

# **Revegetation and Stabilization of Deteriorated and Altered Lands**

**An Annual Review of Activities by the Western  
Coordinating Committee-21  
WCC-21**



**February 20-23, 2001  
Kona, Hawaii**

## **FORWARD**

**This document contains the compiled annual activity reports of the members of the Western Coordinating Committee (WCC-21) for Revegetation and Stabilization of Deteriorated and Altered Lands, as of May 15, 2001.**

**The 2001 annual meeting was held in Kona, Hawaii, February 20-23. The minutes to that meeting can be found elsewhere.**

**Submitted to the WCC-21 Committee this 15<sup>th</sup> day of May, 2001.**

**Dr. John T. Harrington  
Secretary, WCC-21**

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# ALASKA

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## INTRODUCTION

This report summarizes the revegetation and bioremediation research projects at the Agricultural and Forestry Experiment Station (AFES) of the University of Alaska Fairbanks from July 1, 2000, to June 30, 2001. Current AFES revegetation research is shifting from monitoring earlier studies to survey of mycorrhizae on disturbed lands, both natural and mined.

## ONGOING PROJECTS

1. Abandoned Coal Mined Land Revegetation Monitoring (D.J. Helm, AFES; N. Moore, Plant Material Center; B. Novinska, B. McMillen, Division of Mining and Water Management).

One objective of this study is to evaluate natural colonization, especially that of *Populus tremuloides* (aspen), for ruffed grouse habitat on various treatments applied by the Alaska Department of Natural Resources (Division of Mining and Water Management, Division of Agriculture) when reclaiming abandoned coal mined sites in southcentral and interior Alaska. Most woody colonization has continued to be *Populus balsamifera* (balsam poplar), which is locally more common than the *P. tremuloides* in the surrounding area. Colonization by woody plants has been adequate regardless of whether the site was lightly seeded and fertilized or not. The amount of bare ground in the unseeded areas after 4 yr has been a concern to the Division of Mining. The lightly seeded areas have acceptable ground cover and woody colonization. Hence, future areas are being seeded. In the tests of organic fertilizer, grubbing (topsoil), and mineral-fertilized overburden materials, the grubbed site has the best ground cover after 2 yr. On another site that had been regraded, but not treated with fertilizer or seeding, natural colonization of woody plants is being monitored. After 4 yr, *P. balsamifera* has colonized much of the area, but mostly from around the edges. *Betula papyrifera* (paper birch) has colonized mostly toward the center, rather than from the edges. This is believed to result from the *Betula* cones rolling down hill or from better moisture conditions in that area. (Primary funding by Alaska Division of Mining and Water Management Abandoned Mined Land Program)

2. Role of Mycorrhizae in Ecological Recovery Following a Prescribed Burn on Permafrost in the Boreal Forest (D.J. Helm, AFES; G.A. Laursen, W. Woodgate, University of Alaska Fairbanks) (Initial funding by National Science Foundation, followed by McIntire-Stennis Research Forestry Program, and volunteer efforts).

Frost Fire was a prescribed burn in the Caribou-Poker Creek Research Watershed northeast of Fairbanks conducted in 1999. The objectives of this study are to determine pre- and post-fire relations among ectomycorrhizae, vegetation types [*Betula papyrifera* (paper birch), *Picea mariana* (black spruce)], and soil horizons and how they are related to the severity of the burn. Ectomycorrhizal (EM) fungi vary from specialists to generalists both with respect to hosts and substrates. This study is characterizing the EM morphotypes with respect to plant community and substrate, then comparing pre- and post-fire EM communities. Root samples are being obtained from four to eight soil/litter cores in each vegetation type. This was the first full growing season after Frost Fire was ignited. Interestingly, intact EM mantles were found adjacent to charred portions of roots. In the unburned areas, some samples are showing clear stratification of EM morphotypes that were visible in the field, supporting the concept that some EM fungi are associated with different substrates.

3. Ectomycorrhizae on Disturbed Lands in Southcentral and Interior Alaska: A Comparison of Regional Similarities and Differences (D.J. Helm, AFES, McIntire-Stennis Forestry Research Program).

This project is new in 2000, but it builds on several previous Alaskan studies including Frost Fire and Exit Glacier. Ectomycorrhizal fungi (EMF) range from generalists to specialists and may be associated with specific plants and/or substrates. Selection of appropriate fungi or mixes for inoculum in revegetation are important for success. The primary objective of this project is to compare ectomycorrhizal communities in early successional sites across a latitudinal gradient in Alaska to determine whether there are similarities in EMF morphotypes (appearance of fungus-root structure) to assess feasibility of a common inoculum or strategy for revegetation. Roots or soil/litter cores were collected by substrate from three primary locations during summer 2000: Exit Glacier in Kenai Fjords National Park, Muldrow Glacier / McKinley River bar in Denali National Park, and the Frost Fire prescribed burn in the Caribou-Poker Creek Research Watershed northeast of Fairbanks (see previous summary). One surprise occurred at Exit Glacier where the outflow river channels changed again this summer and downcut to reveal an interglacial forest with some of the soils and roots intact. Superficially, the EM on the roots from this forest appear similar to present EM. I have not been able to analyze them in detail yet because the roots were flattened by 3 m. of gravel resting on them for several hundred years (materials have not been aged yet, but this is believed to be a minimal age). The samples from the Muldrow Glacier area were taken from the four youngest stages sampled by L. Viereck in his classic chronosequence study. Relatively new sites were also sampled since his youngest sites that have not been washed away are now over 40 yr old.

4. Vegetation Studies at Usibelli Coal Mine (D.J. Helm, AFES).

No active monitoring occurred on these projects during 2000 because of logistics. Final evaluations will occur in 2001 before the site is mined. (Primary funding by Usibelli Coal Mine, Inc.)

5. Constructed Wetlands for Waste Water Treatment in the Sub-Arctic (D.C. Maddux, Ph.D. Student, School of Agriculture and Land Resources Management, University of Alaska Fairbanks).

This is in the process of being written up for a Ph.D. dissertation, and a final summary should be available next year.

## **POTENTIAL PROJECTS**

1. Inoculated Woody Seedlings: A New Alaskan Crop for Alaskan Revegetation (D.J. Helm, AFES, and David Ianson, ARS).

A preproposal has been submitted to the New Crops Opportunities program. We propose to use reciprocal inoculation and transplanting to evaluate whether mycorrhizal inoculum from one region of the state can be used as inoculum in another region. Currently most seedlings for large-scale plantings in Alaska are grown in Canada or the contiguous 48 using seed collected near the Alaskan site. Our smaller greenhouses cannot compete with the large-scale greenhouses. However, the plant is only one-half of the mycorrhizal symbiosis: the mycorrhizal fungus is the other half. Almost all naturally-occurring plants participate in this symbiosis. The intent is to produce inoculated woody seedlings in Alaskan greenhouses that would provide Alaskan growers with a value-added product that would be superior to seedlings produced elsewhere. This will obviously require careful selection of inoculum based on site characteristics and plant species.

# ARIZONA

## Tucson Plant Materials Center Tucson, Arizona

### INTRODUCTION

The Tucson Plant Materials Center (PMC) cooperates with city, state and federal agencies to achieve the goal of conserving natural resources in the Sonoran and Mojave deserts of the southwestern United States. The Tucson PMC provides plant materials related information for land improvement and protection, pollution control, wildlife enhancement and the improvement of our natural resources. Our current priorities include soil erosion control on rangelands, critical areas and retired farmland; controlling wind erosion and promoting low water use ornamental vegetation; water quality improvement through agroforestry, erosion control along streamcourses using native riparian species such as cottonwood and willow; winter cover crops for cotton rotations such as legumes, annual grasses and grains. These priorities are based on existing needs and are more clearly defined in the Long Range Plant Materials Plan which is updated annually by the State Conservationist's PM Advisory Committee. The Tucson PMC also receives direction from a plant materials advisory group made up of specialists in agronomy, range management, biology and plant materials which makes recommendations to the State Conservationist.

### COMPLETED PROJECTS

1. Vegetative Rehabilitation of Mined Lands on the Cyprus-Tohono Mine Site (Mark Pater, Tucson Plant Materials Center, Bernard Siquieros, Cyprus-Tohono Corporation)

The project goals were to develop successful, cost-effective techniques for native plant establishment to improve harsh visual impacts created by the open-pit mining process. This project focused on collecting data for various native plant species which are indigenous to the site. Evaluations and data collection provided information on plant propagation and establishment techniques for use on mine processed materials capped with overburden material.

2. Propagation and Establishment of Culturally Significant Plant Materials on the Cyprus-Tohono Mine Site. (Mark Pater, Tucson Plant Materials Center, Bernard Siquieros, Cyprus-Tohono Corporation)

This project was aimed at obtaining germination and propagation requirements for saguaro cactus (*Carnegie gigantea* [Engelm.] Britt. & Rose), beargrass (*Nolina microcarpa* Wats.) and soaptree yucca (*Yucca elata* Engelm.). The beargrass and soaptree yucca are two culturally significant species used by the Tohono O'odham to make traditional baskets. The



saguaro is also highly regarded by the Tohono O'odham in that it not only provides food and shelter for many insect and animal species, but also for the O'odham.

## ONGOING PROJECTS

1. Maggie Tank Hay Seeding - Using Grass Hay Bales (Mark Pater, Tucson Plant Materials Center, Kim McReynolds, University of Arizona Cooperative Extension, Willcox, Arizona).

The Maggie Tank Hay Seeding project is located on private land within the Sheep Canyon grazing allotment. The allotment is approximately 12 miles south of Bowie, Arizona in Cochise County. The following people are involved in the project: Larry Humphrey and Ted McRae - BLM; Kim McReynolds - University of Arizona Cooperative Extension; Mark Pater - NRCS Tucson Plant Materials Center; Hugh Peterson - Ranch Manager. This project was designed to facilitate revegetation of deteriorated rangeland. Some natural revegetation had been occurring on the allotment over the past 10 years. However, there are areas that were not showing any significant response to improved grazing management. The idea was to use the cattle as a tool to plant grass seed by trampling around the area where hay was thrown out.

2. Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US (Mark Pater, Tucson Plant Materials Center, Carleton Edminster, USFS, Rocky Mountain Experiment Station, Ron Bemis, NRCS, Douglas Field Office).

The Borderlands Ecosystem Project area covers nearly 1 million acres in southeastern Arizona and southwestern New Mexico and includes the San Bernardino, southern San Simon and Animas Valleys. Much of the region supports semi-desert grass-shrub ranges and woodlands that are vital for livestock growers and local economies. This vegetation type occupies a strip of 50 to 100 miles along the United States-Mexico border in Arizona, New Mexico, and west Texas (Martin 1975). Elevations generally are from 3,000 to 6,000 feet. Precipitation, depending on geographic location along a northwest to southeast axis, ranges from 8 to 20 inches annually. In order to better understand and quantify the effects of different management practices on encroachment of woody species in grasslands and savannas, a multiple year research study is being implemented that considers the effect of several management strategies on ecosystem processes, function and composition. Other partners, in addition to the Rocky Mountain Experiment Station and Coronado National Forest included the Natural Resources Conservation Service (NRCS), the Whitewater Draw Natural Resource Conservation District, Arizona State Land Department, Malpai Borderlands Group, Hidalgo Soil and Water Conservation District, Animas Foundation, and U.S. Fish and Wildlife Service at the San Bernardino National Wildlife Refuge. The objective of the research study is to evaluate the impacts of a number of management treatments on components of the rangeland ecosystem: soils, vegetation, wildlife, and livestock. In Arizona, study locations include the San Bernardino National Wildlife Refuge (NWR), the Malpai Ranch, and the Sycamore Ranch. Locations on both the Malpai Ranch and the Sycamore Ranch include land leased from the State of Arizona. In New Mexico, the locations include the George Wright pasture of the Gray Ranch and a location north of Rodeo on the Roos Ranch. Study areas are easily accessible for logistical reasons and enhanced value for demonstration and learning. The focus of this study is not

eradication of woody species, but rather a reduction of woody species density to improve range and watershed condition and promote development of a viable and productive perennial grass component. A successful treatment would be expected to produce a savanna condition with more widely scattered woody species and improved herbaceous cover, condition and productivity. Past efforts to mechanically control mesquite in the area have focused on either lifting of individual plants and root systems or root plowing and shearing. These treatments result in significant soil disturbance. An alternative mechanical treatment using a Marden duplex drum brush cutter (roller chopper) is being proposed for much of this study. While the brush cutter will not kill plants, it should be effective in breaking down crowns and breaking up the soil surface while incorporating some of the crown organic material into the upper soil layer and minimizing further soil disturbance. The treatment also reduces the transpiring leaf surface area of the mesquite plants. Mechanical treatment will be combined with and without native species seeding appropriate to each site. Sprouting of woody species is expected, however, establishment of an herbaceous layer should allow effective use of prescribed fire to control sprouts in the near future. Herbicides will not be used as part of this study.

3. Riggs Flat #2 (Bruce Munda, Tucson Plant Materials Center).

The goals of this field planting are to promote the use of improved conservation plants for range seeding, evaluate the adaptation of experimental plant lines for use in northern Arizona, and obtain data to update FOTG. Riggs flat is located on the Kaibab Paiute Indian Reservation approximately 6 miles west of Fredonia, Arizona and is immediately adjacent to highway 389. Elevation is 4600 feet and is within Major Land Resource Area 35-4. Annual precipitation is 9.4 inches with 27% received during July through October and 42% received from January through May. Soil is classified as Jocity clay loam, deep and well drained, and the range site is a clay loam bottom. This site was first planted in 1986 and then replanted in 1994. The 1986 planting was a complete failure due to lack of moisture and competition from weeds, primarily cheatgrass. The site was replanted in November, 1994 using 17 grass and 4 shrub species. Based on the results of the 1994 planting, Tucson PMC personnel have installed this larger planting using HycrestII and Vavilov Siberian wheatgrass. The Tucson PMC will be evaluating their establishment with regards to competition with winter annuals and imposing two treatments (disking & herbicides). Disking and herbicide applications will be evaluated with regards to improvement, if any, with stand establishment of the two seeded species.

4. Improving the production and soil protection of rangeland in the Intermountain West and Great Basin States (Bruce Munda, Tucson Plant Materials Center; Mark Pater, Tucson Plant Materials Center; Rick Orr, Caliente Field Office).

The identified needs for this project include: (1) Improved and enhanced basic biological information on plants having rangeland applications, and (2) Development of improved plant materials for special rangeland applications. Proposed actions include: (a) continue to work with Caliente FO and BLM to conduct seeding and plant succession studies on burned watersheds with the objective to control Pinyon and Juniper and replace them with an adapted mixture of grasses, forbs and shrubs for watershed improvement, livestock forage, and wildlife habitat improvement.

## **CURRENT PUBLICATIONS AND PAPERS**

1. Mineland Revegetation Trials, 1995-1999 Final Report. Mark Pater, USDA-NRCS Tucson Plant Materials Center; Bernard Siquieros, Cyprus Tohono Corporation; Bruce Munda, USDA-NRCS Tucson Plant Materials Center; Harry Buck, USDA-NRCS Tucson Plant Materials Center.
2. Saguaro Cactus – Cultural Significance and Propagation Techniques in the Sonoran Desert.  
*In:* Native Plants Journal, Fall 2000 issue. Mark Pater, USDA-NRCS Tucson Plant Materials Center; Bernard Siquieros, Cyprus Tohono Corporation.

# Arizona

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## INTRODUCTION

This report summarizes revegetation and restoration research at the University of Arizona for 2000. Researchers at the University of Arizona investigate whole plant, population, community, and ecosystem processes and dynamics in arid and semi-arid environments. Assembled here are summaries of projects that have direct implications for revegetation and restoration of disturbed land in the western U.S.

## ONGOING RESEARCH

1. Climate change, grass invasion, and woody plant dynamics in semi-arid savanna (Jake Weltzin and David G. Williams, University of Tennessee and University of Arizona).

One aspect of land cover change with regional and global ramifications is the historic increase in the stature and abundance of woody plants within savannas and grasslands of the world. These physiognomic shifts have important implications for local economies, especially within the context of other changes in the global environment. Predictions about the future woody plant dynamics on rangelands in the southwestern U.S. hinge on a better understanding of the interplay between woody plant recruitment, soil water balance, and C<sub>4</sub> grass competition (especially with recently introduced non-native grasses). We will test the general hypothesis that the magnitude and pattern of grassland to woodland conversion under changing global conditions will depend on surficial soil water dynamics, as mediated by the grass species comprising the competitive neighborhood of woody plant seedlings and the geomorphic surface on which the vegetation develops. We will experimentally alter native and non-native C<sub>4</sub> grass cover and seasonal precipitation at field sites characterized by different aged alluvial surfaces with varying degrees of clay horizon development. The demographic and physiologic responses of *Prosopis* introduced as seeds into experimental plots will be used to gauge the potential recruitment of this species under different biotic and abiotic conditions and to investigate linkages between seedling water stress and demographic response. Results from this project will facilitate predictions about the consequences of climate change in the southwestern U.S. for continued mesquite proliferation.

2. Restoration of ponderosa pine savanna in the Black Hills (Guy R. McPherson and Carolyn Hull Sieg, School of Renewable Natural Resources, University of Arizona and USDA Forest Service Rocky Mountain Research Station).

We are investigating use of overstory removal and prescribed fire as tools to restore savanna structure to ponderosa pine forests in the Black Hills of South Dakota. A large-scale field experiment has been initiated with the following dependent variables: level of overstory removal (none, partial, complete) and prescribed fire (burned, unburned). We will evaluate response of soil moisture and population- and community-level response of plants for at least 5 years. A complementary study addresses the seedbank as a potential constraint to restoration of these systems.

3. Fire-based restoration of biodiversity in semidesert grasslands (Guy R. McPherson and Robert J. Steidl, School of Renewable Natural Resources, University of Arizona).

We are investigating use of prescribed fire as a tool to restore biological diversity in semidesert grasslands dominated by Lehman lovegrass (*Eragrostis lehmanniana*). Specifically, we are implementing a large-scale field experiment in southern Arizona. Independent variables include pre-treatment community structure, season of fire, and year of fire. We will evaluate population- and community-level response of plants, invertebrates, and vertebrates for at least 5 years. Complementary experiments focus on the role of soil nitrogen in establishment of native herbs.

4. Groundwater dependence of riparian vegetation: A synthetic dendrohydrology and isotope ecophysiology study (Bob Webb, USGS; Dave Williams, School of Renewable Natural Resources, University of Arizona; Dave Meko Laboratory of Tree Ring Research, University of Arizona).

The purpose of this study is to develop riparian dendrohydrology methods that can be used to assess the relationship between groundwater/surface water and physiological stress in riparian vegetation. We have three basic objectives for tree ecophysiology studies; 1) Examine of  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  variation in tree xylem water and its relation to tree water sources, 2) investigate the utility of leaf and tree ring  $\delta^{13}\text{C}$  for understanding consequences of water source and climate variation for tree physiologic stress, and 3) evaluate the level of clonal resource integration among riparian trees.

## **CURRENT PUBLICATIONS AND PAPERS**

Cooper, D.I., W.E. Eichenger, L. Hipps, J. Kao, J. Reisner, S. Smith, S.M. Schaeffer, and D.G. Williams. 2000. Spatial and temporal properties of water vapor and flux over a riparian canopy. *Agricultural and Forest Meteorology* 105:161-183.

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- Schaeffer, S.M., D.G. Williams, and D.C. Goodrich. 2000. Transpiration in cottonwood/willow forest estimated from sap flux. *Agricultural and Forest Meteorology* 105:257-270.
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# **COLORADO**

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## **INTRODUCTION**

This report summarizes reclamation and restoration research projects at Colorado State University for the period October 2000 through June 2001. Reclamation research has been conducted by the Rangeland Ecosystem Science and Soil and Crop Science Departments and the Center for Ecological Management of Military Lands (CEMML) with funding from the Colorado Agricultural Experiment Station, USDA, EPA, U.S. Army, and the Colorado Department of Public Health and Environment.

## **COMPLETED RESEARCH**

1. Recovery of Rangeland and Abandoned Croplands Following Removal of N Stress (Edward Redente, Mark Paschke, and Donald Klein, Rangeland Ecosystem Science and Microbiology Departments).

This project began in the summer of 1997 and continued for a three-year period. The primary objective of this research was to determine if N-stress related changes in plant community structure and function have long-term consequences following removal of the N-related stress. This project was conducted in the shortgrass steppe of Colorado.

2. Digital Terrain Modeling and Distributed Soil Erosion Simulation/Measurement for Minimizing Environmental Impacts of Military Training (Steve Warren, Helena Mitasova, Mark Jourdan, William Brown, Billy Johnson, Don Johnston, Pierre Julien, Lubos Mitas, Darcy Molnar and Chester Watson, CEMML, Department of Civil Engineering, University of Illinois, and US Army Waterways Experiment Station).

This project began in 1993 to develop geographic information system tools and methods to enhance the accuracy, spatial prediction and visual representation of erosion and deposition on military lands.

3. Reassessment of Revegetation Strategies for Kaho'olawe Island, Hawai'i (Alan Ziegler, Steve Warren, Lyman Perry and Tom Giambelluca, University of Hawai'i, CEMML and Hawai'i State Division of Forestry).

This project began in 1996 to reevaluate revegetation study plots put in place in 1991.

4. Maneuver Lanes at Friedberg Training Area, Germany: Feasibility Study (Steve Warren and Robert Brozka, CEMML)

This project began in 1999 to determine the feasibility of deforesting portions of the Friedberg Training Area to expand military maneuver training opportunities. The primary criteria were soil erosion potential and viewshed analysis from the point of view of surrounding civilian communities.

5. Maneuver Area Expansion at Pfändhausen Training Area, Schweinfurt, Germany: Feasibility Study (Steve Warren and Robert Brozka, CEMML).

This project began in 1999 to determine the feasibility of deforesting portions of the Pfändhausen Training Area to expand military maneuver training opportunities. The primary criteria were soil erosion potential and viewshed analysis from the point of view of surrounding civilian communities.

6. Validation of Enhancements to the Universal Soil Loss Equation Topographic Factor Using <sup>137</sup>Cesium (Steve Warren, Helena Mitasova, Dick Gebhart, Matt Hohmann, Sheldon Landsberger and Felib Iskander).

This project began in 1998 to evaluate enhancements to the Universal Soil Loss Equation. By altering the topographic factor, the USLE can be converted to a multidimensional tool capable of accurately predicting both soil erosion and sediment deposition.

7. Soil Erosion Survey for Camp Guernsey, Wyoming Using New-Generation Multi-Dimensional Soil Erosion Modeling (Steve Warren, Gary Senseman, Paul Block, Tom Ruzycki and DeeDee Wilcox).

This project began in 1999 to evaluate the current erosion status of Camp Guernsey, Wyoming. The project identified the inherent soil stability of Camp Guernsey on a spatially distributed basis and identified those areas that are in current need of land reclamation.



## ONGOING RESEARCH

1. Reclamation at the Summitville Super Fund Site (Edward Redente and Mark Paschke, Rangeland Ecosystem Science Department).

This project began in the fall of 1995 and involves a greenhouse phase and a field phase. The objective of the project is to test reclamation alternatives for stabilizing acid generating waste rock material at an elevation of 11,000 feet.

2. Effects of Biosolids Application on Erosion Control and Ecosystem Recovery Following the Buffalo Creek Fire, Colorado (Ken Barbarick and Edward Redente, Soil and Crop Science and Rangeland Ecosystem Science Departments).

This project was begun in the spring of 1997 and the objective is to determine appropriate organic matter and nutrient inputs from biosolids to facilitate post-burn ecosystem recovery in a forested system southwest of Denver.

3. Metal Toxicity Thresholds for Important Reclamation Species in the Western U. S. (Edward Redente, Mark Paschke, and Ken Barbarick, Rangeland Ecosystem Science and Soil and Crop Sciences Departments).

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.

4. Integrated Control and Assessment of Knapweed and Cheatgrass on Department of Defense Installations (Mark Paschke and Edward Redente, Rangeland Ecosystem Science Department; Don Klein, Microbiology Department; Steve Warren, Center for Ecological Management of Military Lands; Northern Plains Agricultural Research Laboratory—USDA-ARS in Sidney, MT; Department of Energy Remote Sensing Laboratory, Las Vegas, NV)

This project began in April 2000 and will extend for four years. 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.

5. Shrub Establishment Techniques of Coal Mine Lands in Colorado (Edward Redente and Mark Paschke, Rangeland Ecosystem Science Department).

This project began in September 2000 and will extend for four years. The objective is to develop methods for the establishment of woody plants on coal mine disturbances in northwest Colorado. Three mines sites are included in the study and methods include strip seeding, transplanting, testing seed mixtures with relatively low-competitive grasses and forbs, soil depth, soil quality, and fencing to exclude deer and elk.

6. Evaluation of the Long-Term Effects of Biosolids on Revegetation in Northwestern Colorado (Mark Paschke and Edward Redente, Rangeland Ecosystem Science Department).

The purpose of this study is to evaluate the long-term (20 years) effects of biosolids application on plant community development and the residual effects of biosolids application on soil fertility. This is a follow-up study of a revegetation project that compared organic and inorganic N inputs in 1977.

7. Soil Erosion Survey for Fort McCoy, Wisconsin (Steve Warren, Tom Ruzycki and Paul Block, CEMML).

The purpose of this study is to use new-generation soil erosion modeling technology to determine the current erosion status of Fort McCoy and identify those areas currently in need of land reclamation efforts to curb excessive erosion.

8. Diagnostic Tools and Reclamation Technologies for Mitigating Impacts of DoD/DOE Activities in Arid Areas (Kent Ostler, Dennis Hansen, David Anderson, Steve Warren, Christopher Lee, Gene Capelle, Ruth Sparks and Mickey Quillman, Bechtel Nevada, CEMML, California State University at Dominguez Hills, Charis Corporation and Fort Irwin).

This project seeks to identify and develop cost-effective land reclamation products and technologies that can be applied to highly disturbed lands in arid areas.

9. Pilot Production and Arid Land Reclamation Using Cyanobacterial Inoculant to Establish Biological Soil Crusts (Dan Hartman, Jeffrey Johansen, Steve Warren, Mike Riley and Todd Hawkins, Engineering Technology Inc., John Carroll University, CEMML, Midwest Industrial).

This project seeks to develop a cyanobacterial inoculant for use in land reclamation prescriptions on arid lands.

## **PLANNED OR POTENTIAL PROJECTS**

1. Development of practical methods for the control of cheatgrass based on the management of soil N availability.
2. Comparisons of different revegetation techniques to increase plant community recovery following a fire. Treatments include chisel incorporation of composted biosolids, disc incorporation of composted biosolids, rotoclearing without biosolids addition, and paper-mill sludge incorporation.
3. An evaluation of the short-term and long-term successional dynamics of biological soil crusts following wildfire. This knowledge will assist in determining the feasibility and possible strategies to accelerate the recovery of biological soil crusts in disturbed communities.

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- Stevenson, B. A., T. McLendon, and E. F. Redente. 2000. Effects of soil fumigation and seedling regimes on secondary succession in a semiarid shrubland. *Arid Soil Research and Rehabilitation* 14:87-99.
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- Paschke, M. W., C. DeLeo, and E. F. Redente. 2000. Revegetation of roadcut slopes in Mesa Verde National Park. *Restoration Ecology* 8:276-282.
- Paschke, M. W., E. F. Redente, and D. B. Levy. 2000. Zinc toxicity thresholds for important reclamation grass species of the western United States. *Environmental Toxicology and Chemistry* 19:2751-2756.
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- Newman, Gregory. 2000. Long-term revegetation practices in the Piceance Basin, Colorado. M.S. Thesis. Colorado State University. Fort Collins, CO.
- Sydnor, Russell. 2000. An evaluation of long-term plant community development on topsoil treatments overlying retorted oil shale. M.S. Thesis. Colorado State University. Fort Collins, CO.
- Pierce, Bonnie. 2000. Microbial responses to biosolids treatment of rangelands. Ph.D. Dissertation. Colorado State University. Fort Collins, CO.
- Winter, Margaret. 2000. Reclamation of waste rock at the Summitville Mine Superfund Site using organic matter and topsoil treatments. M.S. Thesis. Colorado State University. Fort Collins, CO.
- Meyer, Victor. 2000. The effect of biosolids application on erosion control and ecosystem recovery following the Buffalo Creek fire. M.S. Thesis. Colorado State University. Fort Collins, CO.

- Arthur, Denise. 2000. Restoration at the Rocky Mountain Arsenal National Wildlife Refuge. Ph.D. Dissertation. Colorado State University. Fort Collins, CO.
- Warren, S.D., H. Mitasova, M.R. Jourdan, W.M. Brown, B.E. Johnson, D.M. Johnston, P.Y. Julien, L. Mitas, D.K. Molnar and C.C. Watson. 2000. Digital terrain modeling and distributed soil erosion simulation/measurement for minimizing environmental impacts of military training. CEMML Technical Publication Series 00-2.
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# **COLORADO**

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## **INTRODUCTION**

This report summarizes the reclamation-related research conducted by Dr. Terrence Toy during the period March 31, 2000 to November, 2000. During this time my research was divided between: (1) completing the hillslope erosion project with Dr. George Foster and the Agricultural Research Service, National Sedimentation Laboratory, (2) preparation of publications using the information and data collected during my sabbatical last year, and (3) development of the Revised Universal Soil Loss Equation (RUSLE), version 2.0.

## **COMPLETED RESEARCH**

The hillslope erosion research project with Dr. Foster was completed and the report was filed with Dr. Matt Römken at the National Sedimentation Laboratory. This project focused upon the three-dimensional morphology of hillslopes and the effects this morphology upon soil-erosion rates. The popular erosion-prediction models estimate soil loss along hillslope profiles without taking into account the convergence or divergence of surface flow that occurs on valley-head or spur-end hillslopes, respectively. The first part of this report consists of an extensive literature review concerning three-dimensional hillslope morphology and its influence soil moisture, weathering, pedogenic processes, vegetation growth, hillslope stability, hillslope hydrology, and soil erosion. A second literature review examines the extent to which automated terrain analysis procedures might be used to develop erosion-prediction technologies that include three-dimensional hillslope morphology. Unfortunately, erosion-prediction equations are sensitive to hillslope gradient and automated terrain analysis, with present capabilities, does not compute hillslope gradient with accuracy.

In the second part of this report the theory and mathematical equations are developed that provide the foundation for future expansion of erosion-prediction technologies to take into account three-dimensional hillslope morphology. The next phase of this research is experimental verification of these equations at the National Sedimentation Laboratory using the rainfall simulation apparatus and laser hillslope-profiling equipment. This research may commence next year, funding permitting.

## ONGOING RESEARCH

The main project for the coming year is completion of the university-level textbook concerning soil-erosion processes, co-authored with Dr. George Foster and Dr. Ken Renard. The book is under contract with John Wiley and Sons, Inc. and the manuscript is to be finished by June, 2001.

I am working with Dr. Daniel Yoder and Dr. George Foster on the development of the second version of the Revised Universal Soil loss Equation (RUSLE). This software and manual is scheduled for release to the Natural Resources Conservation Service in April, 2001. My role in this project is to represent the users who are primarily engaged in the reclamation of severely disturbed lands, both mine lands and construction lands. The team is trying to make this erosion-prediction technology both technologically sophisticated and user-friendly.

I am also working with Dr. Waite Osterkamp of the U.S. Geological Survey on a project only tangentially related to reclamation, focusing upon tree-throw (blow-down) as a sediment-mobilizing process and sediment source in high-altitude forests. It is expected that this research will contribute to the understanding of sediment mass-balances in forests.

There are two additional articles in preparation based on the information obtained during the sabbatical in Autumn, 1999:

1. Long-term Planning for Brazilian Mine Reclamation, by Terrence Toy, Carlos Ribeiro, and James Griffith.

The purpose of this article is to advocate long-term planning for surface-mine reclamation in Brazil. There have been many improvements in surface-mine reclamation since 1987 but there is still little long-term planning concerning the future and eventual use of the land following the closing of the mine. The steps for complete reclamation are discussed with a focus on long-term planning. The need for rapid vegetation cover, using the two-phase model, is encouraged in order to control erosion and sedimentation processes. An example of a long-term land-use plan based on agricultural production is presented.

Status: This manuscript is complete and in the process of translation into Portuguese for publication in a referred Brazilian journal. James Jackson Griffith is now responsible for completion of the publication process.

2. Linkages Between Social and Physical Systems in the Reclamation of Disturbed Lands, by James Griffith and Terrence Toy.

The purpose of this article is to demonstrate the linkages between social and physical systems in the successful reclamation of disturbed lands. The relationship between force and resistance in both social and physical systems provides a basis

for systems analysis. The likelihood of successful reclamation can be evaluated on the basis of systems analysis. An example of successful reclamation is discussed.

Status: About two-thirds of the manuscript remains to be written. My part is complete. The finished manuscript will be submitted to the Journal of Environmental Management. James Griffith also is responsible for completion of the publication process.

## **PLANNED OR POTENTIAL PROJECTS**

The second phase of the research concerning experimental calibration of the equations to include three-dimensional hillslope morphology in erosion-prediction models still awaits funding. This could be the year! Nevertheless, at least one journal article may be forthcoming from the earlier report.

Otherwise the on-going projects listed above will fill the plate.

## **CURRENT PUBLICATION AND PAPERS**

### Presentations

Foster, G.R., Yoder, D.C., McCool, D.K., Weesies, G.A., Toy, T.J., and Wagner, L.E., Improvements in Science in RUSLE2. 2000, American Society of Agricultural Engineers, Paper No. 002147 (written paper distributed at meeting)

Toy, T.J., Soil Erosion Modeling, Past, Present, and Future, Sigma Xi, University of Denver Chapter,

### Publications

Toy, T.J. and Griffith, J.J., (In press) Changing surface-mining reclamation practices in Minas Gerais, Brazil. *International Journal of Surface Mining, Reclamation and Environmental Issues*.

Toy, T.J., Erosion. (In press) *Encyclopedia of Science and Technology*, 9<sup>th</sup> ed., McGraw-Hill

### Report

Toy, T.J. and G.R. Foster, The Effect of Three-Dimensional Hillslope Morphology on Water-Erosion Prediction, Report submitted to Agricultural Research Service, National Sedimentation Laboratory, 66p.

## IDAHO

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### INTRODUCTION

This report summarizes plant science work conducted within the Aberdeen Plant Materials Center service area during 2000. The primary focus of the Aberdeen PMC is plant selection and establishment techniques for low precipitation rangeland; riparian and wetland plant selection and technology development; and promotion and demonstration of windbreaks and other agroforestry practices.

### PROJECT ACTIVITIES

#### 1. Native Bluegrass Evaluation Planting

Seed collections from Caliente, Nevada were planted in replicated plots in May, 1996. 'Sherman' big bluegrass and 'Canbar' Canby bluegrass were planted as standards of comparison. The best performing accession (9076402) was positively identified as *Poa fendleriana* (muttongrass). Seed from this accession was harvested in 1999 and 2000 for seed increase and further evaluation.

#### 2. Sandberg Bluegrass Release in Cooperation with USDA - FS

In 1999 the PMC agreed to cooperate with the USDA Forest Service Shrub Lab in the release and seed increase of accession number B5397G1818 *Poa secunda*. This accession was collected by the Shrub Lab in 1997 on the Air Force Saylor Creek Test Range in southwestern Idaho and has been evaluated against 25 other accessions from Idaho. The PMC planted a 1 acre seed increase field in May, 2000 and will be evaluating seed production culture and processing.

#### 3. 'Appar' and Native Blue Flax Comparison

The USFS Shrub Lab and the PMC cooperatively released Appar Lewis flax as a native forb in 1980. Appar was later determined to be a naturalized introduced species from Europe. The Shrub Lab has been evaluating native blue flax accessions and requested the PMC assist in a study to compare Appar to one of the more promising native collections. In May, 2000 two rows



each (80 feet long) of Appar and Maple Grove G1 collection were seeded at the PMC. Preliminary evaluations found the Maple Grove collection to have the best stand and taller plants. The study will be evaluated next year and seed yields will also be evaluated.

#### 4. Hybrid Poplar Initial Evaluation

The purpose of this project is to evaluate hybrid poplar accessions currently being used in commercial production for fiber and fuel in Washington, Oregon, and western Idaho. Presently there is no commercial poplar production in southeast Idaho or northern Utah and this trial may identify accessions that are adapted to this region. Replicated plots were planted at the PMC in May, 1998. Preliminary evaluations indicate that OP-367 and 52-225 (common clones used in the industry) may be the best suited clones to the soils and climate of the Snake River Plains of southeast Idaho. Evaluations in September, 2000 found OP-367 to be 16.7 feet tall and a diameter at breast height (D.B.H.) of 3.1 inches on average. Clone 52-225 averaged 10.1 feet tall and D.B.H. of 1.14 inches.

#### 5. Coffee Point Inter-Center Strain Trial

Coffee Point is located approximately 25 miles northwest of Aberdeen in an 8-12 inch annual precipitation zone. The trial was seeded in November, 1994 to evaluate grasses for adaptation and performance. Production, plant height, cover and vigor data was collected. A summary of five years of evaluation data was completed in 2000. 'Hycrest' crested wheatgrass, 'Vavilov' Siberian wheatgrass and Syn A Russian wildrye consistently had the best stands during the five year evaluation period and Hycrest, Vavilov, 'P-27' and PI-275459 Siberian wheatgrass produced the most forage over the four year period. The site will be maintained for training purposes and periodic evaluations will be conducted to evaluate long term performance of the accessions planted in 1994.

#### 6. Grantsville Inter-Center Strain Trial

Grantsville is located approximately 30 miles southwest of Salt Lake City, Utah in an 8-12 inch annual precipitation zone and a region heavily infested with cheatgrass. The trial was seeded in November, 1994 to evaluate grasses and native shrubs for adaptation, performance and ability to compete with cheatgrass. Production, plant height, cover and vigor data were collected. The site was sprayed with Oust™ on December 2, 1998 to control cheatgrass and to evaluate herbicide effects on the established accessions. The combined effects of herbicide application, dry conditions, and grasshopper damage during the summer of 1999 made it difficult to determine how effective the herbicide application was. Evaluations during 2000 found that 'Secar' Snake River wheatgrass, 'Schwendimar', 'Bannock' and 'Critana' thickspike wheatgrass to be negatively affected by the herbicide. Nordan and Hycrest crested wheatgrass, and P-27 Siberian wheatgrass produced the most forage in 2000. A summary of six years of evaluation data is currently being prepared.

#### 7. Mountain Home Air Force Base Windbreak Demonstration

This project is a cooperative, reimbursable project with the United States Air Force to install and demonstrate the value of windbreaks. Between 1996 and 1999, approximately 52,940 running feet of windbreak were planted at the Air Force Base. A new agreement was developed in 1999 to continue the installation of approximately 44,285 running feet of new windbreaks through 2003. In March, 2000 the PMC planted and installed 8,164 running feet of weed barrier fabric at the Base. The five to six row windbreaks are comprised of Siberian peashrub, Rocky Mountain juniper, Robust poplar, Austrian pine, 'Shuberts' chokecherry and skunkbush sumac. The Air Force has been very happy with the survival and growth of the windbreaks. Idaho Plant Materials Technical Note No. 34 – Guidelines to Reduce Rodent Damage while Establishing Windbreaks was completed based upon experience gained from this project.

#### 8. Mountain Home Air Force Base Woody Inter-center Strain Trial

This trial was established in 1991 to test woody plants for use in windbreaks in southwestern Idaho. There are 111 accessions representing 63 species. Semi-annual evaluations were conducted through 1996 to identify both released and potential plant material for adaptation. The PMC will continue to evaluate the site on a 5-10 year interval to observe long term survival and performance. The site is a valuable demonstration of woody plant material. Idaho Plant Materials Technical Note No.29 Test Results - Woody Plant Materials for Windbreaks was completed as a result of this trial.

#### 9. Idaho Army National Guard

The PMC and the South Bingham Soil Conservation District began working on a reimbursable project with the Idaho Army National Guard in 1996 to research propagation of tapertip hawksbeard and sharpleaf penstemon which are native to the Tank Training Area located south of Boise. The establishment of 3 plant testing sites was completed in 1999. The purpose of the three sites is to test native plant materials and demonstrate seedbed preparation and seeding techniques. During 2000, all test sites were evaluated and the on-site seed orchard of winterfat and sharpleaf penstemon was planted. Winterfat plants were propagated in the PMC greenhouse and were transplanted to the site in February, 2000. Sharpleaf penstemon was direct-seeded in November, 1999. The seed orchard has weed barrier fabric installed to help conserve soil moisture and reduce weed growth.

#### 10. Fourwing saltbush

The PMC has been evaluating fourwing saltbush for future release. Four accessions from the northern range of its adaptation have been bulked to develop material that is more winter hardy than existing releases. A new seed field was established at the PMC in 1999. It is planned to release accession 9067480 as a selected release during 2001.

## 11. Winterfat

The PMC has been evaluating winterfat for future release. Four accessions from the northern range of its adaptation have been bulked to develop material that is more winter hardy than existing releases. A new seed field was established at the PMC in 1999. It is planned to release accession 9067481 as a selected release during 2001.

## 12. Breeder and Foundation Seed Production

The Aberdeen PMC is responsible for Breeder and Foundation seed production of 17 plant releases. During 2000, the PMC had Foundation seed fields of 'Magnar' basin wildrye, 'Goldar' bluebunch wheatgrass, 'Rush' intermediate wheatgrass, 'Bannock' thickspike wheatgrass, 'Ephraim' crested wheatgrass, 'Appar' Lewis flax, Richfield Selection firecracker penstemon and Clearwater Selection alpine penstemon. Breeder fields of Bannock, Magnar, and 'Nezpar' Indian ricegrass established in 1997 were harvested in 2000.

## 13. Constructed Wetland Systems

Constructed Wetland Systems (CWS) are designed and built to mimic a natural wetland's water purification function. CWS use the wetland plants and the microbial populations associated with the roots to breakdown and remove various pollutants such as nutrients, sediments, pesticides, heavy metals, and bacteria. The Riparian/Wetland Project has worked on two different types; 1) CWS to treat agricultural wastewater (irrigation and animal) and stormwater CWS to treat urban wastewater. The following CWSs have been installed or are in the process of being installed:

\* **Nature Conservancy (TNC) CWS** - Located near Hagerman, Idaho. This site was built in 1994 to treat irrigation tailwater from the Northside Canal Company main canal before it enters springs owned by TNC and eventually the Snake River. This project is also a response to a court order to clean up irrigation return flows before they enter the middle Snake River area. The site was planted in 1995 and 1996. This system is being used for research and demonstration.

\* **Cedar Draw CWS** - This site is located on property owned by the Twin Falls Canal Company and Idaho Fish & Game Department. The site was constructed and planted in 1996. This is a cooperative project between the Twin Falls Canal Company, University of Idaho, Idaho Fish & Game Department, USDA - NRCS Aberdeen Plant Materials Center, Idaho Power Company, and Coors Brewing Company. The site is designed and installed around an old fish hatchery. The raceways are used to test individual wetland plant species, CWS design, and management practices. This CWS is being used as a research and demonstration site.

\* **Fairview CWS** - Located near American Falls, Idaho on the Neil Poulson farm. This CWS treats furrow irrigation wastewater from a 160-acre farm that raises grain, grass seed, and cattle. The wastewater is treated before it enters American

Falls Reservoir on the Snake River. The design was based on replicated components, different plant species, and varying plant communities. Two years of baseline data and extensive water quality data from the surrounding area has been collected. Idaho State University researchers are working with the Riparian/Wetland Project to set up a variety of experiments including microbial populations, rate of establishment, nutrient breakdown in relationship to age of the plants, PAM studies, invertebrate and vertebrate populations, and others. We are helping with design, data collection, plant selection, plant procurement, and planting.

\* **H-Drain CWS** - Located near Paul, Idaho and located on property owned by USDI-Bureau of Reclamation. The site was built and planted in 1995. This project was constructed to treat irrigation wastewater from irrigated farms in the A & B Irrigation District. The area originally fed well which injected the irrigation wastewater into the Snake River Aquifer. This project is currently functioning and evaluations are being completed on a 5 year schedule.

\* **CSI CWS** - This CWS is situated on the College of Southern Idaho Campus in Twin Falls, Idaho. This system was constructed to treat geothermal water that heats the campus buildings, stormwater runoff from the city of Twin Falls, and agricultural wastewater that enters Perrine Coulee above the city. The site was built in 1995 and planted in 1996. Water entering the CWS is about 85°F. The site is used for research and demonstration.

\* **City of Pocatello Stormwater CWS** - We are assisting the City of Pocatello with the design, construction, and planting of a Constructed Wetland System to treat stormwater that flows through the city from the surrounding watershed. The CWS encompasses about 4 acres. We advised the City in the purchase of plants, planting schedules, and planting. The CWS was planted in 1998. We are evaluating the vegetation and cooperating with the USGS in the water-monitoring plan.

#### 14. Riparian Projects

The following riparian projects are designed to test and demonstrate bioengineering structures either individually or in conjunction with rock structures. We are studying riparian area management, riparian enhancement, and riparian restoration. The main emphasis of our research is performance-tested native species, planting techniques in the arid and semi-arid west, and community maintenance. The following projects were installed or are being installed:

\* **Arimo Ranch Riparian Grazing Demonstration Project** – This study involves 4.1 miles of Marsh Creek located on private property south of Pocatello, Idaho. One half of the stream is excluded from cattle grazing, and one half is under a managed planned grazing system. One half of the enclosure and one half of the grazed portions have been or are being planted and/or having bioengineering structures installed. This site is being used as a research and

demonstration site. This is a cooperative project between USDA-NRCS, Plant Materials Center and Idaho Fish and Game Department. EPA 319 funds have been used to construct the exclosures.

\* **Camas Creek/Larson Farms Site** - This site is a 10 mile section of Camas Creek located on Larson Farms north of Hamer, Idaho. Camas Creek is dewatered through irrigation diversions during most of the summer months. The riparian vegetation has been removed through farming operations over the last 20 plus years. The soils are sands and sandy loams. Tons of sediment are eroded from the banks and washed down to the Camas National Wildlife Refuge and Mud Lake each year. The Riparian/Wetland Project was asked to assist with a restoration plan that would significantly reduce the amount of sediment coming from Larson Farms using a combination of rock and bioengineering structures. This site is a good demonstration of the feasibility of using rock and bioengineering structures to create a streambank erosion reduction design on a working farm in a semi-arid climate. Two field planting demonstrations studying adaptation of PMC willow materials have been installed along this project area.

\* **Trout Creek Off-Center Advanced Test Site** - The Trout Creek site is the oldest riparian testing site for Aberdeen PMC. Grazing was originally excluded in 1988. We have been testing willow, cottonwood, and dogwood accessions in addition to planting methods since 1990. In addition, several streambank bioengineering structures were installed during a Riparian Workshop in 1995. This site has some of the best long-term data available to our program.

\* **Upper Portneuf River Demonstration Project** – This project is located on the upper Portneuf River near Chesterfield Reservoir in southeastern Idaho. This section of the Portneuf River, located on an active cattle ranch, was moved, straightened, and incorporated into a canal delivery system to provide water to irrigators on the Arimo Ditch and the Downy Canal. The bank vegetation was totally removed by cattle over the last 30 years. Our goal is to restore the riparian vegetation, reduce streambank erosion, and improve fish habitat. This will help reestablish critical fish habitat downstream in areas that have not been straightened and defoliated. In partnership with the ranch owner, the canal company, and the Idaho Fish and Game Department, the Interagency Riparian/Wetland Project has installed a series of stream barbs and bioengineering structures to restore the streamside vegetation and reduce the streambank erosion.

\* **Sheridan Creek, Henry's Fork Watershed, Riparian Recovery** – Sheridan Creek is a perennial stream that flows into Island Park Reservoir located in the Henry's Fork Watershed in Northeastern Idaho. The Sheridan Creek area is partially owned by a large cattle ranch and partially by the State of Idaho (Idaho Department of Lands). It has been heavily grazed in the past and almost all of the willows were removed resulting in unstable streambanks. Sheridan Creek was recently listed in the state's TMDL 303(d) list. With the help of the Henry's Fork Foundation and the rancher, we are putting together a restoration plan. A

bioengineering project was installed in the fall of 1999 on one area of the Creek as part of a riparian workshop.

## **FIELD AND DEMONSTRATION PLANTINGS**

Within Idaho and Utah, there are currently 157 field or demonstration plantings. These plantings are installed primarily on private lands in cooperation with the landowner, local soil conservation district and NRCS field office staff. These plantings enable NRCS and the PMC program to field test materials under development, promote materials that have been recently released, and to demonstrate to local planners, land users and landowners the value of the plant(s) to solve resource problems and needs. Each of these plantings is evaluated to determine the performance of the plant(s) under the specific soil, climate and management conditions present at the test location. Evaluation summary reports are available on request from Dan Ogle at [dan.ogle@id.usda.gov](mailto:dan.ogle@id.usda.gov) or telephone (208) 378-5730.

## **PLANT RELEASES FROM THE ABERDEEN PMC**

**Alkali bulrush** (Bear Lake, Bear River, Fort Boise, and Stillwater Selections), a long-lived, native, perennial, aggressively sod-forming grass-like plant that often forms large colonies in wet marshy or shoreline areas. Released in 1997 for MLRAs B and D.

**‘Appar’ blue flax**, a short-lived, naturalized, perennial, naturally reseeding forb used on rangeland, minespoils, highway right-of-way, and ornamental plantings. Released in 1980.

**Baltic rush** (Railroad Valley, Roswell, Sterling and Stillwater Selections), a long-lived, native, perennial, wiry, aggressively sod-forming grass-like plant that often forms large colonies in semi-wet meadow and saturated areas. Released in 1997 and 1998 for MLRAs B and D.

**‘Bannock’ thickspike wheatgrass**, a long-lived, native, very drought tolerant, weakly sod-forming grass used in rangeland and other natural area plantings. Released in 1995.

**Creeping spikerush** (CJ Strike, Malheur, Mud Lake, and Ruby Lake Selections), a long-lived, native, sod-forming grass-like plant that can be singular or in large colonies in very wet meadows to shallow water areas. Released in 1997 for MLRAs B and D.

**‘Delar’ small burnet**; a long-lived, evergreen, perennial forb used primarily in rangeland, disturbed areas, and wildlife plantings. Released in 1981.

- ‘Ephraim’ crested wheatgrass**, a long-lived, introduced, somewhat drought tolerant, bunchgrass used in critical area plantings for stabilization and erosion control. Released in 1983.
- ‘Goldar’ bluebunch wheatgrass**, a long-lived, native, somewhat drought tolerant, bunchgrass used in rangeland and other natural area plantings. Released in 1989.
- Hardstem bulrush** (Camas, Hagerman, Ogden Bay, and Stillwater Selections), a long-lived, native, very tall, aggressively sod-forming grass-like plant that often forms large colonies in very wet shallow water areas. Released in 1997 for MLRAs B and D.
- Laurel willow** (Aberdeen Selection), a long-lived, naturalized, tall shrub used primarily in windbreak and ornamental plantings. Released in 1997.
- ‘Magnar’ basin wildrye**, a long-lived, native, drought tolerant, very large bunchgrass used in herbaceous windbreak, rangeland, and other natural area plantings. Released in 1979.
- Nebraska sedge** (Centennial, Modoc, Ruby Lake, and Sterling Selections), a long-lived, native, perennial, highly palatable, densely sod-forming grass-like plant found in wet to semi-wet areas. Released in 1997 for MLRAs B and D.
- ‘Nezpar’ Indian ricegrass**, a long-lived, native, very drought tolerant bunchgrass used for sandy soil stabilization and as winter forage for livestock and wildlife. Released in 1978.
- ‘Paiute’ orchardgrass**, a long-lived, introduced, high producing, highly palatable bunchgrass used primarily in non-irrigated or irrigated pasture plantings above 16 inches rainfall. Released in 1983.
- Penstemon, Firecracker** (Richfield Selection), a long-lived, native, drought tolerant, very showy, perennial forb used in rangeland, minespoils, highway-right-of-way, and ornamental plantings. Released in 1994.
- Penstemon, Alpine** (Clearwater Selection), a long-lived, native, showy, perennial forb used in rangeland, minespoils, highway-right-of-way, and ornamental plantings. Released in 1994.
- ‘P27’ Siberian wheatgrass**, a long-lived, introduced, very drought tolerant bunchgrass used primarily on rangeland seedings. Released in 1953.
- ‘Regar’ meadow bromegrass**, a long-lived, introduced, high vigor, rapid regrowth, highly palatable, mildly sod-forming grass use primarily in non-irrigated or irrigated pasture plantings above 14 inches rainfall. Released in 1966.

**‘Rush’ intermediate wheatgrass**, a long-lived, introduced, high seedling vigor, rapidly growing, high producing, highly palatable, mildly sod-forming grass use in rangeland, non-irrigated, and irrigated plantings above 11 inches rainfall. Released in 1994.

**‘Sodar’ streambank wheatgrass**, a long-lived, native, very drought tolerant, sod-forming grass used in critical area, erosion control, rangeland and other natural area plantings. Released in 1954.

**‘Tegmar’ dwarf intermediate wheatgrass**, a long-lived, introduced, late maturing, sod-forming grass used in critical area and erosion control plantings. Released in 1968.

**Common threesquare** (Fort Boise, Malheur, Market Lake, and Wayne Kirch Selections), a long-lived, native, perennial, aggressively sod-forming grass-like plant that often forms large colonies in semi-wet meadow and saturated areas. Released in 1997 and 1998 for MLRAs E and D.

**‘Topar’ pubescent wheatgrass**, a long-lived, introduced, saline tolerant, low fertility tolerant, sod-forming grass used in pasture and erosion control plantings above 11 inches rainfall. Released in 1957.

## CURRENT PUBLICATIONS AND PAPERS

Bentrup, G. and J.C. Hoag. 1998. *The practical streambank bioengineering guide, a user's guide for natural streambank stabilization techniques in the arid and semi-arid West*. Interagency Riparian/Wetland Plant Development Project. Plant Materials Center, USDA - NRCS, Aberdeen, ID.

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8. Alfalfa Management Guide. June 1997.
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10. Planning a Seeding. October 1994.
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22. Idaho Crop Improvement Association; Idaho Rules of Certification. June, 1998.
23. How to Plant Willows and Cottonwoods for Riparian Rehabilitation. September 1993.
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26. PVP Plant Variety Protection Program for Conservation Plants. October 1995.
27. Plant Release Procedures, Cultivar-Tested-Selected-Source Identified. January 1996.
28. Glossary of Terms for use on Native Species Issues. October 1995.
29. Test Results - Woody Plant Materials for Windbreaks. January 1996.
30. Perennial Ryegrass for Irrigated Pasture. October 1996.
31. Two-Year Results from Switchgrass Seeding Trial. October 1996.
32. Users guide to description, propagation and establishment of native shrubs and trees for Riparian Areas in the Intermountain West. February 2000.
33. Plant and Seed Vendors for Colorado-Idaho-Kansas-Montana-Nebraska-New Mexico-North Dakota-South Dakota-Utah-Wyoming. April 1997.
34. Guidelines to Reduce Rodent Damage while Establishing Windbreaks. April 1999.
35. A Quick Method to Estimate Germination Percentages for Seed Species
36. Optimize Forage Quality by Afternoon Harvesting. August 1999.

## **WETLAND/RIPARIAN PROJECT INFORMATION SERIES**

- 1 - Planting techniques for vegetating riparian areas from the Aberdeen Plant Materials Center.

- 2 - Planning a Project: Selection and Acquisition of Woody and Herbaceous Plant Species and Materials for Riparian Corridors, Shorelines, and Wetland Restoration and Creation.
- 3 - Use of Willow and Cottonwood Cuttings for Vegetating Shorelines and Riparian Areas.
- 4 - How to Plant willows and Cottonwood for Riparian Rehabilitation. (Short 4 page synopsis of Tech Note 23. For use as a handout to interested people.)
- 5 - Collection, Establishment, and Evaluation of Unrooted Woody Cuttings to Obtain Performance Tested Ecotypes of Native Willows and Cottonwoods.
- 6 - Seed and Live Transplant Collection Procedures for 7 Wetland Plant Species.
- 7 - Use of Greenhouse Propagated Wetland Plants Versus Live Transplants to Vegetate Constructed or Created Wetlands.
- 8 - Constructed Wetland System For Water Quality Improvement Of Irrigation Wastewater.
- 9 - Design Criteria for Revegetation in Riparian Zones of the Intermountain Area.
- 10 - Perigynium removal and cold-moist stratification improve germination of *Carex nebrascensis* (Nebraska sedge).
- 11 - Getting "Bang for your Buck" on your next Wetland Project.
- 12 - Guidelines for Planting, Establishment, Maintenance of Constructed Wetland Systems.
- 13 - A Reference Guide for the Collection and Use of Ten Common Wetland Plants of the Great Basin and Intermountain West.
- 14 - Harvesting, Propagating and Planting Wetland Plants.
- 15 - Costs and considerations of streambank bioengineering treatments.

## **PLANT FACT SHEETS**

1. Nebraska Sedge, *Carex nebrascensis*
2. Creeping Spikerush, *Eleocharis palustris*
3. Baltic Rush, *Juncus balticus*

4. Hardstem Bulrush, *Scirpus acutus*
5. Alkali Bulrush, *Scirpus maritimus*
6. Common Threesquare, *Scirpus pungens*
7. Aberdeen Selection of Laurel willow, *Salix pentandra*
8. 'Rush' Intermediate Wheatgrass, *Elytrigia intermedia*
9. 'Bannock' Thickspike wheatgrass, *Elymus lanceolatus ssp. lanceolatus*
10. Richfield Selection, Firecracker Penstemon, *Penstemon eatonii*
11. Clearwater Selection, Alpine Penstemon, *Penstemon venustus*

## PLANT GUIDES

1. Basin Wildrye, *Leymus cinereus*
2. Blue Flax, *Linum species*
3. Bluebunch Wheatgrass, *Pseudoroegneria spicata*
4. Crested Wheatgrass, *Agropyron cristatum*
5. Crested Wheatgrass, *Agropyron desertorum*
6. Indian Ricegrass, *Achnatherum hymenoides*
7. Intermediate Wheatgrass, *Elytrigia intermedia*
8. Pubescent Wheatgrass, *Elytrigia intermedia*
9. Siberian Wheatgrass, *Agropyron fragile*
10. Small Burnet, *Sanguisorba minor*
11. Streambank Wheatgrass, *Elymus lanceolatus spp. psammophilus*
12. Thickspike Wheatgrass, *Elymus lanceolatus spp. lanceolatus*
13. Western Wheatgrass, *Pascopyrum smithii* (Rydb.) A. Löve

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## WORKSHOPS AND TRAINING SESSIONS

\* **Multiple - State Plant Materials Training** - For NRCS employees, other federal, state and local agencies, and private landowners. This is a three-day course with one and a half days in the classroom and one and a half days in the field. The course introduces the student to plant materials as an alternative to solve resource management problems, PMC functions, classes of seed, seed tags, fundamentals of seed production, planning a seeding, seed quality, seeding rates, seed mixtures, drill calibration, planting evaluations, use of rice hulls, seedbed preparation, and the integration of plant materials into field office activities. The PMC farms, ongoing projects and studies, and one off center test site are used to give the students a more practical training opportunity.

\* **Bioengineering Workshops** - For NRCS employees, other federal, state and local agencies, and private landowners. A two-day course with one day in the classroom discussing riparian zone ecology, management, and restoration principles and the second day in the field installing a variety of bioengineering structures as alternatives to hard structures.

\* **Wetland Creation and Enhancement Workshops** - For NRCS employees, other federal, state and local agencies, and private landowners who are interested in Constructed Wetland Systems or enhancement of existing wetlands. A two-day workshop with one day in the classroom reviewing wetland functions, hydrology, plants, plant establishment principles, and plant community maintenance. A second day is in the field planting wetland plants and looking at existing designs.

# 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 the period of May 1, 2000 through February 1, 2001. The focus of the NWRC revegetation/disturbed land program is to characterize establishment requirements of native grass and shrub species and to optimize restoration strategies for disturbed rangeland in the Great Basin region of the western United States.

## ONGOING RESEARCH

### 1. NEXRAD Meteorology for Distributing Precipitation Estimates

NWRC has developed new programming tools for utilizing NEXRAD Level 3 radar data for projecting precipitation estimates in a 4-km by 4-km grid within a 230 km radius of National Weather Service radar locations. These tools include programs and protocols for decoding the data, georeferencing relative to gauge data, and calibrating radar reflectivity for ground measured precipitation values. NWRC has obtained period-of-record radar data for all measurement locations in the contiguous United States and is evaluating the data relative to the national network of meteorological sites at ARS watershed and rangeland research units. These data will be used to evaluate spatial variability in rainfall and can be used to supplement meteorological instrumentation in remote research sites.

### 2. Carbon Application for Release of Shrub Seedlings

NWRC, in cooperation with Nancy Shaw of the USFS Rocky Mountain Research Station, established a 3-year field study to investigate spot treatment applications of sucrose to suppress weeds and increase water availability for shrub seedlings. This research is a follow-up study to evaluate alternative carbon-treatment strategies for economical rangeland-weed management.



## COMPLETED RESEARCH

### 1. Carbon Application for Annual Weed Control

Annual weeds that proliferate following wildfires dominate millions of hectares of rangeland in the western United States. Revegetation with native perennial plants is not feasible in these areas without some form of weed control. Carbon application in the form of sucrose has been shown to suppress annual weeds by temporary immobilization of nitrogen in the soil profile. NWRC scientist Stuart Hardegree and USFS-RMRS scientist Nancy Shaw completed a 3-year study to assess the efficacy of sucrose for annual weed suppression under a wide range of treatment applications in multiple years. The study was conducted on an area in the Snake River Birds of Prey National Conservation Area that burned in 1997. Sucrose was applied in either early December or in both December and February at 0, 200, 400, 600, 800, 1000, 1200, 1600, or 2000 total kgC ha<sup>-1</sup>. Maximum carbon treatments resulted in >75% reduction in biomass production of the 2 main weed species, cheatgrass (*Bromus tectorum*) and tumble mustard (*Sisymbrium altissimum*). Application rates necessary for adequate weed control are not economical for broad-scale application after wildfire. Use of sucrose as a carbon source may still be feasible for some high-intensity, small-area applications and in areas where herbicide use is not acceptable.

### 2. Seedbed Microclimate Modeling

NWRC scientists, Gerald Flerchinger and Stuart Hardegree used the Simultaneous Heat and Water Model (SHAW) for estimating seedbed temperature and water content at seeding depth for every hour of the period October 1962 - June 2000. The model was parameterized with a historical weather dataset from the Boise airport and Orchard meteorological field site in Ada County, Idaho. Hydrothermal germination response models for 6 seedlots of 3 species (cheatgrass, bluebunch wheatgrass and bottlebrush squirreltail) were used to assess potential cumulative germination response under planting conditions subsequent to planting on any given hour during the 38-year test period. These scientists are currently evaluating cumulative germination as a function of planting date to develop a more ecologically relevant basis for comparison of species and seedlot performance.

## PLANNED OR POTENTIAL PROJECTS

### 1. Economical Carbon-Application Strategies for Rangeland Weed Control

Development of laboratory procedures to evaluate alternative carbon sources for nitrogen immobilization in the soil. These procedures may identify more cost effective immobilization strategies and will provide data for development of models for predicting the impact of soil temperature and moisture on soil carbon utilization by micro-organisms. A grant proposal was submitted to CSREES

proposing a 3-year study to develop alternative carbon sources and application procedures for weed suppression and release of planted species.

#### **CURRENT PUBLICATIONS AND PAPERS**

Hardegree, S.P., D.H. Levinson, C.L. Hanson and S.S. Van Vactor. Utilizing National Weather Service NEXRAD (WSR-88D) precipitation data for assessment of rangeland revegetation projects. In: Abstracts of the 54th Annual Meeting, Society for Range Management, Kona, HI, Feb 18-23, 2001.

# MONTANA

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## INTRODUCTION

This report summarizes revegetation and restoration research conducted in 2000 by the Reclamation Research Unit and the Department of Land Resources & Environmental Sciences at Montana State University, and the Division of Biological Sciences at The University of Montana, where much of Catherine Zabinski's research was initiated, prior to her appointment at Montana State University. The Reclamation Research Unit has a 30-year history of rehabilitation of semiarid lands. Recent research activities have been diverse including large scale reclamation studies of acid metalliferous mine and smelter tailings at Montana's Superfund sites, phytoextraction and phytostabilization investigations, synergistic benefit of coupling waste reprocessing and revegetation, microbiological amelioration, development of data predicated reclamation decision tools, and revegetation strategies for coal ash disposal ponds. In addition to these applied research activities, the faculty is frequently called upon to assist federal and state regulatory agencies in formulating land reclamation/restoration policies and regulations.

## COMPLETED PROJECTS

1. Clean Tailings Reclamation (Stuart Jennings and Jane Krueger, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University and October S. Moynahan, Division of Biological Sciences, University of Montana and Catherine Zabinski, Department of Land Resources and Environmental Sciences, Montana State University).

Clean tailing technology was developed as an innovative alternative to conventional reclamation methods for sulfide bearing mine wastes. The high cost of lime for *in-situ* treatment and concern for subsequent release of metals undermine the widespread treatment of metal mine tailings *in-situ*. Similarly, the high cost of capping technologies and associated scarcity of soil resource limit the use of soil cap technologies. The need for effective, low-cost reclamation techniques for metal mine sites is undisputed. The plausibility of using conventional mineral processing equipment to reprocess sulfide mine tailings was explored as a reclamation method. Reprocessing resulted in the creation of a low sulfide silicate media and high grade concentrate. The low-metal reprocessed tailing was subsequently used as a plant growth media and treated with organic amendments to enhance plant growth.

Laboratory and greenhouse testing was initially performed to validate the effectiveness of the treatment. Adequate plant growth was observed in the reprocessed tailings coincident with

removal of sulfide minerals and associated metals. At completion of this phase of the project, it became apparent that availability of nutrients to plants rather than phytotoxicity from metals was significantly affecting plant growth. Soil borne microbes impart an important influence on nutrient cycling in soil. Organic amendments were evaluated to test the degree to which each contributed to diverse and abundant microbial populations in reprocessed mine tailings. Sawdust, manure and compost were evaluated as organic substrates to enhance plant growth.

The final phase of the research was a field demonstration of tailing reprocessing. Approximately 4000 tons of sulfide mine tailings were reprocessed, amended and seeded. Transplants of mycorrhizal inoculated species were also included in the revegetation design. The cleaned tailing test plots were seeded along side a run-of-mine tailing test plot and an alluvial coversoil test plot to contrast the treatment effectiveness of each. The summer of 2000 was the first growing season. Good vegetation establishment was observed on all plots where compost was included as an amendment.

Adequate vegetation response in both the greenhouse and field setting suggest that tailing reprocessing is a viable technology for creating plant growth media at metal mine sites. Metal levels were typically reduced by reprocessing, sometimes notably. Clean tailing technology, therefore, is a promising approach to achieving revegetation goals without the use of imported coversoil, and with the environmental benefit of reduced soil metal and arsenic levels.

2. Time Critical Removal of Arsenic and Metal Contaminated Soils Near Deer Lodge, MT  
(Dennis Neuman, Doug Dollhopf, and Greg Vandeberg, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

Some irrigated lands along the Clark Fork River, near Deer Lodge, Montana contain elevated levels of arsenic, cadmium, copper, lead and zinc. These elevated metals originated from river-transported mine wastes associated with metal mining, milling and smelting operations in the Butte and Anaconda, Montana areas. In May 1999, the U.S. Environmental Protection Agency ordered the responsible party to reduce contamination on historically irrigated lands along the Eastside Ditch near Deer Lodge, Montana. These lands consist of residential properties and adjacent pastures. The preferred action for the residential yards was the removal and replacement of soils (up to 18 inch depth) in which average arsenic values exceed the trigger value of 120 mg/kg. The preferred remedial action for adjacent pastures was tillage to varying depths (up to 24 inches) to evenly distribute arsenic and metals into the soil profile, and lime was added to neutralize potential and active acidity. Soil samples were collected from 17 residences and adjacent pastures and 2 agricultural lands in 1998 and 1999. The soil samples were analyzed for arsenic, copper, lead, zinc and pH. Soils were excavated and replaced in 8 residential yards as of November 1999 (remaining soil arsenic levels are typically below 70 mg/kg). In addition, 10 adjacent pastures were tilled and limed as of November 1999. Further sampling and remedial activities were completed in 2000.

3. Restoration of Highly Impacted Subalpine Campsites (Catherine Zabinski, Department of Land Resources and Environmental Sciences, Montana State University, Tom DeLuca, School of Forestry, The University of Montana, David Cole, Aldo Leopold Wilderness Research Institute, USFS, and October S. Moynahan, Division of Biological Sciences, The University of Montana).

The effects of restoration amendments on soil parameters were assessed at four subalpine campsites in the Eagle Cap Wilderness, northeastern Oregon. Plots were established at four campsites on three subalpine lakes in which soils were scarified, compost-amended, and planted to native species. Three years post-treatment, we sampled surface soils (0 – 15 cm) on undisturbed sites (between and under vegetation), and unamended and compost-amended campsite soils. Unamended campsite soils had significantly lower levels of potentially mineralizable N (PMN), microbial biomass, basal respiration, and number of substrates metabolized in carbon utilization profiles. Compost addition elevated all these parameters on campsite soils, although only the number of substrates metabolized in the carbon utilization profiles was significantly higher on compost-amended soils than on undisturbed soils. Levels of PMN indicate that campsite soils may lack sufficient N for rapid plant regeneration, whereas amended and undisturbed soils contained adequate quantities of available N. This work suggests that compost amendments can ameliorate impacts to soil chemistry and microbial populations caused by camping without exceeding the N fertility found on undisturbed soils.

4. Microbial Community Structure and Carbon-utilization Diversity in a Mine Tailings Revegetation Study (October Seastone Moynahan, Division of Biological Sciences, The University of Montana, Catherine Zabinski, Department of Land Resources and Environmental Sciences, Montana State University, and James Gannon, Division of Biological Sciences, The University of Montana).

In a mine-waste revegetation project near Butte, Montana, we measured microbial community structure and carbon-utilization diversity in treatment plots, including raw tailings either with, or without tilling, shallow-tilled lime addition, deep-tilled lime addition, lime-slurry injection, topsoil addition, and an undisturbed area near the tailings. Heterotrophic bacteria counts were significantly higher in the limed and topsoil treatment plots than the control plots, while the actinomycete and fungal counts increased in the tilled control plot as well. Endospore counts were significantly higher in the topsoil addition and the undisturbed plots than the other treatment plots. Carbon-utilization activity was very low in untreated plots, intermediate in lime-treated plots, and very high in topsoil and undisturbed plots. Arbuscular mycorrhizae (AM) colonization levels of two grass species showed low levels of colonization on control, shallow-limed, and lime slurry-injected plots, and high levels on the deep-limed and topsoil addition plots. Plant and soil system components increased across the treatment plots, but individual components responded differently to changing environmental conditions.

5. Characterization of Mycorrhizae and Seed Bank Composition in an Eastern Montana Wetland (Catherine Zabinski, Department of Land Resources and Environmental Sciences, Montana State University and Lih-An Yang, Montana Department of Environmental Quality).

The majority of soil survey work in the context of mine reclamation has focused on the physico-chemical quality of soil, with little attention on biological properties. This study characterizes the mycorrhizal colonization levels in wetland plants, mycorrhizal infectivity potential of wetland soils, and seed bank composition. The work took place in a portion of a drainage bottom that is classified as jurisdictional wetland at the Absaloka Mine (Westmoreland Resources, Inc.), Big Horn County, Montana. The hydric soil was slightly alkaline, non-saline, and rich in total nitrogen and phosphorus. Soil samples were collected along bank-to-bank

transects across the wetland and analyzed for mycorrhizal inoculation potential and seed bank composition. Hydrophytic plants, including *Spartina pectinata*, *Carex nebraskensis*, and *Carex lanuginosa*, were analyzed for mycorrhizal colonization level. Mycorrhizal colonization levels were high in *S. pectinata* and *C. nebraskensis*. Mycorrhizal inoculation potential was also high, but decreased at the center of the wetland. Understanding the role of AM fungi in wetland plant establishment will contribute to wetland soil handling and revegetation efforts. The density of seeds in the seed bank did not differ between sites with the wetland. There was a high proportion of weed species found throughout the wetland. An assessment of the seed bank is important prior to management decisions about using wetland soils as a source of seeds for restored wetland sites.

6. Understanding the Factors that Limit Restoration Success on a Recreation-impacted Subalpine Site (Catherine Zabinski, Department of Land Resources and Environmental Sciences, Montana State University and David Cole, Aldo Leopold Wilderness Research Institute, USFS).

Factors that limit successful revegetation of a subalpine site in the northern Rocky Mountains were studied through a combination of soil assays, greenhouse studies, and field manipulations. Campsite soils had higher available nitrogen, lower microbial community diversity, and lower seed bank density than undisturbed soils. In the greenhouse, there was no significant difference in plant growth on disturbed vs. undisturbed soils. In the field, seedling establishment patterns did not vary between experimental plots with five different soil treatments (ranging from a control to a compost and inoculum amendment). Addition of seeds and transplants increased seedling density, but not growth. Microclimatic variation may be the overriding limiting factor at this site.

## ONGOING PROJECTS

1. Ash Disposal Pond Revegetation (Frank Munshower, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

This is long-term investigation of the potential to revegetate the surface of the coal ash disposal ponds near Colstrip, MT. Permanent reclamation of the ponds is the ultimate goal of this study. Initial objectives were to determine 1) how much soil is necessary over the ash to permit establishment of a permanent vegetation cover; 2) to determine if a diffusion barrier is necessary to seal the ash from the soil and prevent movement of salts into the soil; 3) to determine if topsoil is necessary over the soil layer to provide an adequate plant growth medium; and 4) to determine what plant species should be seeded on the site to insure survival of a permanent plant cover that can be grazed by wildlife and/or livestock.

Replicated field plots were constructed of varying materials and depths, with and without barriers, with and without topsoil, and species selection trials were integrated into the experimental design. The hydrologic and vegetation response to the different treatments have been monitored throughout a ten-year period.

2. Phytoextraction of Selenium and Metals from Contaminated Soils (Doug Dollhopf, Reclamation Research Unit, Department of Land Resources and Environmental Sciences, Montana State University).

An oil refinery creates a waste stream that is applied to soils within an 11-acre impoundment. Soil microbes are able to degrade the petroleum based waste constituents. However, metal concentrations in the soil have risen over the 20 years that the disposal impoundment has been in operation. Elevated soil selenium concentrations are of particular concern. This research is seeking a cost-effective method of removing these metals and selenium from these soils. The objectives of this research are to evaluate the abilities of several selenium accumulating plant species to establish in the contaminated soils, and to determine which of these species is the most effective at removing selenium from the soil. While the selection of plants for this project was based specifically on the ability of each plant to accumulate selenium, the abilities of these plants to phytoextract arsenic, chromium, lead and zinc will also be monitored.

3. Development of a Riparian Evaluation System for the Clark Fork River, Montana (Dennis Neuman and Stuart Jennings, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University and Paul Hansen, School of Forestry, University of Montana, Missoula, MT).

Mining for gold, silver, and especially copper began in the late 19th Century in the Butte-Silver Bow Creek area of Montana. Milling and smelting of these ores produced vast wealth and concurrently a variety of wastes including mine and process waters and tailings which were released into Silver Bow Creek and eventually into the Clark Fork River. These wastes retained the metallic signature of the ore bodies and contained elevated levels of several metals and arsenic as well as the acid producing mineral pyrite. Soils and waters within the floodplain and associate irrigated fields are contaminated with metals and arsenic. The Environmental Protection Agency named this site to its Superfund list and cleanup activities (remedial actions) along this 120 mile corridor are to begin in 2002.

A riparian evaluation system has been developed to provide an objective, data predicated decision tool to assess the ecological dysfunction of lands along the Clark Fork River, and to determine whether the identified areas require remedial action, and by extension the intensity of that clean up. The system contains the following elements: Superfund mandated requirements addressing risk reduction, remedial objectives and goals, and legal requirements for clean up of the river corridor; a numerical component that will be used to score the current status of the plant community integrity, contamination severity, and landscape stability; decision diagrams to help guide the selection of remedial actions during design; and the identification of modifying factors that affect the selection of remedial actions for specific lands. The numerical component of the system will be calibrated and validated in the Spring of 2001 and then applied across the landscape concentrating on lentic and lotic positions, as well as wet meadows and upland areas.

4. Ecological Restoration Web Site Development (Stuart Jennings, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

A national, interactive Ecosystem Restoration Technologies Web Site (<http://ecore restoration.montana.edu/default.htm>) devoted to the restoration of disturbed lands has been developed. This site is and will continue to be a compilation of resources relevant to restoration and reclamation of disturbed lands. It is the intent of this site to serve as a central repository for restoration/reclamation information and technologies. Links to existing web sites have and will continue to be established. Research and journal articles are compiled in a bibliographic database format. Case histories are also being compiled and showcased and educational materials are to be introduced. The information is being collected from state and federal agencies, university researchers, mining companies, consulting and engineering firms and other resources. Major components of the site include: Minelands Restoration, Wetlands Restoration, Rangeland Health, Invasive Species, and Fire Rehabilitation.

5. Effect of Alkaline Industrial Byproducts on Plant Growth in Acidic Contaminated Soils (Doug Dollhopf, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

The objective of this study is to determine whether certain alkaline industrial byproducts (Di-Cal, lime kiln dust (LKD), cement kiln dust (CKD) and carbide lime) can be used to revegetate soils and wastes that are of low pH and contain elevated metal concentrations, and to determine their efficacy compared to commercial grade limestone. Using acidic-metalliferous tailings from the Opportunity impoundment and contaminated soil from Stucky Ridge in Anaconda, Montana, the investigation objectives are 1) evaluate plant growth characteristics in a greenhouse setting on tailings and contaminated soils amended with mined limestone ( $\text{CaCO}_3$ ), manufactured lime ( $\text{CaO}$ ), DiCal, and several different sources of LKD, CKD, and carbide lime, and 2) identify those lime sources that are suitable for acid soil remediation projects.

6. Land Reclamation Evaluation System for Anaconda Smelter Superfund Site (Stuart Jennings and Dennis Neuman, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

At least 6,000 ha of land surrounding the Anaconda Smelter in Montana are contaminated from nearly a century of stack emissions from this copper smelter. In the mid-1990s, the Reclamation Research Unit conducted a multi-year laboratory-greenhouse-field research investigation of the potential to reclaim and restore these impacted lands. Based on the results, land reclamation was chosen by the Environmental Protection Agency as the remedial approach (estimated at \$186M) for this Superfund Site. A decision making tool was then developed to help EPA determine which lands are to be remediated, and to what level that remediation should be implemented. The decision tool incorporates legal mandates, estimates of current ecological function, human health risk action levels, and land use interests into a decision matrix that is used in consort with data and informational layers (GIS) to determine the most appropriate land reclamation strategy for a specific land area.



7. Effect of Mechanical and Biological Control Measures on Sediment Movement for High Elevation Regraded Slopes at the Treasure Mine (Doug Dollhopf, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

The purpose of this study is to test two mechanical and one biological method to decrease erosion of newly reclaimed steep slopes. Soil erosion off each test plot is quantified by collecting sediment accumulated in a collection trough at the bottom of each treatment plot. The measured sediment yield (field data) will be compared to the amount predicted by the Revised Universal Soil Loss (RUSLE) v. 1.06 erosion modeling software.

8. Butte Reclamation Evaluation System (Dennis Neuman, Stuart Jennings, and Mari Reeves, Reclamation Research Unit and Department of Land Resources and Environmental Sciences, Montana State University).

Mine land sites have been reclaimed in the Butte, Montana area since the mid-1980s. Recognizing the need to evaluate the success of reclaimed lands, the EPA began formally evaluating these lands in 1992. Since then, EPA has conducted reclamation assessments in Butte, Anaconda, and at a variety of sites throughout the Clark Fork River Basin of Montana. During this period, a variety of soil and vegetation parameters were used to provide data and information regarding the success of reclaimed mined lands. From this work, EPA recognized the need for an evaluation tool that would allow agency personnel to determine whether sites under their jurisdiction were meeting the remedial goals and if that trend was likely to continue. Based on other decision tools being developed for other Superfund Sites within the Clark Fork River Basin, EPA requested that the Reclamation Research Unit design a similar tool that would incorporate the following aspects: utilize soil and vegetation parameters that are key to assessing reclamation success; emphasize the parameters critical to maintaining site stability; be easily and quickly applied in the field due to the large number of sites that need to be evaluated; utilize a minimum amount of equipment; be simple to learn by new evaluators; and, provide precise (i.e., reproducible) results when applied by different evaluators. Initial development and field checking of this tool was completed in 2000, and it will be further assessed during the field season in 2001.

9. The Importance Of Arbuscular Mycorrhizae For Mine Revegetation In Western Montana (October Seastone Moynahan, Division of Biological Sciences, The University of Montana and Cathy Zabinski, Department of Land Resources and Environmental Sciences, Montana State University)

Arbuscular mycorrhizae (AM) are an important component of plant-soil systems that may be crucial for successful revegetation of metal-contaminated soils associated with hard-rock mining. By altering plant nutrient uptake abilities, protecting plants from pathogens, and possibly contributing to plant metal-resistance, AM can enhance plant growth and affect plant community composition. Our research examines the role of AM in mine revegetation in western Montana. Field surveys in both naturally revegetating mine wastes, and in a limed revegetation experiment showed that mycorrhizal colonization was significantly higher in plots with high vegetative cover. In the greenhouse, mycorrhizal *Deschampsia cespitosa* plants had significantly higher biomass than non-mycorrhizal plants. Additionally, plants colonized with AM from a

metal-contaminated soil had higher AM colonization levels than plants colonized with AM from an undisturbed soil.

We have two field projects established to investigate effects of two AM sources on native plant species growing in mine tailings. At each site, a split-plot design was used to examine the effects of compost addition (+/- compost) and AM fungi source (no AM, AM fungi from metals-contaminated site, and AM fungi from a healthy soil). Effects were examined for 3 plant species: tufted hairgrass (), bluebunch wheatgrass (*Pseudoroegneria spicata*) and yarrow (*Achillia millefolium*).

Plants were grown in the greenhouse in sand inoculated with the appropriate AM treatment source. Plants were transplanted to the field during the 1999 growing season, and plant growth was monitored during 2000 and will continue during the summer of 2001.

Additionally, we have two greenhouse experiments in progress to determine the effects of AM source on plant growth in mine tailings. In the first experiment, six plant species--bluebunch wheatgrass, Idaho fescue, tufted hair grass, flax (*Linum lewisii*), western yarrow, and purple cone flower (*Echinacea angustifolia*)—are being grown in tailings, limed to a pH of 7.0, with the same three mycorrhizal treatments described above. We are testing host species differences in response to AM source.

In a second greenhouse experiment, we have limed tailings to obtain a pH ranging from 3.5 (no lime) to 7.0. Plants will be grown with the same three mycorrhizal treatments as described above, to test the hypothesis that plant response to mycorrhizae varies along a tailings-amendment gradient. In this experiment, we are using *Deschampsia cespitosa*, as it is able to grow at a pH of 3.5. Plants from both greenhouse experiments will be harvested after approximately 20 weeks of growth, and analyzed for root and shoot biomass, mycorrhizal colonization levels, and nutrient and metal content.

## **PLANNED OR POTENTIAL PROJECTS**

1. Integration of plant species that have cultural significance to indigenous peoples in reclamation/restoration efforts within the Clark Fork River Superfund Sites.
2. Development of reclamation/restoration success criteria.
3. Phytotoxicity responses of metal and acid tolerant plant species used in reclamation of acid metalliferous mine and smelter tailings.
4. Investigations of cover soil material's suitability for plant establishment and growth.
5. Understanding biological mechanisms that enable plants to grow on naturally occurring acidic soils at geothermal sites in Yellowstone National Park.

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## Montana / Wyoming

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### INTRODUCTION

This report summarizes revegetation and restoration research being conducted by the USDA-NRCS Plant Materials Center near Bridger, Montana for FY 2000. The Bridger PMC collects, assembles, and evaluates plant materials to help solve conservation problems in Montana and Wyoming. The emphasis is on native plant material for reclamation of drastically disturbed lands (including surface strip mines, acid/heavy metal affected sites, saline soils, highway roadsides), windbreaks and shelterbelts, wildlife habitat, livestock forage, native landscaping, threatened & endangered, and culturally significant plants. Cooperative agreements exist with the USDI—National Park Service (roadside restoration in Yellowstone & Glacier Parks) and Deer Lodge Valley Conservation District [develop acid/heavy metal tolerant plants (EPA and Montana Natural Resources Damage Program)].

### COMPLETED RESEARCH

#### 1. Forage Quality Study

Forage production and forage quality were sampled ten times during each growing season (May 8 through November 8) on fourteen species (29 cultivars) of native and introduced forage and reclamation grasses. The objectives of this Master's degree project at Montana State University-Bozeman was to characterize the forage quality at various phenology stages using NIRS, developing calibration curves and equations for each species.

#### 2. Craig Pass Roadside Restoration Trials in Yellowstone Park

Plots were established on north and south facing road cut-slopes along the Craig Pass road project in south-central YNP. The replicated plots compared all combinations of seeded vs. non-seeded, mulched vs. non-mulched, and fertilized vs. non-fertilized. Seeding was done with a grass/forb mixture of native, indigenous plant material. The results indicate that there was not enough of a seed bank in the salvaged topsoil to provide significant site stabilization and plant community diversity. Mulching was beneficial in providing a more favorable germination environment and protection of the soil surface from severe weather events. Plots were also

established to evaluate the success of direct seeding of 12 forb species. This trial was helpful in determining the species that YNP should concentrate on in their restoration efforts.

## **ONGOING RESEARCH**

### **1. Express Pipeline**

At two locations (saline upland and sandy sagebrush flats) in the arid Bighorn Basin of north central Wyoming plots were established on areas disturbed by the installation of the Express Pipeline. Four mixtures (Old-commercially available cultivars, New-new and pending releases, Sandy-new and old releases adapted to sandy soil, and Clayey-new and old releases adapted to clayey soils) were seeded with a double disk drill (with depth bands) at both sites. The initial results exhibit the establishment potential of each of the species and the compatibility in the established plant communities.

### **2. Bluebunch Wheatgrass Recurrent Selection**

Twenty collections of bluebunch wheatgrass were made along the eastern front of the Rocky Mountains in Montana. Three cycles of Recurrent Restricted Phenotypic Selection were utilized to develop a strain that is currently being compared to released cultivars of bluebunch wheatgrass. This is an attempt to develop a strain that is adapted to area in Montana and Wyoming east of the Continental Divide.

### **3. Idaho Fescue Comparative Evaluation**

In the late 1970's and early 1980's a total of 32 collections of Idaho fescue were made in Montana and Wyoming. They were evaluated at a site provided by the State Forest Tree Nursery in Missoula, Montana. The top five performing accessions are presently in a replicated trial in comparison to Joseph (U. of Idaho), an accession in advanced testing at the Pullman, WA PMC, and one collection each from Glacier National Park and Yellowstone National Park. From this trial it is hopeful to make a release for the western mountains and foothills and one for the rolling pine-savanna areas of southeastern Montana and northeastern Wyoming.

### **4. Development of Acid/Heavy Metal Tolerant Plants**

The Acid Tolerant Plant Materials Project, previously funded by a Montana Resource Development Grant, has been given a four year extension with funding from the EPA Mine Waste Technology Program and the Montana Resource Damage Program. Collections of native indigenous plant material are being increased for release to commercial growers, while further testing adaptation and compatibility in mixtures. The plant material will be released as Selected or Tested germplasm via the Pre-Varietal release procedure.

## 5. Restoration With Native Indigenous Plants in National Parks

Through a cooperative agreement between NRCS Plant Materials Centers and the National Park Service the Bridger PMC continues to assist Yellowstone and Glacier Parks in the restoration of disturbances related to road construction and maintaining the aesthetics of tourist attractions. Research activities include the Alpine Light Study (evaluating germination response to varying light allowed by various mulches), timing and protocol for asexual propagation of shrubs, breaking seed dormancy of forbs and shrubs, seed production techniques, seed cleaning and conditioning techniques, and species compatibility in mixtures.

### **PROPOSED RESEARCH**

Comparative Evaluation of Salt Tolerance of Trees and Shrubs.

Comparative Evaluation of Seed Dormancy Breaking Techniques--Indian Ricegrass.

Developing Container Production Techniques for Beargrass (*Xerophyllum tenax*)

Utilizing Native Plants to Compete With Invasive Plants—Evaluation of Site Preparation, Plant Density, and Seeding Techniques.

Screening of Chemicals for Weed Control in Native Forbs and Legumes Seed Production Fields.

### **NEW RELEASES**

Bridger Select Rocky Mountain juniper (Select germplasm) (*Juniperus scopulorum*)

Antelope (Tested germplasm) slender white prairieclover (*Dalea candida*)

High Plains Sandberg bluegrass (Select germplasm) (*Poa secunda*)

Dupuyer silverberry (Source Identified) (*Elaeagnus commutata*)

Pondera silverberry (Source Identified) (*Elaeagnus commutata*)

Garnet mountain brome (Tested germplasm) (*Bromus marginatus*)

(Meeker, CO EPC—Primary Releasing Agency)

### **PENDING RELEASES**

Ponderosa pine (*Pinus ponderosa*)

Snowberry (*Symphoricarpos albus*)

Winterfat (*Krascheninnikovia lanata*)

Gardner saltbush (*Atriplex falcata*)

Western yarrow (*Achillea millefolium*)

Green ash (*Fraxinus pennsylvanica*)

Bur oak (*Quercus macrocarpa*)

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## NEVADA

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### INTRODUCTION

This report summarizes reclamation/restoration projects in progress during 2001 by the Ecology, Paleoecology and Restoration of Great Basin Watersheds Research Work Unit and the Great Basin Ecosystem Management Project for Maintaining and Restoring Riparian Ecosystem Integrity, two USDA Forest Service, Rocky Mountain Research Station projects, located in Reno, Nevada. Cooperators in these research projects include the Humboldt-Toiyabe National Forest; Agricultural Research Service, Reno, NV; Environmental Protection Agency, Ada, OK; University of Nevada, Reno, Reno, NV; Western Carolina University, Cullowhee, WC; Lafayette University, Easton, PA; and Utah State University, Logan, UT.

### ONGOING PROJECTS

1. Great Basin Interdisciplinary Research and Management Project: Maintaining and Restoring Riparian Ecosystem Integrity (Jeanne C. Chambers, Team Leader, RMRS).

This USDA Forest Service, ecosystem management project was initiated in 1994 and has been approved to continue through 2003. The project has been a collaborative effort between the Rocky Mountain Research Station and the Humboldt-Toiyabe National Forest (H-T). The overall objective is to increase our understanding of the structure and functioning of central Nevada watersheds and riparian ecosystems and to develop management guidelines for maintaining or restoring riparian ecosystem integrity. Our specific objectives have evolved to include the following: (1) Determine the effects of longer-term climate change processes and shorter-term natural and anthropogenic disturbance on central Nevada watersheds, riparian corridors, and riparian ecosystems or stream reaches; (2) Determine the successional trajectories and recovery potentials of key riparian ecosystems exhibiting different disturbance regimes and varying levels of degradation; (3) Develop criteria for evaluating the effects of changes in management or restoration activities on watersheds and riparian ecosystems; (4) Evaluate the use of high resolution, low-altitude video imagery for rapidly assessing riparian ecosystem functioning; and (5) Evaluate specific management techniques for restoring or maintaining watershed and riparian ecosystem integrity. Research collaborators include the Agricultural Research Service, Environmental Protection Agency, University of Nevada, Reno, Western Carolina University, Lafayette University, and Utah State University.

2. Importance of Understanding Long- and Short-Term Changes in Vegetation and Geomorphology for Riparian Restoration (Jerry Miller, Indiana University, Purdue University at Indianapolis; Jeanne Chambers, RMRS; Robin Tausch, RMRS; and Dru Germanoski, Lafayette University).

This interdisciplinary research is reconstructing the effects of climate change processes and disturbance on central Nevada watersheds by examining the vegetational and geomorphic histories of key drainage basins. It is focusing on both the Holocene (last 11,500 years) and the period of record (last 50 to 100 years). The examination of the Holocene record is based on the analysis of woodrat midden data to track vegetation dynamics and the examination of the stratigraphic record to determine changes in watershed processes. The recent record is being evaluated by investigating relationships among stream depositional surfaces, the dendrochronologic record, and hydrographic record. Results indicate that climate change processes and their influences on vegetation and geomorphic processes that occurred 2,000 years ago are still influencing stream dynamics. Recent stream incision in these systems began at the end of the Little Ice Age, after about 290 YBP. The tendency for these systems to downcut still exists and the rate of downcutting is being exacerbated by human activities. Currently, stream morphology and riparian ecosystem dynamics are being controlled by episodic flood events. The streams and riparian ecosystems are currently functioning as non-equilibrium systems and restoration to conditions that existed prior to the last 150 to 200 yrs of stream incision is unrealistic. Realistic management objectives include maintaining the integrity of stable reaches and riparian ecosystems, and increasing the stability of systems currently incising or at risk of future incision. This work will continue into the future with the goals of understanding differences in basin sensitivity to both climate change processes and natural and human disturbance.

3. Basin Big Sagebrush Dominated Riparian Corridors - Dry Meadows as Alternative Stable States? (Jeanne Chambers, RMRS; Michael Wright, UNR; Pam Mebine, UNR; and Bob Blank, ARS).

The study uses the dry meadow and basin big sagebrush/giant wild rye ecosystem types as models for examining the potential restoration of or, if a threshold has been crossed, conversion of sagebrush dominated riparian ecosystems to an alternative stable state, i.e., dry meadows. A restoration experiment is being used in which sites in three separate drainages are restored by burning and seeding with native grasses characteristic of the dry meadow ecosystem type. Ecosystem response is being evaluated for restored and paired not restored plots. Because of the importance of water table and microsite conditions (interspace and under shrub), both factors have been included in the study design. Several response variables are being measured including (1) the recovery of the pre-fire vegetation, (2) the role of the soil seed bank in species establishment, (3) the soil system response including changes in soil chemistry, temperature and water, and (4) the establishment response of the seeded species. Information from these studies can be used to prescribe restoration methods for dry meadow ecosystems. This research was funded by a CSRS Rangelands grant and was initiated in the 1996.

4. Instream Flow Requirements for Restoring and Maintaining Riparian Ecosystems (Dave Jewett, EPA; Jeanne Chambers, RMRS; Jerry Miller, Western Carolina University, Mark Lord, Western Carolina University, Eliot Atekwana, Indiana University Purdue).

This study was initiated in 1997 to increase our understanding of the relationships between instream flows and the structure and function of riparian ecosystems. It is examining the relationships among geomorphic position, the surface and subsurface flow systems and riparian ecosystems for gaged stream systems in central Nevada. Because alluvial fans control stream form and function in many central Nevada drainages, the study is examining the effects of alluvial fans on channel form and depth of entrenchment. It focuses on depositional areas, usually characterized by meadow ecosystems, that occur immediately upstream of these fans and erosional areas, usually characterized by willow ecosystems, that occur further upstream of the fans. Within these different geomorphic settings, the stream morphology is being characterized, the surface and shallow groundwater systems examined, and the riparian vegetation and soils quantified. These data will be synthesized in order to determine the effects of geomorphic position and instream flows on ground water hydrology and riparian ecosystems. This administrative study is being conducted in cooperation with and partially supported by the USDA Forest Service, Stream Systems Technology Center.

## **PLANNED PROJECTS**

1. Changing fire regimes, increased fuel loads, and invasive species: effects on sagebrush steppe and pinyon juniper ecosystems. (Jeanne Chambers, RMRS, Durant McArthur, RMRS; Rick Miller, OSU; Robin Tausch, RMRS and 10 other PIs)

This integrated research project is funded by the Joint Fire Sciences Program and will be initiated in 2001 to examine: (1) presettlement fire regimes and the spatial and temporal changes that have occurred in Intermountain Region woodlands and sagebrush steppe ecosystems, (2) changing fuel loads and the consequences for the ecosystem types and conditions that currently exist on the landscape, and (3) the environmental and ecological factors that influence community susceptibility to invasive species. This research will provide both regional and local information on characteristics of woodlands and shrublands at greatest risk of catastrophic fire, most susceptible to cheatgrass invasion, as well as most suitable for restoration via prescribed fire. It will also provide information on the effects of resource availability, community condition, and fire on community susceptibility to cheatgrass and secondary weed invasion.

2. A demonstration area on ecosystem response to watershed-scale burns in Great Basin pinyon-juniper woodlands (Jeanne C. Chambers, Robin J. Tausch, and Michael C. Amacher, RMRS; Dru Germanoski, Lafayette College; Erica Fleishman, Stanford University; Desiderio Zamudio, Humboldt-Toiyabe National Forest).

This project is funded by the Joint Fire Sciences program and will be initiated in 2001. The purpose is to provide a demonstration watershed for illustrating the feasibility and ecological effects of large-scale prescribed fire on pinyon-juniper dominated ecosystems to managers, researchers, and the public. Objectives include: (1) Provide information on the costs associated

with conducting watershed-scale burns; (2) Determine the recovery thresholds and successional trajectories for vegetation communities that have different stand densities of pinyon and juniper and occur at different elevations within the watersheds; (3) Determine the changes in fuel loads that occur with increasing stand densities of pinyon and juniper; (4) Examine the influence of differences in stand density and topographic position on soil properties that influence recovery potential and soil erosion; (5) Evaluate the effects of large-scale prescribed burn projects on stream channels, sedimentation and water quality. (6) Examine the effects of the burn on species richness and occurrence of taxa shown to exhibit quantifiable responses to similar disturbances, i.e., butterflies. The project will be used to develop guidelines for evaluating the effects of stand density/seral stage on vegetation community and soil response to prescribed burns. It will also provide needed information on watershed-scale burns on stream channels, sedimentation and water quality and an important taxa in semi-arid, intermittent systems.

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# NEW MEXICO

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## INTRODUCTION

This report summarizes ongoing and proposed ecosystem restoration projects conducted by the Ecology Group (ESH-20) at Los Alamos National Laboratory (LANL) in Los Alamos, NM. The Ecology Group is within the Environment, Safety and Health Division.

## ONGOING PROJECTS

1. Restoration of Herbaceous Understory Vegetation in Degraded Piñon-Juniper Woodlands of Central New Mexico (Principal Investigators: Samuel Loftin, Los Alamos National Laboratory; Brian Jacobs, Bandelier National Monument).

Approximately 20 ha of piñon and juniper were thinned in April 1995 to test the effects of a simulated fuelwood cut on herbaceous plant recovery and soil stability. Within three years herbaceous plant abundance had tripled in the treated area. Little change in soil stability has been observed. In May, 2000, the control area and part of the thinned area were burned in the Cerro Grande Fire. We had intended to use prescribed fire on the thinned area to control seedling and resprouting trees and we will monitor this site to evaluate the effects of the wildfire. The control site was completely burned, which gives us the opportunity to monitor vegetation and soil stability response to a stand replacement fire in piñon-juniper woodland.

2. Burned Area Emergency Rehabilitation Efforts on the Cerro Grande Fire, New Mexico (Principal Investigators: Santa Fe National Forest; Los Alamos National Laboratory).

In May 2000, the Cerro Grande Fire burned over 43,000 acres of forest on Bandelier National Monument, Santa Fe National Forest, Santa Clara Pueblo, San Ildefonso Pueblo and the Los Alamos National Laboratory (LANL). An Interagency Burned Area Emergency Rehabilitation (BAER) Team was formed to evaluate the extent of the disturbance and prescribe treatments. The LANL Emergency Rehabilitation Team (ERT) was formed to prescribe and implement treatments on LANL property. One of the primary objectives of the emergency rehabilitation effort was to protect on-site and downstream resources from the effects of postfire erosion and stormwater runoff while promoting ecosystem recovery. Treatments such as aerial seeding, straw wattles, log erosion barriers, straw mulch and hydromulch were used to stabilize soils and retain water on moderately and severely burned hillslopes. Monitoring efforts are underway but no data are available.

## PROPOSED PROJECTS

3. Integrated Watershed Management Study: Modeling the Effects of Piñon-Juniper Woodland Thinning on Watershed Hydrology and Water Quality (Principal Investigators: Samuel Loftin, Cathy Wilson, Kenneth Mullen [Los Alamos National Laboratory], and Kelly Bitner [Neptune and Company, Los Alamos, NM]).

The primary objectives of this project are to test the effects of a tree thinning treatment on vegetation, soil stability, watershed hydrology and surface water quality. We are also interested in monitoring the effects of this treatment on wildlife habitat quality and archeological site stability. Our goals are to instrument a pair of watersheds and quantify meteorological inputs and subsequent runoff water quantity and duration (watershed hydrographs) and quality (total suspended solids, contaminants and nutrients) for each runoff event. This is intended to be a long-term project, which would allow us to monitor potential ecosystem maintenance activities such as prescribed fire.

Two watersheds have been identified, meteorological stations have been purchased, and watershed monitoring stations will be installed this spring as a result of the initial BRMP support. Additional support is required to establish the soil and vegetation monitoring activities, process surface runoff samples, maintain equipment and process data. We will require up to three years to calibrate the watershed hydrology, at which time the treatment will be implemented. Tree thinning will be funded through the Wildfire Hazard Reduction Program. We are in the process of applying for EPA 319 Monitoring funds as long-term base funding; however, even if successful, this process can take several years.

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### INTRODUCTION

This report summarizes the revegetation and native plant propagation research associated with the joint revegetation research program between researchers at the New Mexico State University – Mora Research Center and the Natural Resources Conservation Service – Los Lunas Plant Materials Center. The majority of the projects described in this report are associated with research on the direct establishment of container stock onto overburden piles at the Molycorp Inc., molybdenum mine located in Questa, New Mexico. The riparian restoration research discussed in this report reflects several years of on-going research in developing revegetation stock for deciduous riparian species for various riparian sites in the mountainous southwestern United States.

### COMPLETED AND ONGOING PROJECTS

1. Influence of *Pisolithus tinctorius* Inoculation on Initial Transplant Survival of Conifer Seedlings (John T. Harrington, Anne M. Wagner, David R. Dreesen, Leigh Murray, and Piexin Sun).

The purpose of this study was to examine whether inoculation of conifer seedlings in the greenhouse with *Pisolithus tinctorius* would improve first year survival of seedlings transplanted onto overburden material at the Molycorp Questa Mine in northern New Mexico. Seedlings of *Pinus ponderosa*, *P. edulis*, *P. strobiformis*, *P. flexilis*, *P. aristata*, *P. sylvestris*, and *P. nigra* were used in this study. Subsets of each species were inoculated with *Pisolithus tinctorius* at either six or ten weeks after germination or not artificially inoculated. Seedlings were evaluated for growth response in the greenhouse after inoculation and before transplanting. Inoculation significantly impacted greenhouse height growth and caliper growth but the response was species dependent. Overall, seedlings inoculated six weeks after germination were shorter and had slightly smaller caliper relative to those seedlings not inoculated or inoculated at ten weeks after germination. Seedlings were transplanted at the Questa mine site in August 1996 on a site with an approximate elevation of 2,900 meters. and substrate pH ranging from 3.5 to 4.0. The impact

of inoculation with *Pisolithus tinctorius* on survival was variable by species. Only with *Pinus strobiformis* did survival improve with inoculation (>20%). The results of this study will be presented at the 2001 American Society for Surface Mining and Reclamation 18<sup>th</sup> National Meeting in Albuquerque, New Mexico, June 3-7, 2001.

2. Influence of Provenance on *Ribes cereum* and *Symphoricarpos oreophilus* Seed Germination in New Mexico Seed Sources (Lee Rosner, John T. Harrington, David R. Dreesen and Leigh Murray).

Mountain snowberry (*Symphoricarpos oreophilus*) and wax currant (*Ribes cereum*) are two co-occurring shrub species found in the ponderosa pine and mixed conifer forests in New Mexico. These species are candidate species for mined land reclamation in that both can occur in full sunlight and in the understory and are found on a wide range of edaphic conditions. Mountain snowberry seed has both a scarification and stratification requirement for germination, whereas wax currant seed has only a stratification requirement. Two studies were conducted which examined the influence of provenance from within New Mexico, on conventional seed propagation protocols for each species. The study involving wax currant utilized eight seed sources and the mountain snowberry study utilized seven seed sources. Seed sources were selected to represent the latitudinal range of the species in New Mexico and an elevational range at the most northerly latitude sampled. Results indicate there is considerable variability among seed sources of both species in overall germination rates and response to treatment severity. In wax currant, the southern most source did not benefit from stratification, whereas all the more northerly sources benefited from stratification treatments. As was the case with wax currant, there was considerable variability among sources of mountain snowberry in response to scarification treatments, however, no distinct latitudinal trends were apparent. The results of this study will be presented at the 2001 American Society for Surface Mining and Reclamation 18<sup>th</sup> National Meeting in Albuquerque, New Mexico, June 3-7, 2001.

3. Variability in Stratification and Acid Scarification Requirements Among New Mexico Provenances of True Mountain Mahogany (Lee Rosner, John T. Harrington, David R. Dreesen and Leigh Murray).

True mountain mahogany (*Cercocarpus montanus*) is a useful reclamation species due in part to its ability to occupy and improve poor soils. Literature regarding seed propagation of true mountain mahogany is varied and often contradictory, recommending stratification duration of 14 to 90 days, and sulfuric acid scarification periods of zero to 60 minutes. To assess variability in optimal propagation protocol due to provenance, eight New Mexico seed provenances were tested with factorial treatment combinations of scarification and stratification treatments. Eight provenances were selected to encompass a range of elevations at Questa, New Mexico and a range of latitudes throughout New Mexico. Seeds were scarified five or ten minutes in concentrated sulfuric acid, tumbled five or ten days in coarse grit, or left unscarified (control). Seeds underwent subsequent stratification for 0 (control), 30, or 60 days. For all seed provenances, stratification of unscarified seeds improved germination, but improvement was generally less for more southerly provenances and was greatest for the two highest elevation provenances. Averaged across scarification treatments, the two southernmost seed provenances lacked a stratification requirement, while northern seed provenances achieved their highest

germination following the longest stratification duration (60 days). Scarification treatments were less effective in improving germination than stratification treatments, and produced more variable results. A five-minute soak in sulfuric acid was the most effective scarification treatment, but for two seed provenances, this treatment reduced germination. Variability in stratification requirement appears to be an adaptation to macroclimatic differences among seed provenances, whereas differential response to scarification is less easily explained, and may be a response to microclimatic differences. This work is currently being prepared for journal publication.

4. Seed Refinement in *Alnus tenuifolia* and *Betula occidentalis* (Cindy Lee Jones, John T. Harrington, and David R. Dreesen).

Thinleaf alder and water birch, native trees of the mountain west, have the potential to be useful in the rehabilitation of disturbed lands as well as native landscapes. An efficient and economical method of propagation is needed. Although the seed characteristics of these species, such as small size, seed dormancy, and prolific production of low viability seed, make seed propagation problematic, it is the most likely propagation method in order to guarantee the genetic diversity needed for rehabilitative uses. This study examined a modification of Simak's I.D.S. seed refinement method in the improvement of percentage of filled seed in seed lots from 4 sources for each species (Simak 1983). The ability of the method to recover a high percentage of the total filled seeds present in the original sample was also evaluated. With the longest drying times chosen for this study, improvement in percentage of filled seeds of thinleaf alder was similar to that achieved by gravity separation of dry seed using the same separation medium. Intermediate drying times were more useful for recovery of a greater proportion of the filled seed in the original sample in thinleaf alder, but the percentage of filled seed in the resulting partitions of the sample was low. Seed source also affected the efficacy of seed refinement of alder with respect to both improvement of percentage fill and recovery of filled seed. Gravity separation of dry birch seed was more effective than I.D.S. methods for improvement of the percentage fill response. Seed source also affected this response in birch. All methods of refinement gave good recovery of filled birch seeds, with no apparent influence by source. This work is currently being prepared for journal publication.

5. Stratification Requirements for New Mexico Sources of *Alnus tenuifolia* and *Betula occidentalis* (Cindy Lee Jones, John T. Harrington, and David R. Dreesen).

Thinleaf alder and water birch, native trees of the mountain west, have the potential to be useful in the rehabilitation of disturbed lands as well as native landscapes. An efficient and economical method of propagation is needed. Although the seed characteristics of these species, such as small size, seed dormancy, and prolific production of low viability seed, make seed propagation problematic, it is the most likely propagation method in order to guarantee the genetic diversity needed for rehabilitative uses. This study examined the use of stratification in conjunction with seed refinement to improve germination percentage for seed lots from 4 sources for each species (Simak 1983, Jones et al. Earlier this issue). Unrefined seed and partitions of seed refined by a selected method were subjected to 3 levels of stratification. Seed source and refinement influenced germination of thinleaf alder. Response to stratification was variable across seed sources and refinement fractions of thinleaf alder. Birch seed germination was

influenced by seed source, stratification, and refinement. This work is currently being prepared for journal publication.

6. The Influence of Seed Source and Stock Size on First-year Performance of Direct Transplanted Conifer Seedlings (John T. Harrington, David R. Dreesen, Anne M. Wagner, Leigh Murray and Piexin Sun).

The influence of genotype on seedling survival and the large amount of genetic variability within forest tree species has, in part, led the U.S.D.A.-Forest Service, in cooperation with many state forest agencies, to develop seed zones. Seed zone delineation is an attempt to prevent using seedlings from unfit or non-adapted seed sources on a planting project. A current approach in reforestation involves matching planting stock type to site conditions and developing a planting stock with attributes best suited to the site. This system is often referred to as a target seedling system. One target parameter often used is the overall seedling size. The influence of seedling size on reforestation and afforestation success has been well documented. The objectives of this study were to examine the influence of seed source or genotype, and stock size on transplant success of seedlings transplanted directly into overburden piles at the MolyCorp Mine in northern New Mexico. Four sources of ponderosa pine (*Pinus ponderosa*), two northern New Mexico and two southern New Mexico seed sources were evaluated. Seedlings from each seed source were produced in three different container sizes, 1, 7 and 10 in<sup>3</sup> containers to generate three stock sizes. Two planting sites were used at the mine. The overall study design was a randomized complete block design within an overall split plot design with planting sites being main plots. First year survival and covering of seedlings by overburden movement on the rock pile slopes were recorded. Data was analyzed using categorical model analysis with treatment comparisons utilizing a Bonferroni adjustment to reduce the likelihood of making a Type I error. Overall, survival was low (<35%) with the smallest stock sizes having the lowest survival. Smaller seedlings had greater losses (39%) due to covering than did the mid and large size seedlings, 29 and 32%, respectively. Seed source did not influence survival or covering responses. The results of this study will be presented at the 2001 American Society for Surface Mining and Reclamation 18<sup>th</sup> National Meeting in Albuquerque, New Mexico, June 3-7, 2001.

7. Results of Species Trials on Low pH Overburden Materials for Mined Land Reclamation (John T. Harrington, David R. Dreesen, Anne M. Wagner, Leigh Murray and Piexin Sun).

One alternative for reclamation of the mine disturbed areas is direct revegetation of the disturbed areas. In this study materials from the waste rock piles at the MolyCorp Inc., molybdenum mine were evaluated for suitability for direct revegetation using transplant stock. Undisturbed areas surrounding the mine site also have low pH soils and support vegetation indicating there may be native plants in this climatic region which are adapted to low pH conditions and associated soluble constituents. This study was set up to evaluate the survival of different native and exotic plant materials across a range of overburden pHs. Determining what species can survive and grow at different pHs will be instrumental in implementing an effective reclamation program at the site. The overburden materials were graded and mixed to generate 4 different pHs: 3.0, 3.5, 4.5, and 5.5 and placed into 15 gallon horticultural pots located at the Mora Research Center, Mora, N.M. The study used 10 cubic inch container transplants of the following 52 plant types: 10 conifer species, 16 legume species, 5 species forbs and sub-shrubs,

and 21 shrub species. The study was begun in the summer of 1995 and evaluated in 1996. Survival and vigor results for species are presented. When 70% survival and a vigor rating of good are used as the criteria for determining potential for a species to be used in the reclamation program 42 and 38 species or sources are suitable at pHs of 5.5 and 4.5 respectively. At pH 3.5, 21 species or sources are suitable for use in the reclamation of those substrates and at pH 3.0, 5 species or sources are suitable. As an initial screening tool this study has provided information on suitable species for reclamation of low pH sites. Further work is suggested to determine if other species or sources may be appropriate for inclusion in the reclamation program. The results of this study will be presented at the 2001 American Society for Surface Mining and Reclamation 18<sup>th</sup> National Meeting in Albuquerque, New Mexico, June 3-7, 2001.

8. Testing Native Grasses for Survival and Growth in Low pH Mine Overburden (David R. Dreesen, John T. Harrington, Anne M. Wagner, Leigh Murray, and Piexin Sun).

Difficulties in establishing vegetation have compelled an experiment to determine grass species more likely to survive and grow in these low pH overburden materials. The substrate treatments consisted of an unadulterated acid rock, an acid-neutral overburden mixture ratio of 9:1, and an acid:neutral overburden mixture ratio of 3:1. Containerized grass seedlings of 54 species/ecotypes were transplanted into these substrates. These grasses, primarily cool-season natives of the western U.S., were grown from commercially available seed, seed from evaluations at the Los Lunas Plant Materials Center, and seed collected from the vicinity of the Molycorp Mine. Molycorp ecotypes having superior performance in the range of overburden pH and soluble salts tested included *Muhlenbergia montana* (2 ecotypes), *Blepharoneuron tricholepis*, *Festuca* species (3 ecotypes), and a *Poa* species. A number of commercially available grass varieties had good survival and growth in these substrates: *Deschampsia caespitosa* 'Peru Creek', *Festuca arizonica* 'Redondo', *Festuca ovina* 'Covar', *Festuca ovina* 'MX-86', *Festuca* sp. 'Shorty', *Poa compressa* 'Reubens', *Pascopyrum smithii* 'Arriba, Barton, and Rosana', and *Elymus trachycaulus* 'San Luis'. Other native grass species that showed superior survival and growth in these acid rock substrates included *Elymus canadensis*, *Danthonia intermedia*, *Sporobolus wrightii*, *Poa nemoralis*, and *Hesperostipa comata*. The results of this study will be presented at the 2001 American Society for Surface Mining and Reclamation 18<sup>th</sup> National Meeting in Albuquerque, New Mexico, June 3-7, 2001.

9. Preliminary Evaluation on Adventitious Rooting Hardwood Stem Cuttings of *Symphoricarpos oreophilus*, *Ribes cereum*, and *Cercocarpus montanus* from Throughout New Mexico (Lee Rosner, John T. Harrington, and David Dreesen).

Current trends in restoration, reclamation and revegetation are focusing on using local sources of indigenous plants including woody shrubs. However, for many native shrubs propagation techniques are not well researched, resulting in increased production costs for those species. Further, propagation literature is often based on studies with a limited number of sources. This investigation was undertaken to evaluate the suitability of rooting of dormant hardwood cuttings of *Symphoricarpos oreophilus*, *Ribes cereum*, and *Cercocarpus montanus* as a means of plant propagation. Exogenous hormone application dosage and timing of collection were evaluated for seven sources of each species. Sources were selected to represent a range of latitudes from the southern part of the state to the northern part of the state. At the northern-most

latitude, MolyCorp, Inc. mine near Questa, NM, collections were made at three elevations ranging from 8,200 feet to 9,800 feet. Several rooting response variables were measured. *Ribes cereum* and *Cercocarpus montanus* had overall poor rooting in this investigation. Only the *Symphoricarpos oreophilus* had appreciable rooting. Exogenous hormone dosage, timing of collection and source of cuttings all influenced the rooting response. Late winter/early spring cuttings had the highest rooting percentages across all sources with the exception of the most northerly, highest elevation source. IBA/NAA applications from 250 to 1,000 ppm improved the percentage of cuttings rooting. There was considerable variation in rooting among the sources evaluated with the more northerly sources, from the Sandia Mountains northward, having overall the greatest percentage of cuttings rooting. Results of this study were presented at the Plains and Prairie Forestry Association 2000 Conference – Where the Mountains Meet the Plains; Las Vegas, NM August 2000.

### PLANNED PROJECTS

1. Provenance Variability in New Mexico Locust to Seed Scarification Treatments (Nabil Khadduri, John T. Harrington, David R. Dreesen, Leigh Murray).
2. Influence of Fertilization at Time of Planting on the Survival and Growth of Seedlings Transplanted Directly in Hard Rock Overburden (Mohammed Tabbouh, David R. Dreesen, John T. Harrington, Leigh Murray).
3. Comparative Shoot Growth Analysis of Coniferous Seedlings Transplanted directly in Hard Rock Overburden and Coniferous Seedlings Naturally Occurring in Adjacent Forests and Scar Areas (J.T. Harrington and Mark Loveall).
4. Post-establishment Fertility Responses of Woody Plants Growing on Hard Rock Overburden (John T. Harrington, David R. Dreesen, and Mark Loveall).

### RECENT PUBLICATIONS

- Jones, C.L., 2000. Seed upgrade and germination strategies for *Alnus tenuifolia* and *Betula occidentalis*. M.S. Thesis, New Mexico State University.
- Rosner, L., 2000. Variability in seed propagation requirements of two co-occurring montane shrub species *Symphoricarpos oreophilus* and *Ribes cereum*. M.S. Thesis, New Mexico State University.
- Rosner, L., J.T. Harrington, and D.R. Dreesen 2000. Influence of collection date and source on adventitious rooting in three native shrub species. In: Proc. Plains and Prairie Forestry Meeting. August 7 – 10, 2000, Las Vegas, NM.
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## **NEW MEXICO**

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### **INTRODUCTION**

The Rocky Mountain Research Station, Albuquerque Lab, is home to an Ecology Research Work Unit (RWU) and an Ecosystem Research Work Unit. The titles, missions and summarized descriptions of these units are presented below.

Research Work Unit RMRS-4351. “Ecology, Recovery, and Sustainability of Grassland and Riparian Ecosystems in the Southwest.”

Mission: Develop, synthesize, and apply new methods and knowledge on processes, interactions, and human uses of desert, prairie, and riparian ecosystems to restore damaged lands, recover sensitive species, and sustain intact, productive, and diverse plant and wildlife communities and associated abiotic systems in the Southwest.

Problem 1. Nonsustainable management of grazing, fire, woody and alien species, and wildlife has led to widespread disturbance and degradation of southwestern and southern-plains grasslands and associated ecosystems. The development of new methods and knowledge are needed to restore damaged systems and recover sensitive and endangered species.

In order to specifically define the research approach needed to solve Problem 1, its components have been separated into four elements.

Element 1. Evaluate the influence of fire as an agent of natural disturbance that regulates ecological processes in southwestern and national grasslands and assess its value as a means for restoring grassland ecosystems, including the maintenance of native diversity and control of noxious weeds and undesirable woody plants.

Element 2. Determine the efficacy of mechanical and chemical woody plant removal as ecological restoration techniques for grassland ecosystems that require alteration of composition and structure before they can be burned.

Element 3. Assess the habitat ecology and roost site selection of sensitive bat species and identify natural and anthropogenic factors that disturb bat populations.



Element 4. Assess whether grazing schedules can be altered to improve habitats for endangered, threatened and sensitive bird species in grassland ecosystems.

Problem 2. Disturbances such as grazing, roads, stream channel realignments, and exotic plant invasion have altered hydrological, biological, and ecological dynamics of riparian habitats, endangering terrestrial native plant and nongame bird species. New methods and knowledge are required to recover terrestrial riparian systems and associated sensitive species.

To specifically define the research approach needed to solve Problem 2, its components have been separated into the following three elements.

Element 1. Determine how roads and stream channel realignments influence the hydrological and vegetation dynamics of riparian systems and evaluate road engineering techniques designed to repair damaged systems.

Element 2. Determine how the increasing presence of exotic woody plants affects the abundance, migration, and stopover habitat use of Neotropical migratory birds in riparian systems.

Element 3. Investigate the factors that affect and inhibit reproduction, migration, and abundance of the endangered southwestern willow flycatcher, and develop methods to recover its populations.

Research Work Unit RMRS-4652. “Ecology, Diversity and Sustainability of Soil, Plant, Animal and Human Resources of the Rio Grande Basin.”

Mission: Develop, synthesize, and apply new knowledge on processes, interactions, and sociocultural uses of upland and riparian ecological systems for sustaining diverse, productive, and healthy plant, animal, and human populations and associated natural resources in the Rio Grande Basin.

#### Ecological Disturbance and Restoration Research

Watershed and biological studies were initiated in FY94 and FY95 in the middle Rio Grande Basin, defined as the reach between Cochiti Dam and Elephant Butte Reservoir, New Mexico. Current studies are assessing responses of soil nutrients, water, belowground flora and fauna, herbaceous and woody plants, and fish and wildlife populations to 1) disturbances by drought, fire and its suppression, grazing, and past human activities, and 2) restoration treatments to mitigate or reverse disturbance effects.

Drought, overgrazing, and fire exclusion are three of the major factors, interacting in concert, that have resulted in degraded upland and river ecosystems in the middle Basin. Several cooperative studies were implemented to evaluate effects of drought, grazing exclusion, fire suppression, and historic human influence. These studies have involved the use of tree-ring dating, landscape analysis, experiments with cobble rocks, excluding cattle from streams and current and historic inventory data and photo records at Research Natural Areas (RNA). Ecological assessments have detected widespread shifts in grassland/shrubland/woodland

boundaries; influences of early Puebloan cobble mulch gardens on current ecosystem functioning; effects of grazing and hydrology on nutrient composition and retention in streams, and influence of RNA protection on ecosystem health as indexed by plant age and densities, nutrient cycling, and extent of cryptogram crusts.

A recent study initiated by this Research work Unit is the *Rio Grande Bosque Fuels Reduction Project*. The increasing incidence of catastrophic wildfires in the Rio Grande bosque is a result of high accumulations of woody debris and high densities of exotic invasive plants in these forests. These catastrophic fires result in the loss of large tracts of cottonwood gallery forests and threaten property, air quality, and water quality.

The primary goal of the study is to identify the best fuels-reduction practices that will simultaneously:

- reduce fuel loadings and thus the risk of catastrophic bosque fires,
- preserve cottonwoods and other native trees and shrubs,
- control the spread of exotic woody plants such as salt cedar and Russian olive, and
- provide habitat and minimize negative impacts on native wildlife populations.

This is a long-term study that is spread across 4 geographical areas (blocks) along the Rio Grande bosque, north and south of Albuquerque. Within each block four sites have been selected for a total of 16 sites to which treatments will be randomly assigned. The treatments will include: 1. control; 2. mechanical removal of dead and down wood and exotic woody plants; 3. mechanical removal of dead, down, and exotics, followed by revegetation with native understory species; and 4. partial removal of dead, down, and exotics, followed by controlled ground fire.

Diverse agency and interagency teams of biologist, ecologists, hydrologists and others are working together to address our research missions. Recent publications that have been produced from our research are listed below. Additional publications and detailed presentations of our programs, collaborators and accomplishments are on our website at: <http://www.fs.fed.us/rm/albuq/>.

## **PUBLICATIONS AND PAPERS**

Finch, D.M. and S.H. Stoleson (eds.) 2000. Status, ecology and conservation of the Southwestern Willow Flycatcher. Gen. Tech. Rep. RMRS-GTR-60. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 131p.

Ford, P.L. 2001. Biodiversity and fire in shortgrass steppe. p. 884-885. In: Gomide, A.J., W.R.S. Mattos and S.C. da Silva (eds). Proceedings of the 19th International Grassland Congress, 2001 February 11-21, Sao Pedro, Sao Paulo, Brazil.

Ford, P.L. 2000. Scale, ecosystem resilience and fire in shortgrass steppe. Ph. D. Dissertation. University of Arizona, Tucson, AZ. 169 pp.

- Ford, P.L. 1999. Response of buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*) to fire. *Great Plains Research* 9:261-76.
- Ford, P. L. and G. R. McPherson. 1999. Ecology of fire in shortgrass prairie communities of the Kiowa National Grassland. Pp. 71-76. In: Charles Warwick, editor. *Proceedings of the Fifteenth North American Prairie Conference*. October 23-26, 1996. St. Charles, Ill.
- Jemison, R. and D.G. Neary. 2000. Stream channel designs for riparian and wet meadow rangelands in the southwestern United States. Pp. 305-306. In: Ffolliott, P.F., M.B. Baker Jr., C.B. Edminster, M.C. Dillion, and K.L. Mora, *tech. eds.* *Land stewardship in the 21<sup>st</sup> century: the contributions of watershed management: 2000 March 13-16, Tucson, AZ. Proc. RMRS-P-13*. Ft. Collins, CO. USDA Forest Service, Rocky Mountain Research Station. 438p.
- Jemison, R. and C. Raish (eds.) 2000. *Livestock management in the American southwest: ecology, society and economics*. Elsevier Science. The Netherlands. 597p.
- Jemison, R. and A. Edwards. 2000. Roads, Riparian, Restoration. Pp. 493-498. In: Wigington, P.J. and R.L. Beschta (eds.) *Riparian Ecology and Management in Multi-Land Use Watersheds*. American Resources Association, Middleburg, VA, TPS-00-2. 616p.
- Boucher, P.F., S.H. Stoleson, R.S. Shook, R.D. Pope, and J. Monzingo. (In Press) Multi-purpose riparian restoration on the Gila River: bank stabilization creates Willow Flycatcher habitat. In: Sogge, M., B. Kus, M. Whitfield and S. Sferra, (eds). *Proceedings of the conference Ecology and Conservation of the Willow Flycatcher: 2000 October 24-26, Tempe, AZ*. To be published by the Cooper Ornithological Society.

# NORTH DAKOTA

## Bismarck Plant Materials Center

### INTRODUCTION

This report summarizes 2000 project activities at the USDA, Natural Resources Conservation Service, Plant Materials Center located at Bismarck, North Dakota. Current projects have focused on native prairie and riparian restoration. Development of native forbs, legumes and wetland species for conservation use. Work also continues on woody species and foundation grass seed production.

### COMPLETED PROJECTS

Release of 4 native forbs, Bismarck Germplasm purple prairieclover (*Dalea purpurea* Vent.), Bismarck Germplasm narrow-leaved purple coneflower (*Echinacea angustifolia* D. C.), Bismarck Germplasm stiff sunflower (*Helianthus pauciflorus* Nutt. ssp. *pauciflorus*) and Medicine Creek Germplasm maximilian sunflower (*Helianthus maximiliani* Schrad.). These native releases will add diversity to conservation plantings such as range and pasture seedings, wildlife habitat development, prairie restoration and prairie landscaping.

### ONGOING PROJECTS

#### 1. Evaluation of slough sedge (*Carex atherodes*).

Selection of plant materials for future release of this common wetland species that has potential use in wetland restoration, creation or enhancement.

#### 2. Prairie Restoration Partnership.

The fourth year of this five-year study that is a cooperative effort between the Bismarck Plant Materials Center and the North Dakota State Game and Fish Department. Field trials are currently being evaluated and data collected on diverse native seedings. Project plans include the renovation of introduced species with a diverse mixture of native grass forbs and shrubs. Standards and specifications for prairie restoration in the Northern Great Plains will be developed at the end of the study period.

#### 3. Direct Seeding Woody Species into Riparian Zones.

Direct seeding methods are being evaluated as a potential option for renovation of riparian areas. This study is being conducted on lands enrolled into the Emergency Watershed Program.

#### 4. Evaluation of the Effectiveness of Various Grasses and Herbicides in Reducing Leafy Spurge.

Cooperative study with North Dakota State University evaluating various grass mixes and their competitive association with leafy spurge.

#### 5. Native Shrubs for Conservation.

Ongoing data collection and evaluation of native hawthorn (*Crataegus chrysocarpa*) silver buffaloberry (*Shepherdia argentea*), sandbar willow (*Salix interior*), false indigo (*Amorpha fruticosa*), select plum (*Prunus* sp.) and chokeberry (*Photinia melanocarpa*).

#### 6. Native Forbs and Legumes for Conservation.

Evaluation and increase of leadplant (*Amorpha canescens*) and silky prairie clover (*Dalea villosa*).

#### 7. Effect of Selected Herbicides on 7 Native Forbs/Legumes.

Evaluation of selected herbicides on stand establishment.

### **PLANNED OR POTENTIAL PROJECTS**

Seed collection of Prairie Dropseed (*Sporobolus heterolepis*).

### **CURRENT PUBLICATIONS AND PAPERS**

Bismarck Plant Materials Center. 2000. Native Prairie Restoration Annual Report-1999. USDA-NRCS-Bismarck Plant Materials Center, Bismarck, ND. 19 pages.

Bismarck Plant Materials Center. 2000. Notice of Release : Bismarck germplasm narrow-leaved coneflower (*Echinacea angustifolia*). USDA-NRCS Bismarck Plant Materials Center, Bismarck, ND. July 2000. 4 pages.

Bismarck Plant Materials Center. 2000. Notice of Release : Bismarck germplasm purple prairieclover (*Dalea purpurea*). USDA-NRCS Bismarck Plant Materials Center, Bismarck, ND. July 2000. 3 pages.

Bismarck Plant Materials Center. 2000. Notice of Release : Bismarck germplasm stiff sunflower (*Helianthus pauciflorus*). USDA-NRCS Bismarck Plant Materials Center, Bismarck, ND. July 2000. 4 pages.

Bismarck Plant Materials Center. 2000. Notice of Release : Medicine Creek germplasm maximilian sunflower (*Helianthus maximiliani*). USDA-NRCS Bismarck Plant Materials Center, Bismarck, ND. July 2000. 3 pages.

Duckwitz, W. 1999. Development of native forbs and legume germplasms at the Bismarck Plant Materials Center. Native Plants Summit V, Bismarck, ND. Nov. 1999. 1 page. July 2000. 4 pages.

Bismarck Plant Materials Center. 2000. Plant Materials Center Releases- Bismarck, ND and Bridger, MT. USDA-NRCS Bismarck Plant Materials Center, Bismarck, ND. July 2000. 2 pages.

# OREGON / WASHINGTON

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## 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 April 30, 2000 to January 15, 2001. The USGS and the Bureau of Land Management of the U. S. Department of the Interior fund the research reported in this document.

## COMPLETED PROJECTS

Risk and establishment of *Taeniatherum caput-medusae* with management applications  
(Michelle Stubbs, Department of Forest Science, Oregon State University, and David A. Pyke, USGS, Forest and Rangeland Ecosystem Science Center, Corvallis, OR).

During the last century, fire suppression, grazing, and climate change have caused sagebrush grasslands to be altered in both function and form; juniper and sagebrush dominate the landscape at the expense of herbaceous plants. Management efforts to reduce juniper and sagebrush overstory in order to enhance herbaceous components of the ecosystem are currently underway. However, such changes may alter the invasion potential for exotic invasive plant species. We examined what effects prescribed fire and woody removal exerted on the spatial mosaic of nutrients essential for plant development, inorganic nitrogen, and if these practices increased the risk of invasion by a noxious annual grass, *Taeniatherum caput-medusae* (L.) Nevski (medusahead).

Four disjunct sites were selected in central Oregon, treated with prescribed fire and harvesting to remove woody plants, and monitored from 1997 to 1999. We collected monthly soil samples and assessed nitrogen and ammonium concentrations to examine the spatial and temporal dynamics of under canopy versus interspace resource islands. Simultaneously, we planted medusahead seeds and monitored their populations monthly. We developed a matrix model of medusahead's population dynamics to compare among the treatments.

Average ammonium and nitrate concentrations in canopies were higher than interspaces for nearly all months of the year. However, this difference was not always significant and was variable through time. We found that these resource islands were enhanced by fire, but not by woody plant removal. After prescribed fire, both ammonium and nitrate remained significantly higher under former canopies than interspaces throughout the study.

*T. caput-medusae* was a serious threat for invasion in undisturbed, burned and juniper-removal areas in both 1998 and 1999. Results of the demographic matrix model indicate *T. caput-medusae*'s population growth rate is higher in burned areas than control and juniper-removal areas. *T. caput-medusae*'s seedbank remained small but viable for at least two years under field conditions. *T. caput-medusae* populations in canopy areas were more fecund than those in interspace areas.

Harvesting juniper trees did not enhance concentrations of inorganic nitrogen in microsites whereas prescribed burning caused concentrations to increase 10-fold during the first four months after burning. Harvesting is not likely to increase the risk of *T. caput-medusae* invasion above levels found in untreated areas, whereas prescribed fire increased invasion risk. In areas where *T. caput-medusae* is already present or nearby, harvesting may be a better alternative for woody plant removal than prescribed burning.

## ONGOING PROJECTS

1. Changes in plant community dynamics caused by elevated CO<sub>2</sub> and altered precipitation (Richard F. Miller, William E. Winner, Larry L. Larson, Gary L. Kiemnec, Oregon State University, and Tony Svejcar, Agricultural Research Service).

The analysis of biomass shows a significant year by treatment interaction. Overtime the spring precipitation treatment has resulted in significantly lower biomass in the following functional groups: all plants, perennial grasses and perennial forbs. Annual grass biomass was greatest in the winter precipitation treatment reflecting the fact that winter annuals dominate this functional group. Reproductive tiller density and tiller weights for Thurber's needlegrass and squirreltail (native perennial grasses) was significantly lower in the spring precipitation treatment relative to other treatments. However, the Wyoming big sagebrush reproductive shoot density and biomass were highest in the spring precipitation treatment reflecting the ability for plants with later phenology to respond positively to the spring precipitation shift. Data collection on biomass and reproductive effort will continue through 2001.

2. Quantification of vegetation diversity on intact and deteriorated rangelands: Experiment 1 – Plant diversity on sagebrush steppe rangelands varying in ecological condition (Lee E. Eddleman & Pat Dysart, Department of Rangeland Resources, Oregon State University).

No additional data are being collected. Analysis and interpretation of the results is continuing. Some of the additional findings indicate that species richness and diversity are highly dependent on season both within year and between years, but that the individualistic nature of community dynamics may well exceed their usefulness as a discriminators, independent tools for management for these types of semiarid rangeland.

3. 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).

The implementation of the PRISM dataset into VegSpec was delayed by one year when we discovered that the NRCS climate data for some of the required components was incorrectly calculated in the previous climate database. The Oregon State University scientists were forced to halt their model development until the NRCS climate laboratory corrected those data. Most of the corrected data were provided midway through 2000. To date, all PRISM data layers for VegSpec, except the temperature probability maps (1, 2, and 3-in-10 year January minimum temp., and all-time low temp.) are complete. The NRCS is completing the corrected temperature probabilities for climate stations and should ship those to Oregon State in early 2001.

4. Idaho habitat change: Geographic information system formatting of ecological data from the Shoshone Resource Area, Bureau of Land Management, southern Idaho (Steve J. Popovich and David A. Pyke, USGS, Forest and Rangeland Ecosystem Science Center, Corvallis, OR).

Some errors were found in the final GIS layers from this project and the maps and files were recreated. A final report is being prepared, but the corrected files have been transferred to the BLM Shoshone District Office.

5. Evaluating emergency wildfire rehabilitation efforts and monitoring methodologies of sagebrush steppe ecosystems on BLM Land, southern Idaho (Steve J. Popovich and David A. Pyke, USGS, Forest and Rangeland Ecosystem Science Center, Corvallis, OR).

Data analysis are being conducted on this project and a final report is being prepared for submission in the coming year.

6. Fire History in the Intermountain Sagebrush Steppe (Richard F. Miller, Department of Rangeland Resources, Oregon State University, Burns, OR).

The fieldwork was completed in the mountain big sagebrush communities. A total of 37 fire scar samples and 130 tree cores have been sampled across 13 sites in eastern Oregon and northeastern California. All samples have been prepared for analysis. Sixteen fire scar samples have been analyzed at the Dendrochronology Laboratory at the University of Arizona. The remaining 21 samples are presently being analyzed and should be completed this winter. Ages of juniper cores have been recorded and data are being summarized. Fire histories for each of the 9 sites analyzed indicate a mean fire return interval between 12 and 16.4 years. The initial encroachment of juniper appears to be synchronized with the reduction in fire events. The aspen portion of this study has been completed. Aspen stands below 2100 m and interspersed in the sagebrush steppe biome in the northwest averaged 98 years old, with 85% of the stands varying between 70 and 130 years. Juniper invasion began in the 1890s, peaked between 1900 and 1939. Western juniper replaced or dominated 35% of the 91 aspen stands measured and was common in 60%. Aspen age structure across two large stands indicated a mean disturbance frequency within a portion of the stand of 16 years, and total stand replacement to occur about every 60 years prior to 1900. The absence of presettlement juniper within all sampled aspen stands

suggests fire was the primary stand-replacing disturbance in these northwest Great Basin aspen communities.

7. 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).

During 2000, six field sites in the four-corners area of the SW (UT, CO, AZ, NM) and six sites in eastern Oregon (south of Burns OR) were sampled. All proposed field sampling was conducted with the exception of the biomass estimations. The time necessary to conduct this technique extended the time at a field site to more than one workweek for a crew of five. Finding sites that met our criteria was more difficult than we anticipated. Livestock water developments such as wells, digging ponds in ephemerally wet locations, or trucking water to remote water troughs has been effectively applied as a tool to spread cattle use on western rangelands. However, finding sufficient sites for this study can be achieved. We are currently entering field data and analyzing some results while conducting lab preparation of soil and plant samples for further nutrient analyses. Based on preliminary analyses, we will evaluate the continued retention of some techniques and the additions or modifications of others. We will attempt to measure biomass again this year. We are conducting power analyses on some of the data to determine if five locations along a piosphere radial transect are sufficient to determine trends associated with livestock impacts. Using counts of cow pies per area, we have established a decreasing cattle-use trend from the water point to the furthest point from the water. This trend is consistent with the trend seen in other similar studies being conducted in Australia. We will resample three sites in the SW and three in eastern Oregon during the next field season to isolate measured indicators that are consistent among years. We will also add an additional three sites in each location.

## **PLANNED OR POTENTIAL PROJECTS**

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

During this transition year between the Intermountain Greenstripping Project and the Coordinated Intermountain Restoration Project (CIRP), progress occurred in both areas of emphasis. In the Greenstripping Project, the native grass accessions that showed promise in restoration success in the Snake River Plains of Idaho have remained in the seed increase plots in Utah. We anticipate that seed from these accessions will be available for seed growers to begin using during the 2002 field season. As CIRP begins, a Research Associate was enlisted to: (1) identify potential demonstration sites for full-scale restoration projects. Sites include both areas where restoration treatments will be applied, as well as nearby reference areas in good ecological condition; (2) complete a BLM technical reference: Biological Soil Crusts: Ecology and Management; and (3) complete projects investigating functional diversity of soil bacteria and fungi in native and exotic plant communities. Six sites were identified in the region between Kuna and Mountain Home, Idaho with vegetation ranging from salt desert shrub to big and low sagebrush types. Sites reflected prioritized historical plant communities identified in the CIRP

Draft Strategic Plan (Wyoming big sagebrush, winterfat, shadscale, low sagebrush, Basin big sagebrush), as well as priority invasive plants for control (cheatgrass, medusahead wildrye, Russian knapweed, diffuse knapweed, rush skeletonweed). Regarding the second task, the soil crust publication is in the final stages of editing and layout. A final proof will be ready the week of January 14, 2001. Final report of the project titled "Functional diversity of soil bacteria and mycorrhizal fungi (Biolog & Fungilog analysis)" is near completion and will be submitted by 26 January 2001.

## CURRENT PUBLICATIONS AND PAPERS

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- Stubbs, M.M. 2000. Time-based Nitrogen Availability and Risk of *Taeniatherum caput-medusae* (L.) Nevski Invasion in Central Oregon. M.S. thesis, Oregon State University, Corvallis. 97 pp.
- Laws, M.S. 2000. Control of *Lepidium latifolium* and restoration of native grasses. M.S. Thesis, Oregon State University, Corvallis.
- NRCS, USGS, USArmy CERL. 1999. VegSpec 3.1: Creating Vegetative Designs. A web-based expert system. (<http://plants.usda.gov> & follow link to VegSpec under Tools).
- Pyke, D.A. 1999. Monitoring weed populations in biocontrol projects. Pages 39-42, *In*: Isaacson, D. & Brookes, M. (eds.), Weed biocontrol: extended abstracts from the 1997 interagency noxious-weed symposium, December 2-4, 1997, Corvallis, OR. Forest Health Technology Enterprise Team, USDA, Forest Service, FHTET-98-12. Morgantown, WV.
- Pyke, D.A., P.H. Smith, J.M. Patterson, K.A. Ticknor, J.F. Henson, and S.D. Warren. 1999. Selecting Native Plants Using VegSpec – A Web-based Expert System. Pages 159-160, *In*: Rose, R. & Haase, D. (eds.) Symposium proceedings -- Native plants: propagation and planting. Oregon State Univ., Nursery Technology Cooperative, Dept. of Forest Science, Corvallis.
- Rasmussen, G.A., M. Pellant, and D. Pyke. 1999. Reliability of a qualitative assessment process on rangeland ecosystems. Pp 781-782, *In*: Eldridge, D. & D. Freudenberger (eds.) People and Rangelands – Building the Future: Proceedings of the VI International Rangeland Congress, Vol. 2. VI International Rangeland Congress, Aitkenvale, Australia.
- Wirth, T.A. 2000. Emergence, survival and reproduction of three species of forbs important in sage grouse nutrition by two establishment methods. M.S. thesis, Oregon State University, Corvallis.

Youtie, B., J. Ponzetti, & D. Salzer. 1999. Fire and Herbicides for exotic annual grass control: effects on native plants and microbiotic soil organisms. Pages 590-591, *In*: Eldridge, D. and D. Freudenberger (eds.), VI International Rangeland Congress, Aitkenvale, Australia.

# UTAH

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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 2000. Projects range from basic studies of physiology, ecology, and genetics to applied revegetation trials and weed control procedures.

## COMPLETED PROJECTS

1. Effects of Achene Weight of Rubber Rabbitbrush on Establishment (Susan Meyer, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

Achene weights of rubber rabbitbrush subspecies vary by nine fold. Larger achenes are associated with harsher environments and their seedlings have a slower growth rate than those from moderate environments. Dispersal of larger and heavier seeds is facilitated by a correspondingly large pappus. A manuscript has been accepted to *Functional Ecology*.

2. Effectiveness of Anchor Chaining and Revegetation Practices on Plant Communities After Wildfire in Utah (E.Durant McArthur, U.S. Forest Service Shrub Lab, Provo, UT 84401, Jeff Ott, and Bruce A. Roundy, Brigham Young University, Provo, UT 84602).

Paired plots were read to evaluate the effects of drilling, aerial seeding, and subsequent chaining or lack of chaining on 7 study sites burned by wildfire in the summer of 1996 in Utah. Chaining resulted in higher establishment of seeded species and less cheatgrass than aerial seeding alone. Revegetation success varied with soils and topography within and among study sites. A thesis and other manuscripts are currently being prepared to report the details of this research.

## ONGOING PROJECTS

1. Role of Seedbanks in the Management of Semiarid Rangelands Under Grazing (Jaime Kigel, Hebrew University of Jerusalem, P.O. Box 12, Rehovot, Israel, Avi Perevolotsky, Volcani Center, Bet-Dagan, Israel, Bruce A. Roundy, Phil Allen (Brigham Young University, Provo, UT, 84602, and Susan Meyer, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

The objective of this study is to determine the effects of grazing, topography, and soil moisture and temperature on annual plant germination and emergence in the northern Negev Desert. Greenhouse experiments instrumented for moisture and temperature measurement are proceeding to compare germination predicted by a hydrothermal time model and actual emergence of seeds.

2. 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).

This study is to restore native vegetation to a Mojave Desert site physically disturbed by recreational activities. Favorable precipitation has enhanced establishment of native grasses and forbs drill seeded in the fall of 1992, as well as natural recruitment of non-seeded species. Monitoring is continuing to determine if and when annual plant dominance will shift perennial dominance. Fourwing saltbush and Indian ricegrass have especially established well. Annual species occurrence varies from year to year.

3. Ecology and Restoration of Cheatgrass Dominated Sites (Stephen B. Monsen, U.S. Forest Service Shrub Lab, Provo, UT, 84401, Mike Pellant, Bureau of Land Management, Boise, Idaho 83706, and Nancy Shaw, U.S. Forest Service, Boise, Idaho 83702).

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 promising native grass source identified selections, effects of row spacing, configuration and rate of seeding on cheatgrass suppression, and rearing techniques to increase efficiency of native seed production. Studies testing the fuel and fire characteristics of different species and green-strip configurations are being conducted in Utah and Idaho. Effects of the nonselective herbicide Oust on reduction of cheatgrass in native grass stands is being tested. Large-scale seed production is being developed for about a dozen forbs which hold promise for revegetation in the Great Basin.

4. Secondary Succession of Montane and Subalpine Vegetation on the Wasatch Plateau (Stephen B. Monsen, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

Vegetation inside and outside exclosures established by Sampson and Ellison on the Wasatch Mountains east of Ephraim, Utah is being remeasured to determine effects of site degradation and time on seral stage composition. Also, establishment requirements and constraints of native forbs is being studied. Many of these species germinate under snow and are subject to fungal attack associated with saturated soil conditions.

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

This project is to determine the seedbank dynamics and establishment phenology of shadscale, to develop techniques for direct seeding establishment. Field experiments are underway to determine the effects of damping-off organisms and their control by fungicides on seedling mortality. A thermal time model has been successful in predicting changes in the chill response of afterripened seed.

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

This project is determining the reproductive output, seedbank dynamics, and field seedling recruitment of this mast fruiting shrub. Heteromyid rodent population dynamics are currently being studied in relation to masting and seed dispersal of blackbrush. Data on home ranges and caching behavior are being collected.

7. Modeling Dormancy Loss and Germination in the Field of Annual and Perennial Grasses (Susan Meyer, U.S. Forest Service Shrub Lab, Provo, UT, 84401, and Phil Allen, Brigham Young University, Provo, UT 84602).

Laboratory germination data are being used to predict dormancy loss and germination in the field for cheatgrass and squirreltail grass using a hydrothermal time model. The model has been extended to include effects of dynamic temperatures in order to predict germination under field conditions.

8. Ecological genetics of the cheatgrass head smut pathosystem (Susan Meyer and David Nelson, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

This project is determining the potential of using head smut for biocontrol of cheatgrass. The smut infects seedlings, which subsequently do not produce seeds. Basic smut genetics are being investigated in order to eventually determine the limitations of environmental conditions or frequency-dependent selection on infection rates. Inbred cheatgrass lines tested to this point are resistant to smut from other populations but are susceptible to smut strains found within their own populations.

9. Germination characteristics of native forbs (Susan Meyer, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

Requirements for germination are currently being tested for species *Castilleja*. Work on *Eriogonum* has been published.

10. The Relationship of *Atriplex* Genetics to Reclamation Success ( Howard Stutz, retired Brigham Young University, Provo, UT 84602).

Various long-term studies are in progress in conjunction with Broken Hills Products in the four corners area to determine the benefits of *Atriplex* heterozygosity on reclamation success.

11. Enhancing Native Seed Production and Purity (Bruce Welch, U.S. Forest Service Shrub Lab, Provo, UT, 84401).

Experiments determining the most efficient production and cleaning methods of native seed are in progress.

12. 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 determined on herbicide persistence, soil microbes, and shrub and herbaceous plant composition of mountain big sagebrush stands. Rates up to 0.7 kg/ha have not negatively impacted soil microbes and in some cases enhanced their growth, possibly through increased availability of resources. Rates of 0.2-0.3 kg/ha have effectively thinned sagebrush. Herbaceous perennials initially increased, but have varied on both control and treated plots.

13. Herbicide and Grazing Effects on Increasing Diversity of Aspen Parkland (Val Jo Anderson, Brigham Young University, Provo, UT 84602, and Scott Walker, Utah Division of Wildlife Resources, Ephraim, UT 84627).

The effects of cattle and elk grazing, as well as herbicide applications are being measured on tarweed, mule's ear, and thistle dominance and on plant community composition of aspen parklands.

14. Natural Resource Monitoring, Analysis, and Reclamation Activities at Dugway Proving Ground (Val Jo Anderson, Brigham Young University, Provo, UT 84602).

Effects of disturbance and revegetation for cold-desert communities at Dugway are being studied under the objectives of a cooperative agreement between BYU and the Department of the Army. The following studies are in progress: 1) effects of a sweep broom attachment to clear cheatgrass litter on establishment of drill-seeded perennials (wheatgrasses, flax, and four-wing saltbush); 2) effectiveness of 6 species for greenstrip-fire control (kochia, yarrow, burnet, and wheatgrasses); 3) effects of 'Oust' herbicide and mechanical treatments on cheatgrass control and revegetation success; 4) establishment of kochia after fire and soil disturbances; 5) small mammal presence and diversity in relation to vegetation treatments and dominance; 6) cheatgrass invasion into salt desert shrublands; 7) use of wheatgrasses to capture sites from cheatgrass as a precursor to revegetation with native species; and 8) factors that constrain Utah juniper



recruitment. Although various theses and manuscripts are in various stages of preparation or completion, long-term data are still being collected on most of these experiments.

15. Dark Respiration Measured From Microcalorimetry as an Indicator of Plant Adaptation to Temperature and Water Stress (Bruce N. Smith and Lee Hansen, Brigham Young University, Provo, UT 84602).

Collections of native plants from different populations are being measured for dark respiration rates. This technique has promise in predicting adaptive potential of specific ecotypes.

16. Control of Squarrose Knapweed (Pat Fosse, Bureau of Land Management, Philmore, Utah, Steve Monsen, U.S. Forest Service Shrub Lab, Provo, UT 84401, Scott Walker, and Scott Jensen, Utah Division of Wildlife Resources, Ephraim, Utah).

Phenology and reproductive biology and ecology of knapweed are being studied to better understand its ability to invade or be replaced by desirable species. The environmental controls of this species' ability to remain in the rosette until released by disturbance is a key to its control. Revegetation as a follow up to fire and herbicidal control is being studied, as well.

17. Operational Scale Fire Rehabilitation with Native and Exotic Seed Mixes (Tyler Thompson and Bruce Roundy, Brigham Young University, Provo, UT 84602, E. Durant McArthur, U.S. Forest Service Shrub Lab, Provo, UT 84601, Pat Fosse, Bureau of Land Management, Philmore, UT, Jim Davis, Utah Division of Wildlife Resources, Provo, UT 84601, and Jerry Chatterton, USDA, Agricultural Research Service, Logan, UT 84322-6300).

A multiagency cooperative study was installed fall 1999 in Tintic Valley, Utah on land burned by the Railroad Fire during midsummer 1999. Four seed mixes were drilled on five blocks in a burned Wyoming big sagebrush area and were aerial broadcast and covered by 1-way chaining on five blocks in a burned Utah juniper area. Seed mixes included two native mixes, one with a higher number of species and total seeding rate than the other. Also seeded was a mix of selected exotic and native plant materials supplied by the Agricultural Research Service, and the standard Bureau of Land Management fire rehabilitation mix, composed mainly of exotic and some native species. Perennial grass establishment from all mixes was similar, but cover was low (< 5 %) the first year after seeding. Plants established on all seeded blocks and sites except on 2 blocks of very sandy soils that were drilled perpendicular to wind patterns. Excessive seed burial probably limited emergence on those blocks.

## NEW PROJECTS

Changing fire regimes, increased fuel loads, and invasive species: effects on sagebrush steppe and pinyon-juniper ecosystems (Jeanne Chambers, Durant McArthur, Bruce Roundy, and 10 other cooperators and investigators).

This project will compare historical and current fuel load characteristics and determine the effects of residue perennial vegetation on resource availability and invasibility of weedy species.

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# WASHINGTON

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## INTRODUCTION

This report summarizes land rehabilitation and related research at Washington State University from June 2000 through February 2001. Research is conducted through the Department of Natural Resource Sciences and USDA NRCS Plant Materials Center.

## NEW PROJECTS

1. The effects of changing fire regimes and invasive species on pinyon-juniper woodlands in the Intermountain area (J.C. Chambers, R. Tausch, USDA Forest Service, Reno, S.E. Meyer, USDA Forest Service, Provo, R.E. Miller, Oregon State University, R. Blank, USDA ARS, Reno, B. Roundy, Brigham Young University, Provo, and J.P. Dobrowolski, Department of Natural Resource Sciences).

Assistance with examination of the effects of natural differences in soil water on cheatgrass establishment and reproduction, partial and total removal of existing herbaceous species, and the effects of fire on cheatgrass invasion, over an elevational gradient within pinyon-juniper woodlands.

## ONGOING PROJECTS

1. Potential for Bank Stability Decline Due to Drastic Flow Level Change in the Bear River (J.P. Dobrowolski, Department of Natural Resource Sciences).

Research will determine the stability of selected banks of the Bear River in relation to the different conditions during the rising and falling of a ramping event. Changes of bank strength conditions and occurrence of different types of instability will be examined on the basis of physical property change in the near bank environment.

2. Integration of upland, riparian and stream condition monitoring for intermediately sized watersheds on rangelands (G.A. Rasmussen, Department of Rangeland Resources, Utah State University and J.P. Dobrowolski, Department of Natural Resource Sciences).

This two-year study will develop and test a monitoring protocol that will assess the hydrologic stability of rangeland watersheds and link upland and riparian conditions with

downslope or down stream condition within intermediate-sized watersheds (<1000 km<sup>2</sup>). This assessment, with implications for restoration, will allow the interpretation of the overall condition of watersheds and evaluate the individual contribution of each sub-component (upland, riparian or stream). The major product of the research is a watershed based monitoring protocol that will help managers monitor and understand the cause of erosion- and sediment-related environmental changes in a watershed. The protocol uses GIS technology and conceptual and mathematical models for its implementation.

3. Plant materials for western riparian areas (S.M. Lambert, USDA NRCS Washington State University).

Increasing emphasis on improvement of degraded wetlands and riparian areas in the western United States has necessitated development of appropriate plant materials and planting technology. Treatment of damaged wetlands requires restoration of proper hydrologic functioning and reestablishment of native vegetation. USDA NRCS Plant Material Centers in the western U.S. are developing source-identified material of common wetland species adapted to specific geographic areas. They are also revegetation equipment and formulating planting guidelines.

4. Identification of grasses for possible use in upland restoration on eastern Washington and Oregon rangelands (S.M. Lambert, USDA NRCS Washington State University).

The objective of this project is to provide plant identification assistance to restorationists for upland and riparian restoration plantings.

5. Watershed-Scale Research in the Pinyon-Juniper Ecosystem (J.P. Dobrowolski, Department of Natural Resource Sciences and J.C. Malechek, Department of Rangeland Resources, Utah State University).

A long-term, watershed-scale study will perform mechanistic research in pinyon-juniper ecosystem dynamics, e.g. energy flow, water and nutrient cycling, organismal structure and function at relevant scales, sediment source/sink relationships, while simultaneously addressing the more pragmatic concerns associated with management by objectives, the effects of drastic disturbance, or the result of custodial management. This interdisciplinary research effort will involve investigators from across the USU campus, and will be coordinated with other regional studies at Los Alamos National Laboratory, Oregon State University, and the University of Nevada, Reno.

6. Restoration of grizzly bear populations (Robert B. Wielgus, Department of Natural Resource Sciences).

This study evaluates grizzly bear populations to test three hypotheses on the effects of adult male mortality on female reproduction. There are three hypotheses, “no effect” (reproduction should be higher in the population with superior overall diet quality), “increased reproduction” (higher in the hunted population because of lowered numbers of competitive or cannibalistic males), and “decreased reproduction” (reproduction should be lower in the hunted

population because of increased immigration by potentially infanticidal, nonsire males, and/or increased sexual segregation resulting in reduced production of cubs.

7. Two stage sampling to determine vegetation status on reclamation sites (Benjamin A. Zamora, Department of Natural Resource Sciences)

Two stage sampling is tested as a means of measuring the revegetation status of reclaimed pasture, forest or rangeland sites for comparison to vegetation success standards. Study sites are located on reclamation areas in eastern and western Washington. Results of this two stage sampling study are compared to single line transect sampling of the same area. Initial results show two stage sampling producing more consistent measures of variation, is more efficient in application, and is considered more reliable for accurate relocation of macroplots for repeat measurements and monitoring.

8. Effects of shade and defoliation on reed canarygrass (*Phalaris arundinacea* L.) biomass production: A greenhouse study (Daniel J. Forman, Linda H. Hardesty and Rodney D. Sayler; Department of Natural Resource Sciences).

Many wetlands in the Pacific Northwest have become dense monotypic stands of reed canarygrass, reducing biodiversity. Control methods are not well developed. The literature is inconclusive on the effectiveness of defoliation and shade in controlling reed canarygrass. We investigated the effect of combining defoliation and shading on reed canarygrass productivity.

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Forman, D. J. L. H. Hardesty and R. D. Sayler. 2000, The effects of shade and defoliation on reed canarygrass (*Phalaris arundinacea* L.) biomass production: a greenhouse study. Wa. Dept. Transportation reed canarygrass symposium, Olympia, Washington.

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Shaw, N.L., S.M. Lambert, and J. Chris Hoag. 2000. Plant materials for western riparian areas. Proc. Watershed 2000, Vancouver, BC: 1-12.

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Wielgus, R.B. and F.L. Bunnell. 2000. Possible negative effects of adult male mortality on female grizzly bear reproduction. *Biological Conservation* 93:145-154.

# WYOMING

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## INTRODUCTION

This report summarizes the revegetation, seed physiology, and general reclamation research of the Rangeland Resources Research Unit at Cheyenne, Wyoming for the year 2000. Portions of this research are cooperative with the University of Wyoming, Department of Renewable Resources and the mining industry. This research is partially funded from the Abandoned Coal Mine Land Research Program, University of Wyoming and Abandoned Mine Land Division, Wyoming Department of Environmental Quality.

## ONGOING RESEARCH

1. Grass competition and sagebrush seeding rates: Influence on sagebrush seedling establishment (G.E. Schuman, M.I. Fortier, and A.L. Hild; USDA, ARS, High Plains Grasslands Res. Stn., Cheyenne, WY and Department of Renewable Resources, University of Wyoming, Laramie, WY).

This study is examining the effects of grass competition and sagebrush seeding rate on establishment of Wyoming big sagebrush seedlings at the Belle Ayr Mine near Gillette, WY. Experimental plots seeded at three big sagebrush rates (1, 2, and 4 kg PLS/ha) and seven grass seeding rates (0, 2, 4, 6, 8, 10 and 14 kg PLS/ha) were used to assess the effects of sagebrush grass seeding rate and grass competition on sagebrush establishment and survival. Data from sagebrush seedling counts, seeded plant biomass, total biomass, and grass seedling density were collected in 2000. Sagebrush seedling counts showed a significant increase in June 2000 compared to October 1999 for the 2 and 4 kg PLS/ha seeding rate, again demonstrating the importance of seed viability longevity. Sagebrush seedling density did not show a significant response to grass competition; however, sagebrush seedling density was reduced by over 50% at the grass seeding rate of 14 kg PLS/ha. Grass density and grass aboveground biomass showed little difference for the grass seeding rates of 4-10 kg PLS/ha (in almost all cases not significant). Therefore, since the grass community density and production response was not different among these seeding rates we are recommending that the more typical grass seeding rate of 12-16 kg PLS/ha be reduced to 8 kg PLS/ha to limit the competition for sagebrush or other shrubs that have been shown to be affected by grass competition during early stages of growth and

establishment. We believe that greater effects of the grass competition would have occurred in 1999 and 2000 had those years been more normal as far as precipitation and that sagebrush survival will be affected in future years by the grass. We will continue to assess the sagebrush density and we also plan to assess sagebrush plant size and cover as affected by grass competition in 2001.

2. Relationship between soil organic matter content and sustainable nutrient cycling in reclaimed soils (P.D. Stahl, G.E. Schuman, L.K. Spackman, and L. Ingram; Department of Renewable Resources, University of Wyoming, Laramie, WY, USDA, ARS, High Plains Grasslands Research Station, Cheyenne, WY, and Department of Environmental Quality, Land Quality Division, Cheyenne, WY).

Impacts of surface mining on the soil resource often include a reduction in soil organic matter (SOM) content as well as in microbial biomass and activity. Soil organic matter and soil microorganisms are critical components of the plant-soil system due to its role in nutrient cycling, plant nutrition and soil stability. Relationships between SOM levels, microbial biomass and activity, and nutrient cycling in mined lands is poorly understood but critical to ensuring and evaluating reclamation/revegetation success. This research was initiated in July 2000 to examine these relationships on mined lands of various age and various topsoil quality. Preliminary samples collected from four mine sites (two sites at each mine representing a “good” soil and one that was considered “not as good”). Analyses of these samples for total organic carbon, total nitrogen, inorganic carbon, microbial biomass C, and mineralization potential have demonstrated a fairly wide range of soil conditions/quality. These data generally reflect that the soils with lower total organic carbon also have lower nitrogen, mineralization potential, and microbial biomass C. These data will be used to select detailed sampling sites in 2001 to assess the original hypothesis and to relate these to plant community dynamics. We are hopeful that data from this research will enhance the ability of the mining industry and regulatory agencies to develop improved guidelines for topsoil salvage procedures and to assess potential “alternative plant growth media materials”.

3. Designs for Sagebrush Habitat on Wyoming Coal Mined Lands (D.T. Booth, S.H. Anderson; USDA-ARS, Cheyenne, WY, and Wyoming Cooperative Fish and Wildlife Res. Unit, Univ. Wyo.).

Four designed plantings of Wyoming big sagebrush are being compared at the Buckskin and Jacobs Ranch Mines in Wyoming’s Powder River Basin. The designs are (1) Standard Method (SM), in which the mine used their standard shrub establishment method for meeting the Wyoming shrub density requirement; (2) Standard Method + snow fence (SM+SF), which is the same as #1 except that temporary snow fences were erected on the seeded area; (3) Parallel-Belt Design, which consists of 3 belts of fabric mulch, spaced 160 ft (Buckskin) or 80 ft (Jacobs Ranch) apart, arranged perpendicular to prevailing winter winds, and planted with 2 rows of sagebrush; and (4) Underlined V -Design, which is similar to #3 except that 1 belt of fabric mulch is perpendicular to the wind with the other belts at 60 and 120 degrees to the first belt. The plots were seeded fall 1997 and big game exclosures were erected around 1 replication at each mine in 1998. All sagebrush seedings failed and the SM plots were re-seeded in March 1999. Seed spots in the fabric-mulch treatments were re-planted with 3,400 two and three-week-

old, greenhouse raised sagebrush seedlings produced in 0.5 x 5 inch "Booth Tubes" from Western Polyacrylamide, Inc. Installation of the tube transplants was accomplished in 7 hours (on-site planting time) by a 3-person crew. Failed tubes were replanted in April 2000. Overall transplant survival in Oct. 2000 ranged from 34.5 to 83.3% at Buckskin, and from 72 to 100% at Jacobs Ranch Mine. Survival averaged over both mines was 76%. Seedling heights averaged 42 and 92 mm at Buckskin and Jacobs Ranch Mines respectively at the end of the 1999 growing season. This year seedlings transplanted in April averaged 78 mm at Buckskin and 65 mm at Jacobs Ranch while seedlings finishing their second growing season averaged 253 and 258 mm at Buckskin and Jacobs Ranch Mines respectively. At the conclusion of the 3<sup>rd</sup> growing season we will begin collecting data on the plant communities downwind from each windbreak or row of sagebrush and during the 4<sup>th</sup> growing season we will begin collecting data on wildlife use within the designed plantings.

## PLANNED OR POTENTIAL PROJECTS

Long-term effects of variable topsoil depths on plant community response and soil biological, physical, and chemical characteristics (G.E. Schuman and R.A. Olson; USDA, ARS, High Plains Grasslands Research Station, Cheyenne, WY and Department of Renewable Resources, University of Wyoming, Laramie, WY).

This research would assess, after 24 years, the effects of variable topsoil depths on plant community development, soil biological parameters, soil organic carbon, and water infiltration and storage. Plots established in 1977 to assess the effect of topsoil depth replacement on mined land plant productivity will be utilized to study the long-term effects of variable topsoil replacement. This site was seeded to a mixture of grasses and shrubs in 1977 and plant production was evaluated for 4 years at 0, 20, 40 and 60 cm of topsoil. Much interest over the years has been focused on the fact that different plant types (shrubs, sub-shrubs, forbs, and grass) require or desire differing amounts of topsoil. Therefore, this study would enable a much better understanding of the role topsoil (or lack of it) might play in the plant community that develops on mined lands and how the microbial, physical and chemical characteristics of the soil might influence or be influenced by the plant community.

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# WYOMING

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## INTRODUCTION

This report summarizes revegetation and stabilization of disturbed land research activities conducted during 2000 and emphasizes activities of Department of Renewable Resource's personnel at the University of Wyoming. The projects listed below were funded by federal, state and private industry, including the Abandoned Coal Mine Land Research Program (ACMLRP) and 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 the Interior.

## COMPLETED PROJECTS

1. New Strategies for Establishment of Wyoming Big Sagebrush in Wyoming (R.J. Baldwin, B.L. Perryman and P.D. Stahl; Department of Renewable Resources, University of Wyoming and University of Nevada - Reno).

In northeast Wyoming, consistent shrub establishment on surface mine reclamation sites has been episodic depending on various factors including timing and amounts of precipitation. Soil environmental conditions can be enhanced to promote microsites that improve sagebrush establishment. Reducing competition and planting vegetation to trap snow should increase water availability to sagebrush seedlings. Stockpiling soils (at this site for twenty years) greatly reduces soil aggregation, nutrients and microorganisms including arbuscular mycorrhizal fungi. Without microbial interactions, sagebrush seedlings may succumb to desiccation due to drought, wind and intense solar radiation. This project was conducted at the Ash Creek Coal Mine in northeast Wyoming. Study objectives were to test alternative shrub establishment methods for improving success of shrub plantings by determining the influence on establishment and survival of seeded *Artemisia tridentata* ssp. *wyomingensis* of: 1) Companion cropping with sunflower, which should enhance soil water availability by trapping snow and shading the soil surface; 2) co-seeding warm season (C4) grasses, cool season (C3) grasses, and no grasses to determine their effects on soil moisture; and 3) native microbial soil inoculation including mycorrhizal fungi. No treatment differences on sagebrush establishment or survival were noted with the grass seeding or sunflower treatments. Microbial inoculation increased sagebrush density from 3.0 ( $\pm 0.3$ ) m<sup>-2</sup> (non-inoculated) to 5.0 ( $\pm 0.3$ ) m<sup>-2</sup> (inoculated). Soils of inoculated plots had greater amounts microbial biomass than non-inoculated plots, 0.158 vs. 0.137 mg microbial biomass carbon g<sup>-1</sup> soil, respectively. The co-seeded sunflower treatment also had significantly greater soil microbial biomass content. Enhanced microbial communities aid in redevelopment

of perturbed soils by increasing soil aggregation and promoting soil organic matter formation. This study suggests that initial establishment of sagebrush seedlings can be improved by inoculating replaced long term stockpiled topsoils with native microorganisms prior to seeding.

2. Utilization of land evaluation and site assessment techniques and geographical information systems applications for developing management plans (G.F. Vance, B.M. Christensen, L.C. Munn; Department of Renewable Resources, University of Wyoming).

Land-use conversion has resulted in a reduction of rangelands and field crop agriculture areas with the development of subdivisions, recreational sites, and other purposes. Areas that were once considered prime farmland and/or lands of local and state-wide importance are now becoming prized sites for homesteads and vacation areas. This study evaluated the use of Land Evaluation Site Assessment (LESA) combined with a Geographic Information System (GIS) to assist land-use planners in making decisions regarding the conversion of lands. LESA is a systematic evaluation technique developed by the USDA-NRCS to evaluate productivity of agricultural land and its suitability for conversion to non-agricultural use. Areas targeted are those with potential strong development pressure in northwestern Wyoming. Factors used to produce land evaluation scores included land capability classification, soil productivity, and soil potential. A GIS-derived soils map and official soil series descriptions provided necessary information for the land evaluation component of this research. Site assessment included distance from city limits, major roads, and the municipal water supply. Maps showing land most suitable for agricultural purposes within the study area were developed. The results of this study will provide preliminary information for applying LESA to land-use planning within northwestern Wyoming utilizing GIS.

3. Determination of Contribution to Cumulative Groundwater Impacts from Coalbed Methane Development and Surface Coal Mining (L. Borgman, J. Kerr, K. Peacock, M. Brogan, J. Meyer, T. Dobson and R. Shafer, Department of Geology and Geophysics, Spatial Data and Visualization Center, University of Wyoming).

The objectives for this project were to: 1) investigate the existence of anisotropy of hydraulic conductivity in the coal aquifer for the purpose of evaluating modeling methods used by Peacock and Kern (1995), and to verify the presence or absence of inter-aquifer communication at these test sites, 2) develop methods to differentiate groundwater changes due to surface coal mining activities from those associated with non-mining related aquifer stresses, and 3) acquire and assess all available data from Permit to Mine Applications using all available means for the four active mines nearest the Marquiss CBM development. Results from this completed study include: 1) an additional large scale pump test with inner and outer rings of observation wells, 2) finalization of a regional scale geological model for the coal aquifer in the Powder River Basin based on 1996 well logs, 3) development of a regional conceptual hydrogeologic model for the Powder River Basin between Gillette and Wright, Wyoming, 4) setup and application of MODFLOWP to investigate model sensitivity and calibration in steady state, and 5) publication of new statistical techniques for testing the null hypothesis of isotropy versus anisotropy and methods to estimate confidence intervals for axes of anisotropy.

## ONGOING PROJECTS

1. Relationship between soil organic matter content and sustainable nutrient cycling in reclaimed soils (P.D. Stahl, G.E. Schuman, L.K. Spackman and L. Ingram; Department of Renewable Resources, University of Wyoming, USDA, ARS, High Plains Grasslands Research Station, Cheyenne, WY, and Wyoming Department of Environmental Quality-Land Quality Division).

Impacts of surface mining on the soil resource often include a reduction in soil organic matter (SOM) content as well as in microbial biomass and activity. Soil organic matter and soil microorganisms are critical components of the plant-soil system due to its role in nutrient cycling, plant nutrition and soil stability. Relationships between SOM levels, microbial biomass and activity, and nutrient cycling in mined lands is poorly understood but critical to ensuring and evaluating reclamation/revegetation success. This research was initiated in July 2000 to examine these relationships on mined lands of various age and various topsoil quality. Preliminary samples collected from four mine sites (two sites at each mine representing a “good” soil and one that was considered “not as good”). Analyses of these samples for total organic carbon, total nitrogen, inorganic carbon, microbial biomass C, and mineralization potential have demonstrated a fairly wide range of soil conditions/quality. These data generally reflect that the soils with lower total organic carbon also have lower nitrogen, mineralization potential, and microbial biomass C. These data will be used to select detailed sampling sites in 2001 to assess the original hypothesis and to relate these to plant community dynamics. We are hopeful that data from this research will enhance the ability of the mining industry and regulatory agencies to develop improved guidelines for topsoil salvage procedures and to assess potential “Alternative plant growth media materials.”

2. Strontium isotopic characterization of coal and sandstone aquifers, Powder River Basin, Wyoming (C.D. Frost, K.M. Ogle, R.M. Lyman and E.L. Heffern; Department of Geology and Geophysics, University of Wyoming, U.S. Geological Survey, Cheyenne, WY).

This project was funded in early 2000 and has resulted in the following. Ground water samples obtained from USGS-WRD, BLM and the Wyoming State Engineer’s Office have been geochemically and isotopically analyzed, with an additional 50 samples from coal aquifers provided by the USGS Geological Division in Denver for future analysis. Developed a collaborative project with the Jacob’s Ranch surface coal mine that will include aquifer water samples, and rock samples from underburden, coal, overburden, spoil and clinker for rock leachate experiments. A regional study of coal and sandstone aquifers in the Powder River Basin has been developed in conjunction with Barrett Resources, Pennaco Energy, and J.M. Huber Corporation, as well as with BLM and their monitoring wells. Finding to-date suggest that the Wyodak-Anderson coal zone groundwaters have a Sr isotopic composition that is distinct from adjacent sandstone aquifer groundwaters, and is also different from lower coal zone aquifer groundwaters. The Sr isotopic ratio can distinguish aquifers that are indistinguishable in terms of major ion chemistry and stable isotopic compositions. It appears that most of the water samples are derived from isolated aquifers, suggesting that coal bed methane production has not impacted adjacent sandstone aquifers. However, in several instances, intermediate Sr isotope ratios of groundwaters indicate aquifer interactions. In one case this is related to well construction, and in



others it appears the water from an overlying unconfined sandstone aquifer is entering a production coal seam.

3. Research and development of a GIS-based data management and model integration tool for coal mine permitting and reclamation in Wyoming (T.W. Kohley, R.C. Warner, J.D. Hamerlinck, P.J. Schwab, G.E. Jones and L.E. Vicklund; Beartooth Mapping, Inc., Surface Mining Institute, Spatial Data and Visualization Center (SDVC), University of Wyoming, Civil Software Design, Powder River Coal Company, and RAG Coal West, Inc., WY).

The primary objective of this research is to develop a geographic information system-based software application for the management, analysis and reporting of data associated with major components of the permit and bond release processes for coal mining in Wyoming. The study builds upon work recently completed by the University of Wyoming's SDVC that dealt with developing methods for the GIS-based integration of selected surface and ground water models supporting PHC/CHIA-based hydrologic impact assessments. The study focuses on enhancing the application of GIS technology in the hydrologic modeling arena, as well as an expansion of its use to address soils, revegetation, and wildlife management needs in coal mine permitting and reclamation. The study will culminate in delivery of a Reclamation Management Tool (RMT) GIS software application containing components for management, analysis, and/or modeling of hydrology, soils, vegetation, and wildlife data. The completed application will integrate the four components into a comprehensive reclamation "tracking" application with data conversion, management, and report generation functionality. Nine primary tasks have been outlined and include: TASK 1 - Consultation with RMT Advisory Group; TASK 2 - Baseline Module Development; TASK 3 - Hydrologic Module Development; TASK 4 - Soils Module Development; TASK 5 - Vegetation Module Development; TASK 6 - Wildlife Module Development; TASK 7 - Integration Application Development; TASK 8 - Technology Transfer; and TASK 9 - Report Generation. Several of the tasks have been initiated and are in the process of being integrated into the RMT.

4. Grass competition and sagebrush seeding rates: Influence on sagebrush seedling establishment (G.E. Schuman, M.I. Fortier and A.L. Hild; USDA, ARS, High Plains Grasslands Research Station, Cheyenne, WY and Department of Renewable Resources, University of Wyoming).

This study is examining the effects of grass competition and sagebrush seeding rate on establishment of Wyoming big sagebrush seedlings at the Belle Ayr Mine near Gillette, WY. Experimental plots seeded at three big sagebrush rates (1, 2, and 4 kg PLS/ha) and seven grass seeding rates (0, 2, 4, 6, 8, 10 and 14 kg PLS/ha) were used to assess the effects of sagebrush grass seeding rate and grass competition on sagebrush establishment and survival. Data from sagebrush seedling counts, seeded plant biomass, total biomass, and grass seedling density were collected in 2000. Sagebrush seedling counts showed a significant increase in June 2000 compared to October 1999 for the 2 and 4 kg PLS/ha seeding rate, again demonstrating the importance of seed viability longevity. Sagebrush seedling density did not show a significant response to grass competition; however, sagebrush seedling density was reduced by over 50% at the grass seeding rate of 14 kg PLS/ha. Grass density and grass aboveground biomass showed little difference for the grass seeding rates of 4-10 kg PLS/ha (in almost all cases not significant).

Therefore, since the grass community density and production response was not different among these seeding rates we are recommending that the more typical grass seeding rate of 12-16 kg PLS/ha be reduced to 8 kg PLS/ha to limit the competition for sagebrush or other shrubs that have been shown to be affected by grass competition during early stages of growth and establishment. We believe that greater effects of the grass competition would have occurred in 1999 and 2000 had those years been more normal as far as precipitation and that sagebrush survival will be affected in future years by the grass. We will continue to assess the sagebrush density and we also plan to assess sagebrush plant size and cover as affected by grass competition in 2001.

5. The Effects of Varying Topsoil Replacement Depth on Various Plant Parameters Within Reclaimed Areas (B.K. Schladweiler, L.C. Munn, R. Haroian, S. Belden and G.F. Vance; BKS Environmental Associates, Inc., Gillette, WY, Department of Renewable Resources, University of Wyoming, Powder River Coal Company, NA/RC Complex, Gillette, WY).

This project has been divided into five major tasks: 1) review existing vegetation/soil information from the WDEQ-LQD and obtain permission from the WDEQ-LQD to conduct the proposed variable topsoil study on Rochelle Mine; 2) establish and construct the study site at the Rochelle Coal Mine; 3) obtain quantitative field data of three treatments on reclaimed areas and the corresponding reference areas; 4) summarize findings from the field sampling in No. "III" and provide annual/final recommendations; and 5) disseminate that information to interested parties. Initial reference areas were established in Breaks Grassland and Upland Grassland areas within the North Antelope/Rochelle Mine Complex. Three contiguous blocks within each reference area "replicate" that ran perpendicular to the slope, i.e., "top of the slope" (15 cm reclaimed area treatment), "middle of the slope" (30 cm reclaimed area treatment), and "bottom of the slope" (55 cm reclaimed area treatment). Five random 30 meter cover intercept transects were sampled within each treatment replicate. Quantitative sampling was conducted during late July and early August 2000 following WDEQ-LQD, Rules and Regulations, Appendix A methodology (Revised May, 1998) or WDEQ Guideline 14. Cover sampling was conducted within the line transects, with sample hits read at 1 meter intervals along the entire transect. Soil samples were collected at the beginning of each cover transect which was a previously selected random point. Samples were collected at maximum 15 cm increments to the interface between topsoil and backfill. At that point, an additional 15 cm of backfill was collected. All soils will be analyzed for pH and EC, with SAR also analyzed on 25% of the samples. Results of this study will be present next year.

6. Microbial Community Structure in Surface Mine Reclamation Soils (Peter D. Stahl and Daniel L. Mummey, Department of Renewable Resources, University of Wyoming).

We are currently examining microbial communities and physicochemical characteristics of soils at surface mine reclamation sites and adjacent undisturbed areas. Our objectives are to determine how microbial community structure is influenced by and recovers from disturbance. As part of this work we are also examining roles of individual microbial species and groups. We are currently characterizing soil microbial communities using DNA and phospholipid fatty acids extracted directly from soils of the study sites. A number of nucleic acid based molecular methods are being employed in these studies including terminal restriction fragment length

polymorphism (T-RFLP) analysis and techniques based on sequence divergence of small subunit ribosomal RNA, or encoding genes. In addition, we are developing and adapting methods for profiling soil microbial communities and for quantification of individual species or closely related organisms. Results from this work will increase understanding of soil microbial community structure in semiarid rangelands, their response to ecosystem disturbance, and reclamation practices.

7. Designs for Sagebrush Habitat on Wyoming Coal Mined Lands (D.T. Booth and S.H. Anderson; USDA-ARS, Cheyenne, WY, and Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming).

Four designed plantings of Wyoming big sagebrush are being compared at the Buckskin and Jacobs Ranch Mines in Wyoming's Powder River Basin. The designs are (1) Standard Method (SM), in which the mine used their standard shrub establishment method for meeting the Wyoming shrub density requirement; (2) Standard Method + snow fence (SM+SF), which is the same as #1 except that temporary snow fences were erected on the seeded area; (3) Parallel-Belt Design, which consists of 3 belts of fabric mulch, spaced 160 ft (Buckskin) or 80 ft (Jacobs Ranch) apart, arranged perpendicular to prevailing winter winds, and planted with 2 rows of sagebrush; and (4) Underlined V-Design, which is similar to #3 except that 1 belt of fabric mulch is perpendicular to the wind with the other belts at 60 and 120 degrees to the first belt. The plots were seeded fall 1997 and big game exclosures were erected around 1 replication at each mine in 1998. All sagebrush seedlings failed and the SM plots were re-seeded in March 1999. Seed spots in the fabric-mulch treatments were re-planted with 3,400 two and three-week-old, greenhouse raised sagebrush seedlings produced in 0.5 x 5 inch "Booth Tubes" from Western Polyacrylamide, Inc. Installation of the tube transplants was accomplished in 7 hours (on-site planting time) by a 3-person crew. Failed tubes were replanted in April 2000. Overall transplant survival in Oct. 2000 ranged from 34.5 to 83.3% at Buckskin, and from 72 to 100% at Jacobs Ranch Mine. Survival averaged over both mines was 76%. Seedling heights averaged 42 and 92 mm at Buckskin and Jacobs Ranch Mines respectively at the end of the 1999 growing season. This year seedlings transplanted in April averaged 78 mm at Buckskin and 65 mm at Jacobs Ranch while seedlings finishing their second growing season averaged 253 and 258 mm at Buckskin and Jacobs Ranch Mines respectively. At the conclusion of the 3<sup>rd</sup> growing season we will begin collecting data on the plant communities downwind from each windbreak or row of sagebrush and during the 4<sup>th</sup> growing season we will begin collecting data on wildlife use within the designed plantings.

8. Ecological Assessment and Evaluation of Snowfence Areas and Snowfence Mitigations (J.D. Shirley, B.L. Perryman, P.D. Stahl and M.J. Henn, Department of Renewable Resources, University of Wyoming).

Soils and vegetation behind snowfences are subjected to different environmental conditions than those not buried beneath large snowdrifts. The objectives of this study are to determine if snowdrifts are affecting soil properties and to assess the efficacy of previous mitigation activities (seeding trials). Soil sampling is being conducted along transects perpendicular to snowfences to determine if there is a distance gradient of drift altered soil properties. The seeding trial assessment is organized as a randomized complete block design

with 13 monoculture grass species, 2 tillage treatments (till and no-till), and 2 snowdrift treatments (drift and non-drift). We will assess soil fertility, soil microbial biomass, and current vegetative cover and production from the previous seeding trial. This research will aid in determining the effects of large anthropomorphic snowdrifts may alter soil and vegetation behind snowfences. Information obtained will be used to develop a mitigation program for the approximately 210 ha of affected snowfence area in southcentral Wyoming.

9. Systems Approach to Smooth Brome Control in a Reclaimed Cool Season Grassland Community (M.D. Stacy, B.L. Perryman, P.D. Stahl, K.J. Reddy, M.A. Smith and D. Koch, Departments of Renewable Resources and Plant Sciences, University of Wyoming).

Smooth brome invasion of surface mine reclamation areas is now recognized as a problem requiring research to identify efficient and effective control methods that will not damage newly established cool season plant communities. Our study was conducted in north central Wyoming at the Ash Creek Coal Mine. Objectives of the project were to determine: 1) efficacy of burning, grazing and herbicide control measures on smooth brome, native grass and forb production; 2) treatment effects on soil moisture content; 3) treatment effects on arbuscular mycorrhiza formation and propagule density. To augment the reduced soil microbial community in disturbed reclamation soil, some treatments included inoculation with native microorganisms in relatively undisturbed soil. Preliminary results after one growing season indicate burning, grazing, and herbicide reduced smooth brome biomass by 73%, 85%, and 75%, respectively. Results also indicate the herbicide treatment retained the highest soil moisture content and untreated control plots had lowest soil moisture content. Data suggest burning, grazing and herbicide reduce smooth brome biomass production similarly.

## **PLANNED OR POTENTIAL PROJECTS**

1. Coalbed Methane Product Water: What is it, how does it impact our environment and how should it be controlled? G.F. Vance, G.V. Wilkerson, J.D. Hamerlinck, L.C. Munn, C.D. Frost, R. Zhang, J.H. Johnson, B.K. Schladweiler and M.D. Collins; Departments of Renewable Resources, Environmental Engineering and Geology/Geophysics, University of Wyoming, Spatial Data and Visualization Center (SDVC), BKS Environmental Consulting, Gillette, WY; NRCS, Gillette, WY).

Coalbed Methane (CBM) is a major economic resource and management issue in Wyoming. In the Powder River Basin (PRB), CBM development in 2000 has increased 10-fold over 1997 production rates, with the number of CBM production wells increasing from 270 to 2,500 during this 3 yr period. With approximately  $2.9 \times 10^{11}$  m<sup>3</sup> of recoverable CBM in the PRB, the number of CBM wells are expected to reach 70,000 over the next 20-30 years with an anticipated 35,000 CBM wells in place by 2010. CBM is extracted by removing water from coal seams, which is called CBM product water, that is diverted at the surface into drainage basins, impoundments or stream channels. A significant amount of CBM product water results from the extraction process and the quality of the product water is also highly variable. At a rate of 45 to 225 L min<sup>-1</sup> per well, a CBM well may produce up to 325,000 L of water per day for several years; average lifetime of a well is between 10 and 20 years. With 10,000 operating wells, an

estimated  $1.2 \times 10^9 \text{ m}^3$  (120,000 ha m) of water per year could be produced, which is 20% of the amount of irrigation water used in Nebraska. Problems associated with CBM discharge in the PRB include water and soil chemistry (i.e., salinity (high salts) and sodicity (sodium)), facilitated channel erosion and altered aquatic and terrestrial habitats.

We propose to address issues associated with CBM product water quality, aquifer identification, channel erosion and salinization/sodification of the landscape. The potential CBM-related hazards due to product water quality and quantity will be evaluated at a variety of spatial scales (e.g., discharge point, stream reach, watershed, river basin) using laboratory analyses, field studies and Geographic Information System (GIS) technology. Using geostatistics, a model of CBM product water quality for the PRB will be incorporated along with other data layers such as soils, vegetation, elevation, precipitation and landscape erodibility parameters in a CBM impact database. An analytical model will also be evaluated for predicting the erosion potential of channels in the PRB as a function of the quantity of CBM product water discharged. We will combine in-field data collection with remotely sensed imagery and related spatial technologies to establish baseline conditions and monitor the effects of CBM development and product water impacts. Additionally, a wide range of scientific visualization techniques will be developed for hazard characterization and cumulative surface and subsurface impact assessments.

2. Controls of carbon sequestration on Northern Rocky Mountain rangelands (J.M. Welker, G.F. Vance, P.D. Stahl and J.T. Fahnestock; Department of Renewable Resources, University of Wyoming).

The proposed research will address C sequestration in four rangeland ecosystems by investigating: 1) the influence of grazing on short- and long-term soil C sequestration patterns and soil C and N fluxes, including microbial biomass production, N mineralization, soil organic matter (SOM) traits (labile vs. recalcitrant soil C), and 2) the temporal coupling of soil N processes, such as N mineralization, with net CO<sub>2</sub> exchange and long-term soil C storage. We will compare C and N processes in grazed and long-term ungrazed (fenced) areas in four dominant ecosystems (alpine grassland, forest meadow, sagebrush shrubland, mixed grass prairie), representing over 50% of the grazed land in the western U.S. The fenced areas have been in place for at least 20 years at all sites and we have conducted some initial C exchange studies at some of the sites that form the basis of our questions and protocol. Our studies will involve extensive comparisons of the SOM chemistry between grazed and ungrazed areas, and will include assessing soil humic fractions, low-molecular-mass oxidation products, and microbial biomass throughout the seasons of the year. In addition, we will quantify the magnitude of net CO<sub>2</sub> exchange in summer and winter and the net effect on plant, soil and atmospheric C pools and ultimately C sequestration patterns.

3. Long-term effects of variable topsoil depths on plant community response and soil biological, physical, and chemical characteristics (G.E. Schuman and R.A. Olson; USDA, ARS, High Plains Grasslands Research Station, Cheyenne, WY and Department of Renewable Resources, University of Wyoming).

This research would assess, after 24 years, the effects of variable topsoil depths on plant community development, soil biological parameters, soil organic carbon, and water infiltration

and storage. Plots established in 1977 to assess the effect of topsoil depth replacement on mined land plant productivity will be utilized to study the long-term effects of variable topsoil replacement. This site was seeded to a mixture of grasses and shrubs in 1977 and plant production was evaluated for 4 years at 0, 20, 40 and 60 cm of topsoil. Much interest over the years has been focused on the fact that different plant types (shrubs, sub-shrubs, forbs, and grass) require or desire differing amounts of topsoil. Therefore, this study would enable a much better understanding of the role topsoil (or lack of it) might play in the plant community that develops on mined lands and how the microbial, physical and chemical characteristics of the soil might influence or be influenced by the plant community.

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