs Under Field Conditions to Determine Success. (Nine shrubs with three replications.)

3. Greenhouse Study to Determine Germination Rates without Stratification. (Same shrubs used as in study No. 2 above)

4. To determine the success of direct seeding some better performing shrubs under field conditions. (Sixteen shrubs with three replications)

The following are 2006 demonstration plantings.

1. The Use of Woody Species for Windbreaks. (Phase I with one species planted)

2. Grass and Forb Releases and Experimentals for Demonstration Training and Education. (Forty-five species planted.)

3. Harvey Gap Demonstration Planting. (Twenty releases or accessions of grass were planted near Rifle, Colorado.)

The following are new field plantings.

1. The Bluebell, Utah, FEP was started in 2006. Located NW of Roosevelt, Utah, the planting will examine the performance of native grasses and shrubs. (Only grasses were planted in 2006, will have 50 entries with four replications.)

2. Questar FEP Wyoming. Assisted in a shrub planting southwest of Pinedale, Wyoming. The shrub planting is seen as a critical step to help avert any long-term negative impacts on wintering mule deer in this heavily utilized winter range.

In August, a meeting and tour was provided for the North Platte, White, and Yampa River Watershed Program. Approximately 30 participants attended the meeting and tour.

The PMC manager attended the West Region Plant Materials Program Meeting in Portland, Oregon. Information was exchanged relating to projects and plant materials development as well as national issues.

Training of Colorado and Wyoming NRCS employees in plant materials was provided by the plant center in 2006. Eleven participants attended the two day session.

A two-day training was conducted for US Forest Service personnel on seed collection. One day was spent in the mountains near Steamboat Springs, Colorado, and one day at the plant center.

Plant Guides, Fact Sheets, and Brochures were developed for two releases from the plant center: ‘Timp’ Utah sweetvetch and Maybell antelope bitterbrush.

ONGOING PROJECTS

1. Release of Maybell Source Antelope Bitterbrush
   Antelope bitterbrush, *Purshia tridentata,* is a native shrub given high priority for oil shale restoration, wildlife habitat improvement, and rangeland seeding. The Maybell source was collected near Maybell, Colorado. A selected class release was approved in early 1997, and seed is available to commercial growers. A project has been initiated to re-establish Maybell bitterbrush on its original site after a series of fires destroyed most of the original stand. Bitterbrush has been planted and evaluated at the site. A study on the fate of fall-sown bitterbrush seed at Maybell, Colorado was completed in 2002. A project to examine the effects of seed age on bitterbrush establishment was completed in 2004.

2. Northwest Colorado Prairie Junegrass Crossing Block
   Seed from the crossing block was bulked and used for a 1-acre planting in 2002. The 1-acre planting was harvested in 2003, 2004, 2005, and 2006. The seed will be used to develop a Northwest Colorado release of prairie Junegrass.

3. Increase of Salina Wildrye
   Salina wildrye is a native, cool season, bunchgrass found on rocky slopes and

sagebrush hills in Colorado, Idaho, Utah, and Wyoming. The grass is quite drought and alkali tolerant and should be important for reclamation of mined lands, roadsides, surface-disturbed sites, and areas of heavy use. Two plantings on the center are harvested, but have only provided small quantities of seed. Both plantings were harvested in 2006. An additional planting of Salina wildrye was added in 2004.

4. Shrub Orchard – Transplanted Woody Species
   Shrubs have been evaluated for survival, vigor, and wildlife usage. Certain accessions have been identified for xeriscape landscaping and horticulture plantings. An updated report on this project is developed each year.

5. Cooperative Agreements – National Park Service - In 2006, UCEPC had cooperative agreements with Rocky Mountain, Mesa Verde, Grand Teton, Bryce Canyon, and Great Sand Dunes National Parks, and Dinosaur National Monument.

   Colorado BLM – The plant center renewed an agreement with BLM for the production of five species that will be used for revegetation after fires.

   Uncompahgre Restoration Project – The plant center is producing four species from small seed increase plantings that are targeted by seed growers for restoration of the Uncompahgre Plateau in Colorado and Utah.

6. UCEPC is currently responsible for breeder's class and/or foundation class seed of the following cultivars:

'Arriba' western wheatgrass	Maybell – source antelope bitterbrush
ARS-2678 Kura clover	'Montane' mountain mahogany
'Bandera' Rocky Mountain penstemon	'Peru Creek' tufted hairgrass
Garnet mountain brome	'Redondo' Arizona fescue
'Hatch' winterfat	'San Luis' slender wheatgrass
'Hobble creek' mtn. big sagebrush	'Summit' Louisiana sage
'Hycrest' crested wheatgrass	'Timp' northern sweetvetch
'Luna' pubescent wheatgrass	'Volga' mammoth wildrye

CURRENT PUBLICATIONS AND PAPERS

Maybell bitterbrush – Division of Wildlife – 2006 project report 08A210, (which includes COPMC-T-9802-WL Caching and Tubling Plants in Plots and COPMC-T-9803-WL Tubling Plants in Rows).

Seed production – a plant center report for 2006

Live plant production – a plant center report for 2006

Transplanted orchard woody species – 2006 project report 08I020J

2006 reports for National Parks:

Bryce Canyon
Dinosaur National Monument
Grand Teton
Great Sand Dunes
Mesa Verde
Rocky Mountain

Northwest Colorado Junegrass – 2006 project report 08A207

Monthly and annual weather report for plant center, 2006

Smooth brome comparison – 08A209

Notice of release for both Pueblo and Wapiti germplasm bottlebrush squirreltail

IDAHO

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INTRODUCTION

This report summarizes the studies and activities conducted by the NRCS Aberdeen Plant Materials Center during calendar year 2006.

COMPLETED PROJECTS

1. Native Plant Restoration (NPS Craters of the Moon National Monument)

   Seed processing and propagation of 2150 plants from 10 native seed collections. Seed harvested summer, 2004 and 2005. Plant propagation begun late fall 2005. Delivered 230 antelope bitterbrush *Purshia tridentata* and 100 limber pine *Pinus flexilis* September 2006.

ONGOING PROJECTS

1. Department of Defense (U.S. Army)

   Seed production of 3 test species (western wheatgrass, Siberian wheatgrass, and slender wheatgrass) and eventual release. Fields established spring 2005 and first seed harvest summer 2006. 3 year seed increase.

2. Grand Teton National Park
   Seed production of slender wheatgrass, blue wildrye, mountain brome and Sandberg bluegrass for revegetation of disturbed areas following road construction. Fields established spring 2006. 3 year seed increase.

3. Bureau of Reclamation

   Ongoing riparian/wetland work.

4. USDA FS – Ogden

   Ongoing riparian/wetland work.

5. Foundation Seed Production (Utah Crop Improvement Association, Idaho Crop Improvement Association, USDA FS Rocky Mountain Research Station)

   Anatone and Goldar bluebunch wheatgrass, Paiute orchardgrass, Bannock thickspike wheatgrass, Maple Grove Lewis flax, Snake River Plains fourwing saltbush, Northern Cold Desert winterfat, Richfield firecracker penstemon, Clearwater Venus penstemon.

6. Study 01-W08 Seagull Bay Wetland Enhancement (Bureau of Reclamation)

   Planted willows around Seagull Bay wetland to create structure for wildlife and to improve water quality.

7. Study 2000-R18 Medicine Lodge Creek Assessment and Revegetation

   Evaluate stream assessment procedures and develop revegetation plan(s) to restore stream functions.

8. Study 2000-R19 Sheridan Creek Riparian Demonstration Project

   Test bioengineering treatments on an overgrazed stream and restore the natural fish habitat.

9. Study 87-R01 American Falls Reservoir Idaho Shoreline Erosion Control Project (Bureau of Reclamation)

   Develop vegetative techniques to control erosion on shorelines of lakes, reservoirs, and ponds.

10. Study 87-R02 Trout Creek Nevada Riparian Evaluation Site

    Test woody riparian accessions on streams in the arid and semi-arid west. Test planting techniques for woody riparian plants.

11. Study 92-W08 Fairview Wetland Idaho Constructed Wetland System (Idaho State University)

    Determine the effectiveness of various wetland species to remove nutrients from an individual farm's irrigation wastewater. Develop design criteria for sizing system components.

12. Study 96-R13 Trout Creek Nevada Bioengineering Demonstration

    Demonstrate the effectiveness of bioengineering techniques in stabilizing streambanks in low precipitation zones of the arid and semi-arid west. Treatments tested include brush mattress, vertical bundles, fascines, and willow structure to stop headcut.

13. Study 98-01 Hybrid Poplar Initial Evaluation

    Identify commercial accessions of hybrid poplar used for fuel and fiber adapted to eastern Idaho and northern Utah.

14. Study 98-R10 Carson River Nevada Riparian and Bioengineering Demonstration

    Demonstrate the effectiveness of bioengineering in conjunction with traditional engineering practices to stabilize streambanks in the arid and semi-arid west.

15. Study 98-W07 Pocatello, ID Stormwater Constructed Wetland System (City of Pocatello)

    Create Constructed Wetland System to treat stormwater from the SE side of Pocatello, ID. This wetland is an attempt to help the city meet the EPA phase II requirements.

16. Study ABPMC-S-0203-RA Mutton bluegrass (9067402) initial seed increase and evaluation

    Seed increase G1 and evaluation.

17. Study ABPMC-T-0315-RI Upper Carson River Bioengineering Demo

    Develop bioengineering treatments to stabilize severely eroding streams in low precipitation areas.

18. Study IDPMC-T-0403-RI Willow cutting soaking trials

    Evaluate efficacy of pre-soaking hardwood cuttings to aid in establishment.

19. Study IDPMC-T-0406-WE Wetland species direct seeding evaluation (National Park Service)

    Evaluate techniques to establish wetland plants through direct seeding.

20. Study IDPMC-T-0505-RA Orchard display and adaptation evaluation (USDA FS Rocky Mountain Research Station)

    Establish and evaluate native and introduced grasses, forbs and shrubs.

21. Study IDPMC-T-0506-RA Great Basin forb propagation and initial evaluation (USDA FS Rocky Mountain Research Station)

    Greenhouse propagation and evaluation of 7 native forb accessions for transfer to RMRS.

22. StudyIDPMC-T-0507-RI Willow Pre-soak field trial

Compare effectiveness of willow pre-soaking treatments under field conditions. Planted 350 hardwood cuttings of 3 woody riparian species on degraded creek bank at Arbon Valley, ID.

23. IDMPC-T-0605-RA Anatone bluebunch wheatgrass Growth Curves

    Develop growth curves for inclusion in ecological site descriptions.

24. IDPMC-P-0407-RA USDA FS R1 Bluebunch wheatgrass IEP (USDA FS Region 1)

    Evaluate collections of R1 PSSPS for possible selected class release.

25. IDPMC-P-0408-RA USFSR1 Sandberg bluegrass IEP (USDA FS Region 1)

    Evaluate collections of R1 POSE for possible selected class release.

26. IDPMC-P-0409-RA USFSR1 Blue wildrye IEP (USDA FS Region 1)

    Evaluate R1 collections of ELGL for possible selected class release.

27. IDPMC-P-0410-RA USFSR1 Idaho fescue IEP (USDA FS Region 1)

    Evaluate R1 collections of FEID for possible selected class release.

28. IDPMC-P-0411-RA USFSR1 Tufted hairgrass IEP (USDA FS Region 1)

    Evaluate R1 collections of DECA for possible selected class release.

29. IDPMC-P-0412-RA USFSR1 Western Yarrow IEP (USDA FS Region 1)

    Evaluate R1 collections of ACMI for possible selected class release.

30. IDPMC-P-0504-RA Basin Wildrye advanced evaluation

    Evaluate Magnar, Washoe Germplasm and Trailhead against promising accession from Nevada.

31. IDPMC-P-0508-RA Caribou-Targhee NF Slender wheatgrass IEP (USDA FS Caribou-Targhee and Bridger-Teton National Forests)

    Evaluate CT and BT collections of ELTR7 for possible selected class release.

32. IDPMC-P-0509-RA Caribou-Targhee NF Mountain Brome IEP (USDA FS Caribou-Targhee and Bridger-Teton National Forests)

    Evaluate CT and BT collections of BRMA4 for possible selected class release.

33. IDPMC-P-0602-RA Muttongrass (*Poa fendleriana*) AEP

    Compare 9076402 to accessions from other researchers for potential release.

34. IDPMC-P-0615-RA Coffee Point- Basin Wildrye Off-Center Evaluation Nov. 2006

    Evaluate released and test material in field conditions at Coffee Point Test Site.

35. IDPMC-P-0616-RA Coffee Point-Sandberg bluegrass Off-Center Evaluation

    Evaluate accessions of Sandberg bluegrass under field conditions.

36. IDPMC-P-0617-RA Coffee Point-Bluebunch Wheatgrass Off-Center Evaluation

    Evaluate accessions of PSSPS under field conditions.

37. IDPMC-P-0618-RA Coffee Point-Snake River Wheatgrass Off-Center Evaluation

    Evaluate SRWG under field conditions.

38. IDPMC-P-0619-RA Coffee Point- Thickspike wheatgrass Off-Center Evaluation

    Evaluate releases of ELLAL under field conditions.

39. IDPMC-P-0620-RA Coffee Point- Western Wheatgrass Off-Center Evaluation

    Evaluate western wheatgrass under field conditions.

40. IDPMC-P-0621-RA Coffee Point- Slender Wheatgrass Off-Center Evaluation

    Evaluate ELTR materials under field conditions.

41. IDPMC-P-0622-RA Coffee Point- Bottlebrush Squirreltail Off-Center Evaluation

    Evaluation of bottlebrush accessions under field conditions.

42. IDPMC-P-0623-RA Coffee Point- Shrub Off-Center Evaluation

    Evaluation of native shrubs under field conditions.

43. IDPMC-P-0624-RA Coffee Point- Forb Off-Center Evaluation

    Observe native forb releases under field conditions.

44. IDPMC-P-0625-RA Coffee Point- Introduced Grass Off-Center Evaluation

    Evaluate introduced grass accessions under Idaho field conditions.

45. IDPMC-T-0505-RA Orchard display and adaptation evaluation

Display nursery of native and introduced grasses, forbs and shrubs. Evaluate establishment and performance.

46. IDPMC-T-0601-RA Forb Herbicide tolerance trial (UI Extension)

In cooperation with U of I to evaluate potential herbicides for weed control in forb seed production.

47. IDPMC-T-0603-Ri Effects of pre-soaking dormant hardwood cuttings of coyote Willow

Evaluate length of time and water temperatures to increase survivability.

48. IDPMC-T-0604-RA Great Basin Forb Initial Increase and Evaluation

Develop propagation techniques and evaluate plant growth and seed production characteristics in increase blocks.

49. IDPMC-T-0604-WE Options and cost breakdown for direct seeding wetlands with Baltic rush

Develop alternatives and costs for direct seeding Baltic Rush.

50. IDPMC-T-0606-RA *Eriogonum* stratification requirements

Investigate optimum stratification durations for 2 Eriogonum species, *E. umbellatum* and *E. heracleoides*.

51. IDPMC-T-0607-RI Salato Creek Soil Bioengineering Demonstration Site

Demonstration of soil bioengineering treatments in low precipitation areas of the SW. Soil Bioengineering treatments were combined with harder structures to show how they can fit together and function together.

52. IDPMC-T-0608-RI Restoration techniques for the Hopi Indian Reservation

Development of riparian planting techniques for the arid SW on the Hopi Reservation. These techniques utilize native culturally significant riparian woody species to restore the riparian areas on the reservation.

53. IDPMC-T-0609-RI Lemhi River Soil Bioengineering Demonstration near Salmon, ID

Stream bank Soil bioengineering demonstration on the Lemhi River near Salmon, ID. This project evaluates different soil bioengineering treatments that can work at high elevations and in high pH water.

54. IDPMC-T-0610-RI Moose WY streambank soil bioengineering demonstration project

    Demonstration of Stream bank Soil Bioengineering treatments on the Snake River. This project will demonstrate the use of bioengineering treatments in a large river with high velocities and high ice loads.

55. IDPMC-T-0612-WE Stratification requirements for Indian Valley Sedge (*Carex aboriginum*)

56. IDPMC-T-0613-CP Evaluation of Hairy Vetch populations for winter hardiness

    Determine if any of 5 hairy vetch accessions are winter tolerant in ID.

57. IDPMC-T-0614-RA Propagation protocol for containerized *Eriogonum umbellatum* and *E. heracleoides*

    Create greenhouse propagation protocols for ERUM and ERHE2. Study examines stratification requirements, planting depths and irrigation schedules.

PROPOSED OR PLANNED STUDIES

1. Development of ecoregion specific vegetative riparian restoration guidelines following removal of Tamarisk (salt cedar), Russian olive and other invasive species

2. Skull Valley Inter Center Strain Trial

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HASLEM SALINITY TRIAL – DUCHESNE COUNTY, UT
FINAL REPORT
2006

Dana Truman, Range Specialist, Price, UT
Dan Ogle, Plant Materials Specialist, Boise, ID
Brett Prevedel, District Conservationist, Roosevelt, UT

The Haslem Salinity Trial was designed to evaluate the performance of 13 accessions, some traditionally used as well as several new varieties, when grown in saline soils of Duchesne County, Utah. Many farms in the area have had a history of irrigation related problems that have resulted in severe salinity, erosion, and other agronomic limitations. Due to the soil limitations of the area, there has always been some interest in finding species or management techniques that would improve yields.

This salinity tolerance trial tested 13 different varieties or accessions:

1. Greenar intermediate wheatgrass
2. Alkar tall wheatgrass
3. RS Hoffman (natural quackgrass X bluebunch wheatgrass)
4. NewHy hybrid wheatgrass (quackgrass X bluebunch wheatgrass
5. Bozoisky Russian wildrye
6. Fawn tall fescue
7. Magnar basin wildrye
8. Hycrest II crested wheatgrass
9. SYN-A Russian wildrye
10. Tetraploid Russian wildrye
11. M5 giant wildrye X basin wildrye
12. Vinall Russian wildrye
13. Garrison creeping foxtail

The location for the plots was chosen because of the soils (a very heavy clay loam), variable levels of salinity, and access to irrigation. Before the trial, this area was an old alfalfa field with weed and salinity problems. The salinity ranged from 1.7 to 21.7 mmhos. The pH was 7.5 to 8.5; the lower values may have been a result of the buffering capabilities of gypsum. The total water holding capacity was two inches per foot. Whitetop and foxtail barley were prevalent invaders.

Plots of each species were approximately 8 feet wide and 24 feet long. All 13 accessions were planted in the same area and replicated 4 times along the saline gradient resulting in 52 total plots. For irrigation purposes, the plots were designed to fit into one set of a wheel line. The area was seeded in 1993 without fertilizer. Because the test area was an old alfalfa field with weed problems, a post emergent herbicide was used to control the volunteer alfalfa.

Results

The intermediate wheatgrass and tall wheatgrass had the highest yields and salt tolerance, but the lowest palatability. NewHy and RS Hoffman preformed well, with high yields at lower salinity levels. Bozoisky Russian wildrye had the best performance of the wildrye varieties.

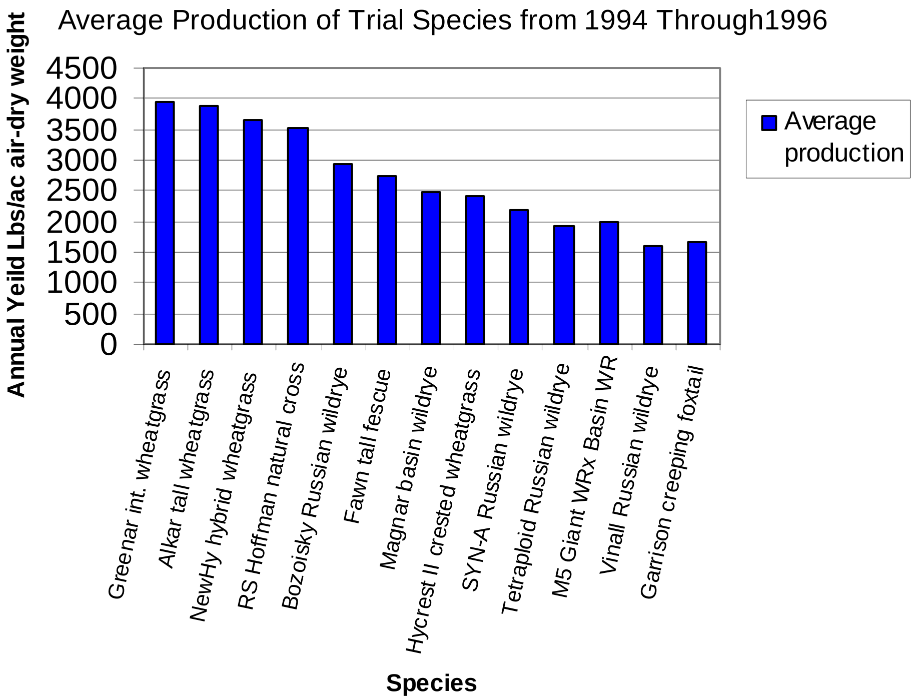
Observations

Plants	
Greenar intermediate wheatgrass	Good salt tolerance and productive, but low palatability.
Alkar tall wheatgrass	Tall wheatgrass had very high salt tolerance and high productivity, but low palatability. It provides good standing cover in winter.
RS Hoffman	Similar to NewHy in behavior, but appears to utilize nitrogen better and does not display the chlorosis traits that NewHy does.
NewHy hybrid wheatgrass	This plant showed high levels of salt tolerance. It had low to moderate germination rates, good seedling vigor, good palatability and proved to be productive at low to moderate salinity levels. At high salinity levels, survival was good, but production dropped off dramatically. It also tended to have chlorosis at all salinity levels.
Bozoisky Russian wildrye	This variety seeded well, and was moderately salt and drought tolerant. It greened up well in the fall for good fall forage.
Fawn tall fescue	Very high drought tolerance and salt tolerance. Low palatability and poor overall production. The plant did not respond well to irrigation during the growing season.
Magnar basin wildrye	Productive if a good stand is achieved. It has good traits for cover habitat and standing winter forage crop. However, the plant had sparse establishment and was coarse with low palatability
Hycrest II crested wheatgrass	This variety had good early spring and late fall green up. Salt tolerance was low, greater than 7 mmhos the plant was negatively affected. The plant had poor regrowth response to irrigation during the growing season.
SYN-A Russian wildrye	Performed similar to Bozoisky Russian wildrye.
Tetraploid Russian wildrye	Less productive and vigorous than Bozoisky Russian wildrye.

M5 giant wildrye X basin wildrye	This plant had poor establishment and low seedling vigor. However, after 4 years the stand appeared vigorous and it was spreading.
Vinall Russian wildrye	This variety did not perform well and had no advantage over Bozoisky Russian wildrye. It had poor establishment and low production.
Garrison creeping foxtail	This variety was negatively affected by drought and did not perform well perhaps due to less irrigation than it required. In this trial it did not appeared salt tolerant beyond 6 mmhos.

Table 1 – Yield data by species in air-dry pounds per acre

Plants	**1994**	**1995**	**1996**	**Average production**
Greenar intermediate wheatgrass	3,600	5,200	3,000	3,933
Alkar tall wheatgrass	3,000	5,800	2,800	3,867
RS Hoffman – natural cross	4,000	4,000	2,600	3,533
NewHy hybrid wheatgrass	3,600	5,200	2,200	3,667
Bozoisky Russian wildrye	2,800	4,000	2,000	2,933
Fawn tall fescue	3,400	3,200	1,600	2,733
Magnar basin wildrye	2,000	3,400	1,000	2,133
Hycrest II crested wheatgrass	2,800	3,200	1,200	2,400
SYN-A Russian wildrye	2,000	2,600	1,000	1,867
Tetraploid Russian wildrye	2,000	2,400	1,400	1,933
M5 giant wildrye X basin wildrye	1,800	2,800	1,400	2,000
Vinall Russian wildrye	1,400	2,400	1,000	1,600
Garrison creeping foxtail	1,600	2,400	1,000	1,667



Discussion

With good management nearly all species evaluated do well up to 8 mmhos (similar to the tolerance of barley). On more extreme sites, the options are still limited, but NewHy, RS Hoffman, intermediate wheatgrass and Russian wildrye have potential to be used as alternatives to tall wheatgrass.

Benefits from this project are estimated to be 55 tons per year salt load reduction to the river system, 17 acre feet deep percolation reduction, and a substantial increase in crop production. Brett Prevedel and the landowner initiated the project. Howard Horton with ARS coordinated efforts and completed the planting. If there is further interest in this project, please contact Brett Prevedel at the Roosevelt, UT, NRCS Field Office.

Photos


RS
HYBRID

SNOWBALL SALINITY TRIAL, EMERY COUNTY, UT
FINAL REPORT
2006

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Dan Ogle, Plant Materials Specialist, NRCS, Boise, ID
Tony Beals, Agronomy Specialist, NRCS, Price, UT

This trial was designed to test the drought and salt tolerance of several varieties of irrigated forage plants. The replicated plots were established in 1991 and 1992 with the cooperation of several agencies and the landowner.

This salinity tolerance trial tested 18 varieties or accessions.

14. Prairieland Altai Wildrye
15. Magnar Basin Wildrye
16. Shoshone Beardless Wildrye
17. Revenue Slender Wheatgrass
18. San Luis Slender Wheatgrass
19. Tall Wheatgrass
20. Monarch Cicer Milkvetch
21. Garrison Creeping Foxtail
22. Fawn Tall Fescue
23. NewHy Hybrid Wheatgrass (Quackgrass X Bluebunch Wheatgrass
24. Birdsfoot Trefoil
25. Festorina Tall Fescue
26. Forager Tall Fescue
27. Alsike Clover
28. Matua Rescuegrass or Brome
29. RS Hoffman (Natural Quackgrass X Bluebunch Wheatgrass
30. Kura Clover
31. SP90 Kura Clover.

The trial was located near Elmo, Utah on the Richard Snowball farm. This location was chosen because the landowner was very interested in improving his pasture productivity, access to irrigation, and marginal soils. The soil are moderately to highly saline with pH ranges from 8.5 to 8.9 and electrical conductivity (EC) from 5.7 to 20 plus. The area prior to planting was bare ground or covered with salt grass. The test area was 300 x 50 feet and ran east to west. Figure 1 details the plot layout. Within the fenced trial area, three replications of 100 x 40 feet plots were delineated. In each of the replications, species 1 through 10 were seeded in randomly replicated 10 x 40 feet wide strips in the fall of 1991. The entire plot was surrounded by a 5 feet border of NewHy hybrid wheatgrass. In the spring of 1992, species 11-18 were added at the east end with no replications except for the fescues which were replicated. Most grasses were planted with a drill. A few species were planted with plugs. The seedbed was well prepared, but possibly a little soft. The soil surface was kept damp until all the species germinated. Species in all three replications germinated well. Garrison creeping foxtail and Monarch cicer milkvetch were the last species to come up. Fertilizer, soil amendments, irrigation, and palatability tests were conducted over the seasons and both NRCS and the Emery County Extension have copies of the data.

Results

Information about relative palatability and salt tolerance and actual yield (clipped weights) were collected for 4 years after establishment. Table 1 summarizes the results by ranking the plants.

Table 1: Relative Salt Tolerance, Yield and Palatability by species

Species/Variety	Salt Tolerance	Yield	Palatability
1. Tall Wheatgrass	1	2	16
2. Shoshone Beardless Wildrye	2	12	9
3. Prairieland Altai Wildrye	3	13	17
4. Magnar Basin Wildrye	4	14	15
5. Revenue Slender Wheatgrass	5	9	13
6. San Luis Slender Wheatgrass	6	11	14
7. NewHy Hybrid Wheatgrass (quackgrassX bluebunch wheatgrass)	7	7	7
8. RS Hoffman (Natural quackgrass X bluebunch wheatgrass)	8	8	8
9. Fawn Tall Fescue	9	6	12
10. Festorina Tall Fescue	10	4	10
11. Forager Tall Fescue	11	5	11
12. Birdsfoot Trefoil	12	18	5
13. Monarch Cicer milkvetch	13	1	1
14. Garrison Creeping Foxtail	14	10	6
15. Alsike Clover	15	3	2
16. Kura Clover	16	15	3
17. SP90 Kura Clover	17	16	4
18. Matua Rescuegrass	18	17	18

Observations

Best Production

Grasses – Tall Fescues, Tall Wheatgrass, NewHy, Slender Wheatgrasses (Note: Slender wheatgrasses were short lived 3-5 years). The area between the drill rows were almost totally weed free.
Legumes – Cicer Milkvetch, Alsike Clover

Best Mid-Summer Regrowth
Grasses- Tall Fescues
Legumes – Alsike Clover

Palatability

Highest – All Clovers and Cicer Milkvetch
High - NewHy, RS Hoffman, Garrison Creeping Foxtail
Medium – Tall Fescues, Shoshone, Slender Wheatgrass
Lowest – Tall Wheatgrass and Wildrye accessions

(Palatability depends on many factors including the time of year, growth stage, moisture content, etc. The above observations were based on use of a small band of sheep during mid season in 1993.)

Best Irrigated Grasses

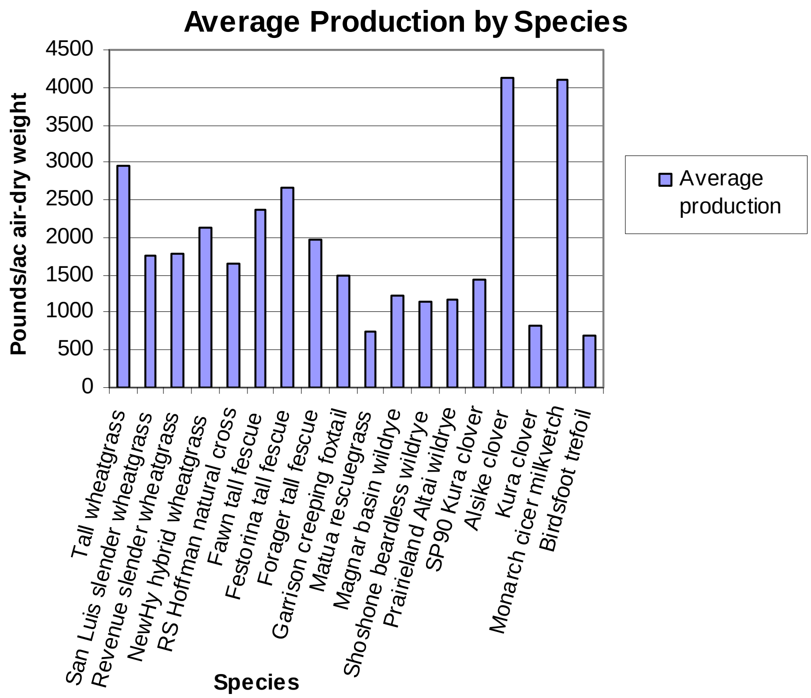
NewHy – Well suited for good to fair soils, easy to establish, and spreads to a heavy stand. Somewhat drought (14 inch + MAP) and very salt tolerant. Good early and late season production and fair regrowth in mid season. Very palatable even in later growth stages

Forager Tall Fescue – Good yields, easy to establish with good salt and drought tolerance. Good midseason regrowth. Better palatability that older varieties of tall fescue.

Garrison – For best production plenty of water and good fertility is required. It will tolerate dry periods from mid to late growing season. It will not tolerate EC levels much above 10. It is very palatable and likes significantly more water that it received in this study.

Discussion

Most accessions germinated readily in all of the replications; however, the slender wheatgrass accessions, tall fescue, and NewHy were outstanding with very thick stands established. Tall wheatgrass had the highest tolerance to salinity, the highest production for a grass, but was near the lowest in palatability of the species tested. Much of the data indicate that varieties that were the most salt tolerant were also the lowest in palatability. However, NewHy and RS Hoffman grasses preformed well; being tolerant of salts with moderate production and moderate palatability. Cicer milkvetch and Alsike clover had very high yields and were very palatable, but their low tolerance of saline conditions makes them difficult to recommend for use under extremely saline soils conditions.



In the less saline soils (replication 1) weed competition negatively affected establishment. Negative impact from the weeds was reduced through mowing and the irrigation regime. The plots were mowed twice at 3-4 inch height. Unfortunately the mowing treatments severely reduced the wildrye plots productivity. The most prevalent weed was kochia with salt grass, sunflower, bindweed, nightshade, and Russian thistle present.

Most years the plots received 30 inches or more of applied irrigation. However in 1994, there was a drought, with only 55% of normal irrigation water available. Including the natural precipitation and the irrigation water, only 23.3 inches of water were applied. The data shows that both slender wheatgrass accessions produced very well under drought conditions (Table 2) indicating good drought tolerance. Also, observations were made that the sprinkler irrigation helped to improve the pH levels in the root zone. Fertilizers were used; Live Earth product was also applied the first year and in the fall of 1992 nitrogen was applied. There was a very evident beneficial effect where the powdered Live Earth product was used. The data showed a 14% increase in yield for slender wheatgrass to a 47% increase in yield for Fawn tall fescue where the Live Earth product was applied.

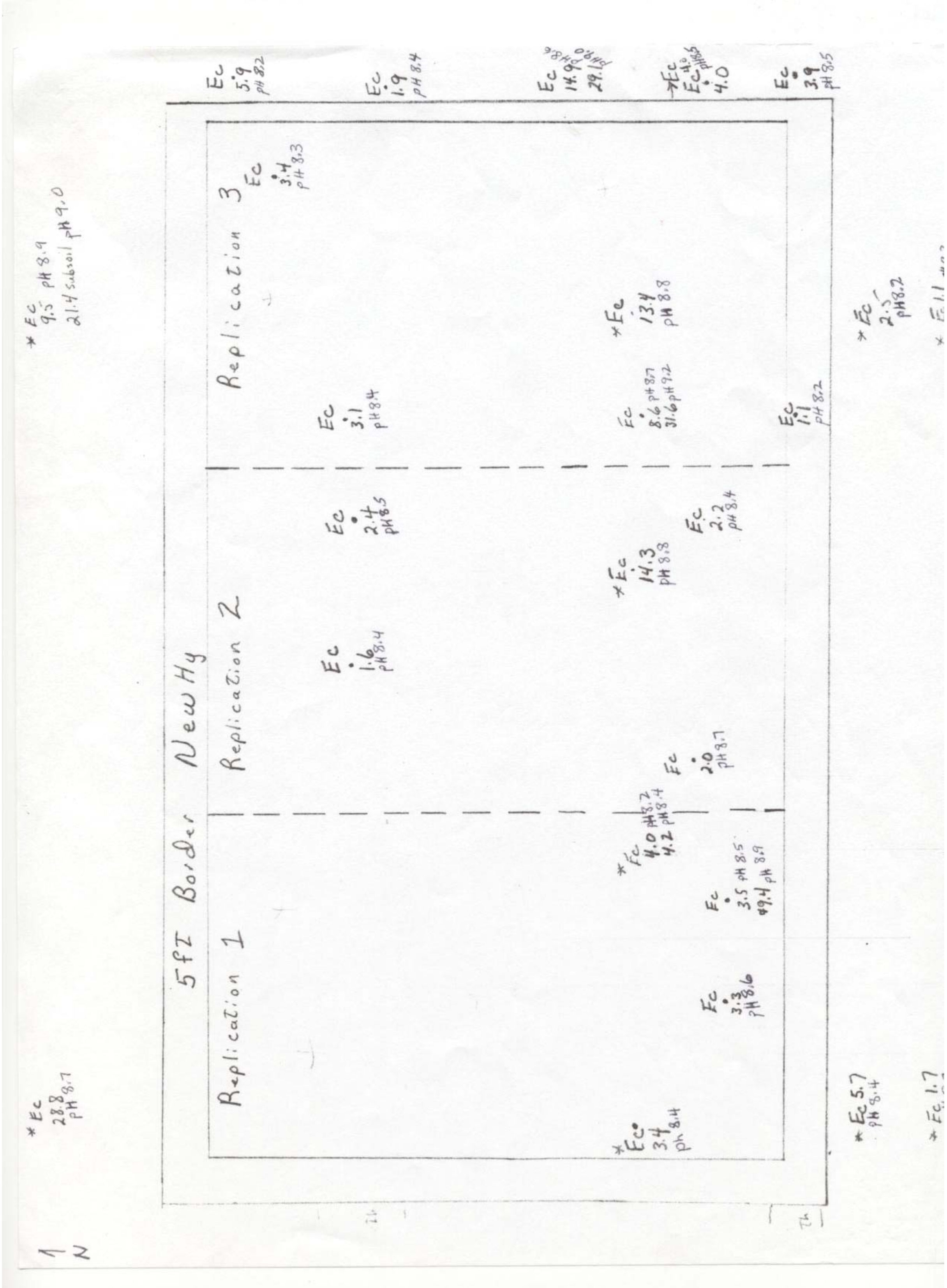
Table 2 – Yield data by species in Air-dry lbs/ac.

Plants	1991	1992	1993	1994	Average production
Tall Wheatgrass	2,430	6,515	1,444	1,464	2,963
Fawn Tall Fescue	2,335	3,873	1,842	1,385	2,359
San Luis Slender Wheatgrass	871	2,159	1,380	2,587	1,749
Revenue Slender Wheatgrass	1,238	2,609	924	2,326	1,774
NewHy Hybrid Wheatgrass	1,374	4,124	1,312	1,673	2,121

RS Hoffman Wheatgrass	na			1,646	1,646
Festorina Tall Fescue	na	2,307	4,170	1,490	2,656
Forager Tall Fescue	na	1,640	2,802	1,437	1,960
Garrison Creeping Foxtail	894	2,543	1,440	1,045	1,481
Matua Rescuegrass	na	708	winterkill	784	746
Magnar Basin Wildrye	882	1,090	1,800	1,124	1,224
Shoshone Beardless Wildrye	773	1,709	726	1,359	1,142
Prairieland Altai Wildrye	637	1,479	1,230	1,333	1,170
Berseem Clover (annual)	na	1,450	na	na	1,450
Alsike Clover	na	940	6,462	4,986	4,129
Kura Clover	na			836	836
Monarch Cicer Milkvetch	526	1,203	9,381	5,279	4,097
Birdsfoot Trefoil	na			679	679

Tony Beals (NRCS), Dennis Worwood (Emery Co. Ext. Agent) and the landowner initiated the project. Howard Horton with ARS coordinated efforts and completed the planting. If there is further interest in this project, please contact Tony Beals at the Price NRCS Field Office.

Figure 1: Plot Layout



Photos

Close-up of slender wheatgrass and its weed control attributes

Weather station donated by BOR gathered local data for use in evaluating the salinity trials

Shell-Pinedale Comparative Evaluation Planting.
Field Evaluation Planting FEP MT-05-100.

A partnership in Wyoming is addressing the need to determine the best native plants and establishment techniques for restoring, enhancing, and maintaining native rangeland and sagebrush ecosystems. The cooperative agreement among several federal, state, and private entities considers plant diversity, forage production, and wildlife habitat. Objectives 1, 2, and 3 of the Pinedale Resource Area Cooperative Working Agreement are:

1. Test grass, forb, and shrub **species** for adaptation to the Pinedale Resource Area with emphasis on plant species native to the Rocky Mountain Region that provide forage production, a diverse ecosystem, and habitat for sage grouse, mule deer, antelope and other wildlife species, especially those dependent upon sagebrush communities.
2. Test **cultivars and varieties** of grass, forb, and shrub species for adaptation to the Pinedale Resource Area with emphasis on plant species native to the Rocky Mountain Region that provide forage production, a diverse ecosystem, and habitat for sage grouse, mule deer, antelope and other wildlife species, especially those dependent upon sagebrush communities.
3. Test **seeding mixtures and rates** for adaptation and desired ecological diversity in the Pinedale Resource Area.

The Shell FEP is located 48 kilometers south of Pinedale, on the west side of Highway 191 and is a short distance off of the Luman Road. It is in the Major Land Resource Area 34A and the ecological site description is Sandy, in a 254-356 mm precipitation zone of the foothills and basins. The elevation is 2,193 meters. The initial phase of the project is on an existing well pad leased by Shell Exploration on BLM land.

In 2005, the first study began with site preparation and seeding of the site with 32 grasses, 24 forbs, and 16 shrubs. A precision cone-seeder was used to seed each entry in 4 rows at 0.3 m spacing by 6 m long, in a completely randomized block with four replications. Grasses and forbs were seeded at 9 pure live seeds (PLS) per meter, and shrubs were seeded at 6 PLS per meter. Seeding depth was 13 mm for all entries, except western yarrow was seeded at a depth of 6 millimeters. Two different seed mixtures were each broadcast-seeded in 0.2-hectare plots. The Bridger mix was seeded at 4 PLS seeds per m^2 and is 72% grass, 23% forbs, and 5% shrubs. The Shell mix was seeded at 13 bulk seeds per m^2 and is 35% grass, 15% forbs, and 52% shrubs. The two mixes were each drill-seeded in 0.4-hectare plots with a Truax range drill. The Bridger mix was seeded at 11.2 PLS kg -ha (4 PLS seeds per m^2) and the Shell mixture was seeded at 5.8 bulk kg -ha (7 bulk seeds per m^2). The Shell mixture was applied at 5.8 bulk kg -ha (2,242 kg -ha fiber) with a hydro-seeder on disturbed areas outside of the plots.

The study was evaluated in July 2006, and in the 288 replicated plots, all species expressed emergence except fringed sagewort. The average percentage stand was grass 16, forb 4, and shrubs 1. The best performing grasses were Copperhead Germplasm slender wheatgrass, L-45 and L-46 basin wildryes, P-24 bluebunch wheatgrass, and

Bannock thickspike wheatgrass. The two flax entries, Appar and Maple Grove, silverleaf phacelia, and several penstemon species were the best performing forbs. Wytana and Snake River Plains Germplasm fourwing saltbushes were the best performing shrubs. In the two broadcast-seeded plots, the Bridger mix establishment was 0.06 plants per m^2, and the Shell mix establishment was 0.07 plants per m^2. The best establishment of Wyoming big sagebrush was in the Shell broadcast treatment, with an average 5 plants per m^2. The sage seeding rate was 42% of the Shell mix. In the drill-seeded plots, the Bridger mix was 0.04 plants per m^2, and the Shell mix was 0.06 plants per m^2. On the hydro-seeded area, establishment of the Shell mix was 0.01 plants per m^2. Due to poor establishment with the hydro-seeding, that area was re-planted in mid-November 2006. At the time of evaluation, average annual precipitation was less than 25% of normal and average temperature was above normal.

The site was reviewed in October 2006 and the continuation of extremely dry conditions revealed a pretty bleak picture. A few species had improved condition since the evaluation in July. The four-wing saltbush entries achieved a considerable amount of growth, and the Rocky Mountain beeplant had flowered and was setting seed. There is a pretty good chance that many of the seeds simply did not germinate and may yet emerge in the next growing season.

Questar-Pinedale Comparative Evaluation Planting.
Field Evaluation Planting FEP MT-06-0076.

A partnership in Wyoming is addressing the need to determine the best native plants and establishment techniques for restoring, enhancing, and maintaining native rangeland and sagebrush ecosystems. The cooperative agreement among several federal, state, and private entities considers plant diversity, forage production, and wildlife habitat. Objectives 1, 2, and 3 of the Pinedale Resource Area Cooperative Working Agreement are:

4. Test grass, forb, and shrub **species** for adaptation to the Pinedale Resource Area with emphasis on plant species native to the Rocky Mountain Region that provide forage production, a diverse ecosystem, and habitat for sage grouse, mule deer, antelope and other wildlife species, especially those dependent upon sagebrush communities.
5. Test **cultivars and varieties** of grass, forb, and shrub species for adaptation to the Pinedale Resource Area with emphasis on plant species native to the Rocky Mountain Region that provide forage production, a diverse ecosystem, and habitat for sage grouse, mule deer, antelope and other wildlife species, especially those dependent upon sagebrush communities.
6. Test **seeding mixtures and rates** for adaptation and desired ecological diversity in the Pinedale Resource Area.

The second phase of the project is located 5 kilometers south of Pinedale on the west side of Highway 191 off of the Mesa Road. It is in Major Land Resource Area 34A and is described as a Cool Central Desertic Basin and Plateau. The ecological site description is loamy (limy), in a 254-356 mm precipitation zone of the foothills and basins. The elevation is 2,291 meters. The study area is a previously disturbed well pad in need of reclamation leased by Questar Exploration on BLM land. It is located in critical mule deer winter habitat that is presently under heavy development for oil and gas exploration.

Site preparation was conducted in 2005 and 2006, and in October 2006, the site was seeded with 29 shrub entries of 25 species, and 5 grass entries of 3 species. Single-row belt seeders were used to seed each shrub entry in 4 rows at 0.6 meters wide by 6 meters long. The shrub seeding rate was dependent on seed size and ranged from 6 to 12 pure live seed per meter. Seeding depth ranged from nearly surficial to 25 millimeters, depending on seed size. The study design is a completely randomized block with four replications. Five different bluebunch wheatgrasses were each broadcast-seeded in 0.02 hectare plots, at 4 pure live seeds per m^2. Study evaluations will begin in 2007 and continue for 15 years, or for the life of the planting.

Development of Acid/Heavy Metal Tolerant Releases (DATR)
2006 Activities

A Report to
EPA Mine Waste Technology Program
and
Montana Natural Resource Damages Program

By Deer Lodge Valley Conservation District
in cooperation with the
USDA-NRCS Plant Materials Center

To date, there have been four official germplasm releases by the DATC (DATR) project: Washoe Selected Class germplasm of basin wildrye (*Leymus cinereus*), Old Works Source Identified Class germplasm of fuzzytongue penstemon (*Penstemon eriantherus*), Prospectors Selected Class germplasm of common snowberry (*Symphoricarpos albus*), and Copperhead Selected Class germplasm (2006) of slender wheatgrass (*Elymus trachycaulus*). Presently there are 15 collections of 9 species (see Seed Increase section) that have been established in seed increase fields for potential future release. Two commercial growers in Montana are growing Washoe basin wildrye, while a grower in Idaho and one in Washington have recently established seed production fields of Old Works fuzzytongue penstemon.

WOODY COMPARATIVE EVALUATION PLANTING

Conclusion

Several dead plants were dug up and it was observed that the roots of these plants had not penetrated the native soil beyond their soil media plug area. It seems probable that plants whose roots were able to tolerate the low pH and metalliferous surroundings beyond their plug area flourished, while those with roots sensitive to the edaphic contaminates declined.

The accessions that have had good survival and are now putting on substantial growth include:

- Pinus ponderosa (Deer Lodge County, MT)
- Pinus ponderosa (Lawrence County, SD)
- Ribes cereum (Deer Lodge County, MT)
- Rosa woodsii (Deer Lodge County, MT)
- Shepherdia argentea (Deer Lodge County, MT)
- Symphoricarpos albus (Deer Lodge County, MT)
- Symphoricarpos occidentalis (Weston County, WY)

Comparative Evaluation of Grasses, Forbs, and Seed Mixtures from “Local” versus “Non-local” Origins Moto-X—Stucky Ridge

Grass Trials (2006)

The grasses were evaluated and sampled on August 28 & 29, 2006. There has been some change in the order of performance but the top performers from 2003-2005 are still in the top 10. Slender wheatgrass (9081620) is still the top overall performer with and average stand of 78.13% (table 18), average plant height of 77.31 cm (table 19), and average biomass production of 2311.11 kg/ha (table 20). Other top performers include 9081633 big bluegrass, 9081621 slender wheatgrass, 9081635 Canbyi bluegrass, and 9081624 basin wildrye. Western wheatgrass (9081968) dropped down from a standing of number 7 in 2005 to number 15 in 2006. The released cultivars, Secar Snake River wheatgrass, Pryor slender wheatgrass, San Luis slender wheatgrass, Rosana western wheatgrass, and Trailhead basin wildrye were still among the top performers; but their overall performance had not improved by any significance.

Seed Mixture Trial

CONCLUSION

Not all of the potential germinable seeds germinated the first year (2003). The record high temperatures and low precipitation in July and August, along with the late spring planting date (May 13), are considered to be the primary factors affecting the incomplete germination and emergence during the 2003 growing season. There was a significant amount of new grass seedling emergence detected during the June 30, 2004, evaluation, particularly in the Indian ricegrass, western wheatgrass, big bluegrass, and basin wildrye plots and some new germination of forbs in 2005.

In the single-species plots, the ‘local source’ plants that exhibited superior performance include 9081620 and 9081621 slender wheatgrass, 9081633 big bluegrass, 9081968 western wheatgrass, 9081624 and Washoe Germplasm basin wildrye, 9081628 Indian ricegrass, 9081636 bluebunch wheatgrass, and 9081635 Canbyi bluegrass. The superior indigenous plant material is being further increased for potential release to the commercial seed industry. Worth noting was the performance of some of the released cultivars such as Pryor and Revenue slender wheatgrass, Rosana western wheatgrass, Rimrock Indian ricegrass, Trailhead basin wildrye, Secar Snake River wheatgrass, and Goldar bluebunch wheatgrass.

The forb/subshrub trial had poor emergence and consequently poor seedling densities with the exception of Open Range Germplasm winterfat. The low densities were most likely the result of the late spring planting that resulted in an insufficient period of cold-moist stratification. An additional problem may have been sowing small-sized seed too deeply. There was also heavy surface erosion on this portion of the trial site.

In the Seed Mixture Trials, the 'Experimental' mixes that contained native 'local source' were far superior to the 'Developed' mixes that consisted of native 'nonlocal source' (Upland mix) and introduced cultivars (Waste Management Areas). However, it was estimated that the majority of plants in the Experimental mixtures, both Upland and Waste Management Areas, were 9081620 slender wheatgrass, which was the best overall performer on this particular site.

The tissue analyses show that the heavy metal concentrations in and on the plant tissue sampled from the Stucky Ridge plots were generally within the tolerable limits for both domestic livestock and wildlife.

The overall performance on the Stucky Ridge plots was quite variable, with strips running north and south that had poorer plant vigor and biomass production. The Pryor slender wheatgrass strips between replications (running east and west) exhibited waves of good and poor establishment and performance. Soil samples (0-6 in.) were taken under four plant stands of slender wheatgrass ranging from excellent to very poor in hopes of explaining this variability. It was thought that the incorporation of the amendments may have created strips with varying pH. Soil analysis for pH indicated no difference in pH (all 6.8 to 7.3) under the varying stand of slender wheatgrass. Therefore, this variability is still unexplained.

The DATR (formerly DATC) project has identified numerous plants (grasses, forbs, shrubs, and trees) that exhibit tolerance of acidic and metaliferous soil conditions and have the potential for use by reclamationists in restoration efforts of severely impacted sites. Thus far the DATR project has been instrumental in the release of germplasm of four plants;

Washoe Selected germplasm basin wildrye (*Leymus cinereus*)
Old Works Source Identified germplasm fuzzy-tongue penstemon (*Penstemon eriantherus*)
Prospectors Selected germplasm common snowberry (*Symphoricarpos albus*)
Copperhead Selected germplasm slender wheatgrass (*Elymus trachycaulus*)

Information brochures have been published on three releases and are distributed to potential seed growers and potential seed-purchasing customers. The Copperhead slender wheatgrass brochure has not been published but is being worked on. G_1 (Foundation quality) seed of Washoe basin wildrye has been distributed to two commercial seed growers in Montana, and seed of Old Works fuzzy-tongue penstemon has been distributed to one grower in Washington and one grower in Idaho. No growers have yet shown interest in the production of Prospectors common snowberry.

During the winter of 2007 **Opportunity** Selected class germplasm big bluegrass (9081633) will be submitted for release approval to the Variety Release Committee at Montana State University and the Pure Seed Committee at the University of Wyoming. This accession of big bluegrass has performed exceptionally well on the amended Stucky Ridge Trial site. If the release is successful G_1 seed will be available to commercial growers in the spring of 2008.

The DATR Project has established seed increase fields of all plant species that have exhibited superior establishment and performance in field test plantings in the Anaconda vicinity on smelter and mining-impacted sites. The USDA-NRCS Plant Materials Center, in cooperation with the Deer Lodge Valley Conservation District, plans to continue releasing superior plant materials that have exhibited tolerance of acid/heavy metal-contaminated sites. Some of the potential releases are as follows:

9081968 western wheatgrass (*Pascopyrum smithii*)
9081636 bluebunch wheatgrass (*Pseudoroegneria spicata*)
9081628 Indian ricegrass (*Achnatherum hymnoides*)
9081632 silverleaf phacelia (*Phacelia hastata*)
9076274 woolly cinquefoil (*Potentilla hippiana*)
9081334 silver buffaloberry (*Shepherdia argentea*)
9081638 Woods' rose (*Rosa woodsii*)
9081623 horizontal juniper (*Juniperus horizontalis*).

Plant material that is being considered for release in FY2008 is 9081636 bluebunch wheatgrass. Other releases within the next three years include 9081968 western wheatgrass, 9081632 silverleaf phacelia, and 9081334 silver buffaloberry.

NEVADA

Steven Perkins
Great Basin Plant Materials Center
USDA-Natural Resources Conservation Service
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INTRODUCTION

This report summarizes the activities of the Great Basin Plant Materials Center in relation to revegetation and stabilization of deteriorated and altered lands from 2006 through the present.

ONGOING PROJECTS

1. Wiley Field (Steven Perkins, Great Basin Plant Materials Center; Jay Davison, University of Nevada Cooperative Extension; Tom Lowry, Lahontan Conservation District)

   In many areas of Nevada, water rights have been transferred from agriculture to urban areas to support population growth. This has resulted in large acreages of farmland that have been abandoned. After water is removed, the abandoned farmland becomes highly susceptible to wind erosion and the establishment of noxious weeds. The objective of this project is to identify plant species that can stabilize soils and reduce noxious weed establishment on abandoned cropland.

   The study site for this project is farmland on Swingle Bench near the city of Fallon, NV. In October, 2006, the seed bed was prepared for planting, including disking and harrowing. On October, 26, 2006, 14 species were planted at the site, which included 9 grasses, 3 forbs, and 2 shrubs. After the planting, the field was irrigated once. During 2007, the field will receive supplemental irrigation as needed. After 2007, water rights will be transferred from the field and supplemental irrigation will no longer be available. The site will be monitored and evaluated on an annual basis.

   It is expected that the results of this study will identify species that can stabilize soils and reduce noxious weed establishment on abandoned cropland, as well as identify the cultural practices necessary to enhance the establishment of desirable species.

2. Winnemucca (Steven Perkins, Great Basin Plant Materials Center; Mike Zielinski, Bureau of Land Management; Jay Davison, University of Nevada Cooperative Extension)

Cheatgrass (*Bromus tectorum*) has invaded and degraded much of the rangeland in Nevada and other western states. In Nevada, there are areas where cheatgrass die-off has occurred, providing a window of opportunity for other species to become established before cheatgrass re-invades the site. The objective of this study is to identify species that can become established in these areas and prevent the reestablishment of cheatgrass.

In November, 2006, 7 species/varieties were planted at the site, including 6 grasses and 1 forb. No seed bed preparation was done prior to planting. The site will be monitored and evaluated on an annual basis.

It is expected that the results of this research will identify plant species that can be used to revegetate areas where cheatgrass die-off occurs and prevent reestablishment of cheatgrass.

3. McNamara (Steven Perkins, Great Basin Plant Materials Center; Michelle Langsdorf, Mason Conservation District)

High flows in the Walker River have resulted in severe erosion along the banks of the river in many locations. The objectives of this study are, 1) Study grass species that can effectively stabilize soils on the stream bank to prevent further erosion, and 2) Determine whether erosion control netting can be used to keep the seed in place and create microsite conditions that enhance seedling establishment.

The study site is located near the city of Yerington, NV. In December, 2006, the streambank was re-contoured to create a 2:1 slope. On December 22, 2006, seed from 5 grass species was broadcast on the slopes. Erosion control netting was then placed on approximately 60% of the area. The site will be monitored and herbicides will be used to control weeds if necessary.

It is expected that the results of this study will identify grasses that can effectively stabilize soils on streambanks and determine whether erosion control netting can enhance establishment of the grasses.

4. Snyder (Steven Perkins, Great Basin Plant Materials Center; Michelle Langsdorf, Mason Conservation District)

This project is located near the McNamara Project, and the project description is the same with the following exceptions:

a) The stream bank slope was 3:1
b) The site was planted on January 18, 2006