Minutes WERA40 Meeting in Steamboat Springs, Colorado September 17-18, 2009

Present: Laurie Abbott (NM), Mike Borman (OR), Maria Fernandez-Gimenez (CO, chair), Clayton Marlow (MT), Mike Smith (WY), Eva Strand (ID, secretary)
Additional field trip participants: Emily Kachergis (Graduate Student), Kathy McKinstry (BLM), Hunter Seim (BLM)

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September 17
Morning session 8-10 am

Welcome by Maria Fernandez-Gimenez. Maria presented her team's current research 'Sagebrush Steppe State-and-Transition Model Based on Local Knowledge.' In this approach local land owners in the Elkhead watershed in Colorado are asked to describe vegetative states in their local landscape and perceived transitions between states. Emily Kachergis, Ph.D. student under Maria Fernandez-Gimenez presented her work on collecting vegetation and soil field data along with landowner interviews. The data is being analyzed using ordination techniques.

Field trip 10 am – 6 pm

The group departed for a field trip to the Elkhead watershed where Emily and Maria have conducted field sampling on public and private lands for development of state-and-transition models. Two major ecological sites were sampled, namely claypan and mountain loam sites. Claypan sites are broadly characterized by clay soils and alkali sagebrush while the mountain loam sites are characterized by soils with higher organic content and big sagebrush. We stopped at four sites where Emily described the ecological site, state, and discussed possible transitions:

1) Claypan. Alkali sage with diverse understory. No livestock grazing for ~10 years
2) Mountain loam. Mountain big sagebrush with a diverse understory. Low to moderate grazing history
3) Claypan. Alkali sage/bluegrass. Low/moderate grazing history
4) Claypan and mountain loam side by side. Eroding alkali sage on one site and dense mountain sage on the other side of the road.

Discussions and synopsis from the field trip is included later in the minutes (September 18).

Dinner 7-8:30 pm

Dinner and informal discussion with the WERA40 group

September 18
Morning session 8-12

The group suggested that agency representatives (e.g. ARS) should be invited to WERA40 meetings, realizing that there might be budget constraints. Agency representatives can also be invited to and engaged in the field tours.

STM symposium

The meeting continued with a discussion of the planned STM symposium at the Denver SRM meeting in February 2010. Pat Shaver has been invited to give a presentation at the symposium. The Southwest region is not well represented in the symposium, however Maria is willing to cover some southwest topics. The group agreed to invite Maria's Ph.D. student Emily Kachergis to submit an abstract for the SRM symposium. The day for the STM symposium has not yet been scheduled, but it will likely be Tuesday of the SRM meeting. Each speaker will be allocated 30-40 minutes, Maria will find out the exact time.

Symposium participants will be asked to submit proceedings of their presentation to Clayton Marlow. Montana Extension may be able to cover printing and online publication costs (.pdf format). If possible, authors should submit manuscripts by February.

The WERA40 group will write a synthesis paper to be published in Range Ecology and Management based on the symposium and submitted proceedings. This publication will be discussed by the authors at the SRM meeting in Denver. The WERA40 group will act as a review board for the synthesis article. A Wiki web site will be used to coordinate writing of the synthesis paper. Laurie and Clayton will set up this web site and invite the other authors.

Accomplishments and Impacts

- A symposium on the applications of state-and-transition models at the SRM 2010 is approved, speakers are invited and the meeting is being organized.
- Symposium abstracts have been submitted to SRM.
- We have secured support for publishing the proceedings from the SRM symposium from Montana State University Extension.
- A synthesis paper based on the symposium will be submitted to REM. We discussed how to cover the page charges if the paper is accepted, this will be determined later.

Synopsis of meeting discussions

- A more thorough and transparent inclusion of soil characteristics in STMs would be desirable.
- Better consistency in what goes into STMs is needed. What type of information needs to go into an STM (for ESDs), soil characteristics, rangeland health indicators, vegetation characteristics, etc.
- A state is assumed to be stable but some are not. For states that are undesirable and/or unstable and we need to better identify what conservation measures can be applied.
- STMs are dynamic and need to be updated as our knowledge evolves. STMs may become incorporated in agency regulatory policy. We need to develop guidelines for proper use of STMs to avoid inappropriate use. STMs are useful to better understand ecological processes and inform management but they are not prescriptive and are unsuitable for regulatory policy and management.
- We need to better identify how STMs can be used in education and outreach
- We need to better understand and define how STMs can be used at different scales and across landscapes incorporating several ecological sites

Afternoon session 1-4 pm

Laurie Abbott demonstrated how a wiki (PBWorks) can be used to collaborate in writing manuscripts online (http://pbworks.com). Using this tool, several authors can access the current version of the manuscript and make changes. Previous versions are saved in an archive online.

Maria called the business meeting and passed out the minutes from 2008. They were approved.

Next year

Clayton Marlow presented an invitation to meet collaboratively with the WERA65 meeting in 2010 in Bozeman, Montana. WERA65 works on intensively managed pastures. Intensively managed pastures could give relief to native rangelands when needed. We discussed where to take the field tour next year. It was decided to tour the Murphy Fire Complex in southern Idaho.

Eva Strand was voted to be chair for the meeting 2010. Clayton Marlow was selected secretary but may not be available to be chair in 2011.

The state reports (State reports are attached as Appendix A)

Montana Report

Department: Animal and Range sciences
Degree in Natural Resources and Rangeland Ecology. Two options 1) Rangeland Ecology and 2) Wildlife Habitat

Graduates 68 students per year, 100% increase. Offers 15 range courses with two faculty members. A new industry funded building is being built on the MSU campus with classrooms and new laboratories. The department is planning to move in within a year. A national search for a new department head has been approved. Only animal science faculty on the search committee.

Wyoming Report

Department: Renewable Resources
BS degree in Rangeland Ecology and Watershed Management. MS and PhD degrees in REWM, Entomology and Soils
89 undergraduates, 69 research grants $5.6 mil.
John Tanaka is the new department head as of August 2009. Twenty-three faculty in Renewable Resources. Five are at least marginally competent in range science. Nine APs of which three are permanent, one is an extension specialist. Four staff members (accountants and secretaries). Two new hires. Kristina Hufford in Restoration Ecology (25% outreach) is in place. The other person will be a Rangeland Systems Ecologist which has not been advertised yet.

Oregon Report

Department name: Rangeland Ecology and Management

New Dean Sunny Ramaswamy (entomology). Discussing merger between range department and animal science department. Potential new department name Animal Range Science. Five range faculty on campus in Corvallis. Two faculty in La Grande. Undergraduate 15 in Corvallis 65 in La Grande. Seven graduate students, low at the moment. Approved faculty position Arid Lands Plant Community position will be advertised when the hiring freeze is lifted.

Research themes: Animal behavior related to wolf reintroduction, Riparian livestock use GIS/GPS, Weed ecology and management, DNA process to study livestock diet

New Mexico Report

NMSU's range program currently has 46 undergraduate students majoring in Range Science, and 11 graduate students. The Range Science program is scheduled for the SRM re-accreditation review in November 2009. There are six teaching faculty in Range Science (Laurie Abbott, Kelly Allred, Derek Bailey, Andres Cibils, Sam Fernald, and Jerry Holechek). Kirk McDaniel retired in Spring 2009. Research priorities focus on: livestock-vegetation interactions, livestock distribution, livestock grazing systems, plant taxonomy, invasive species ecology and management, rangeland restoration, and watershed management. Current research projects include collaborations with other departments at NMSU, USDA Jornada Experimental Range, University of Arizona, Colorado State University, and international collaborative research in Jordan.

Idaho Report

Department: Rangeland Ecology and Management
Recent hires are Kelly Crane in extension and Beth Newingham in restoration ecology.
The range department does not fulfill the University of Idaho criteria for department size and size of graduate program. Most likely the range department will be merged with the Forest Resources Department; however the range curriculum and accredited program will remain as a subunit within this new department.
Research topics: Rangeland and fire ecology, rangeland and livestock management, grazing management, animal behavior, and weed management, restoration ecology, ecophysiology, landscape ecology and GIS, and remote sensing.

Colorado Report

Department of Forest, Rangeland and Watershed Resources
21 undergraduates, 40 graduate students. Constant change in Department Heads and Deans. Merger with Human Dimensions is being discussed with maintenance of degree programs. Natural Resources Ecology Laboratory is trying to become a new department.

Research, see attached state report from Colorado

Appendix A

Montana State University – Bozeman
2008-2009 Annual Report
Clayton B. Marlow, Animal and Range Sciences Department
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Education Program:

I. Current Conditions

A. Teaching Appointments
1. Marlow – 0.6 COA
2. Olson – 0.3 COA (serving as interim Department Head)
3. Sowell – 1.0 COA
4. Frisina – (split appointment from Montana Fish, Wildlife and Parks)
5. Adjuncts
   a) Bob Leinard
   b) Dr. Rachel Frost

B. Student Enrollment

Year	Range	NRM
2003	38	NA
2004	34	NA
2005	34	NA
2006	28	15
2007	13	38
2008	9	46
2009	14	54

C. Service Courses
1. ARNR 125 – Nature of Yellowstone (university-wide)
2. ARNR 236 – Small Pasture Management (Equine, Livestock Industry, Agricultural Education)

D. Courses for Majors
1. ARNR 101 – Natural Resource Conservation
2. ARNR 102 – Montana Range Plants
3. ARNR 235 – Range and Pasture Monitoring
4. ARNR 240 – Natural Resource Ecology

5. ARNR 325 – Wildlife and Livestock Range Nutrition
6. ARNR 345 – Riparian Ecology and Management
7. ARNR 350 – Vegetation of Western Wildlands
8. ARNR 351 – Biomes of Western Wildlands
9. ARNR 353 – Grazing Ecology
10. ARNR 354 – Fire Ecology and Management
11. ARNR 355 – Wildlife-Livestock Habitat Restoration
12. ARNR 426 – Topics in Wildlife – Livestock Habitat
13. ARNR 438 – Wildlife Habitat Ecology
14. ARNR 453 – Habitat Inventory and Analysis
15. ARNR 541 – Range Ecophysiology
16. ARNR 543 – Riparian Processes and Function
17. ARNR 544 – Advanced Grazing Management and Ecology

II. Anticipated Changes

In August 2008, work began on a $16 million, 40,000 square-foot Animal Bioscience building, a building that will offer animal science and natural resources/rangeland ecology students state-of-the-art classrooms and laboratories for instruction and research. It is one of few buildings on the MSU campus that houses a single department. The building is scheduled to be completed in June 2010, time for the class of 2014 to move in with us. Almost 50% of the funding for the building has been from private contributions, large and small. The plan is for this building to be part of an Animal Biosciences Complex, which will include a $24 million USDA ARS Research Building, about 50 m to the west of our MSU Animal Biosciences Building. The USDA building will focus on beef cattle genomics and proteomics with five-seven federal scientists and their support staff.

Historically, the Animal and Range Sciences Department has had separate beef cattle, sheep, and more recently, an equine advisory committee. In November 2007, I formed a departmental advisory committee, including prominent members in the state representing those different species, plus 3-4 members representing range, wildlife and natural resources. We meet every 6 months to educate and update the committee, and for the committee to provide advice and support to the department.

Thirty-four B.S. students were enrolled in the Range Science program in the fall of 2002. A year or so later we modernized the names of many of our undergraduate courses, e.g. “Range Measurements” became “Habitat Inventory and Analysis”. Effective Fall Semester 2006, we changed our undergraduate degree name from “Range Science” to “Natural Resources and Rangeland Ecology” (NRRE). Under this new degree title, we created two options “Rangeland Ecology and Management” and “Wildlife Habitat Ecology and Management”. To support the latter option, we added three courses to the curriculum: “Topics in Wildlife-Livestock Habitat”,

"Wildlife-Livestock Nutrition", and "Wildlife-Livestock Habitat Restoration". We have a few B.S. students who are finishing their Range Science program. Combining these students with students studying under the new degree title, we have 68 students enrolled in the program this fall, a 100% increase since 2002. Overall, the number of majors in the Animal and Range Sciences Department has grown slightly the last five years, primarily reflecting the increase in NRRE students, and "Equine Science" option students in our B.S. in Animal Science program.

I have served as interim head of the department for over three years. This is not a record at MSU. This fall, there will be a national search to hire a permanent department head. In the last few years, several faculty vacancies have been created in the department, mostly via retirements with one resignation. Those that have left represented the following discipline areas: extension natural resources specialist, beef cattle nutrition-reproduction, shrubland ecology, beef cattle systems, breeding and genetics, extension swine specialist, and extension equine specialist. Because of budget constraints in extension, the extension specialist positions will not be advertised for the next two years. We had an unsuccessful search for a "beef cattle metabolic physiologist" last spring, which would have replaced the beef cattle nutrition-reproduction position. Presumably, the other research-teaching positions are "on hold" pending the successful hire of a permanent department head.

To better inform our clientele about activities and accomplishments of faculty and staff in the department, we created our first on-line, quarterly newsletter in October 2008. The most recent newsletter is at http://animalrange.montana.edu/documents/July2009.pdf. Previous newsletters can be accessed at our home page http://animalrange.montana.edu/.

Bret E. Olson
Interim Head, Animal and Range Sciences Department

Research Efforts

Marlow – Impact of Irrigation Cessation on Wetland Communities in Grand Teton National Park; University of Wyoming/National Park Service Consortium

Using Camelina Waste to Construct Pelleted Seed for Wildfire Rehabilitation; Montana Department of Transportation.

Teaching: Developed a week long field course on wildlife/livestock habitat improvement. Course takes place on a private ranch in north central Montana. Students have opportunity to evaluate earlier improvement projects, develop new projects to promote ranch goals and make recommendations to operator. 2009 was second offering; four students in 2008; nine in 2009.

Sowell - Wildlife habitat studies which focus on plant-animal interactions near Yellowstone National Park and eastern Montana

- Sagebrush/sage-grouse
- Aspen-beaver
- Aspen-willow-elk-wolves
- Willow-beaver reintroduction
- Crested wheatgrass renovation for wildlife

Teaching:

Changed introductory class on range principles to a global view of natural resource conservation using films to introduce global topics.

Teaching a nutrition class which emphasizes the energy and protein requirements of free ranging wild ruminants.

Oversight of new degree offering - Natural Resources and Rangeland Ecology; Rangeland Ecology and Wildlife Habitat Options.

Still teach freshmen 60 common range plans in Montana.

Olson – serving as interim department chair until new hire is completed

University of Wyoming
Renewable Resources – 2009 Summary of Activities

The Department of Renewable Resources currently has 89 undergraduate majors and 20 minors and 38 graduate students. The Range Club has actively participated in the Society for Range Management at the state and international levels. Sarah Hanlon won the international Undergraduate Range Management Exam competition and the team placed fifth. Guinevere Jones was selected as the Gamma Sigma Delta Outstanding MS student.

Our faculty has 69 active grants bringing in over $5.6 million to support our research, graduate students, and employ undergraduates. They also participate on grants through the School of Energy Resources, Program in Environment and Natural Resources, Wyoming GIS Center, Wyoming Reclamation and Restoration Center, and others. Projects cover diverse areas of rangeland ecology and watershed management, soil science, and entomology including those focused on sage-grouse habitat, invasive and native plant species, remote sensing, insect pests and ecology, reclamation of gas wells, water quality monitoring, soil moisture, groundwater management, clean coal technology, and carbon sequestration and other climate change issues.

We are providing Extension programs are aimed at Wyoming landowners, agency personnel, and also develop materials distributed via the internet. Programs include the insect identification clinic, poisonous plants, plant identification, reclamation and restoration, rangeland monitoring, grazing allotment assessments, grazing management practices, sustainable livestock systems, small acreage land management, soil science, and the UW Insect Museum.

Christina Hufford will be joining our faculty in April 2010 in restoration ecology. We have begun a search for a rangeland systems ecologist. Peter Stahl was appointed as the Director of the Wyoming Reclamation and Restoration Center as Steve Williams returned to his faculty position. John Tanaka joined the faculty in August as the new department head.

Department of Rangeland Ecology and Management
Oregon State University

The Agricultural Experiment Station at Oregon State University has been represented by Dr. Tamzen Stringham in recent years. Dr. Stringham has moved on to the University of Nevada – Reno. We have approval to fill a new tenure-track faculty position of Plant Community Ecologist after OSU's hiring freeze has been lifted. Until then progress on addressing 'State-and-Transition' issues in arid/semi-arid rangeland systems will be minimal. Once this position has been filled, we anticipate additional efforts within Oregon on 'State-and-Transition' issues in the arid and semi-arid systems in Oregon and in collaboration with surrounding western states.

The College of Agricultural Sciences and the OSU Agricultural Experiment Station have a new Dean and Director. Dr. Sonny Ramaswamy began officially on August 1, 2009. Dr. Ramaswamy joined us from his position as Director of the Agricultural Research Station at Purdue University.

The Departments of Animal Sciences and Rangeland Ecology and Management are pursuing planning for merging the two departments. OSU has begun planning for reorganization to reduce numbers of and increase size of academic units. Based on numbers proposed by the Provost, the Department of Rangeland Ecology and Management has too few graduates, majors, and faculty to satisfy proposed minimums. The College of Agricultural Sciences has too many departments and units to satisfy the proposed maximum number of departments/units within a College. Discussions with the Department of Animal Sciences and with the College of Agricultural Sciences Deans have focused on maintaining a Range program within a merged department. Timing of the merger is not yet determined.

The College of Agricultural Sciences has had an OSU Agriculture undergraduate program, including Rangeland Ecology and Management, at Eastern Oregon University in La Grande, OR.

In the Department of Rangeland Ecology & Management, we currently have the following faculty and student numbers:

Tenured/tenure-track faculty: five in Corvallis, two in La Grande
Undergraduate range majors: approximately 15 in Corvallis, 65+ in La Grande
Graduate students: seven in Corvallis

Our current research projects focus on:

1) Animal behavior with a focus on livestock behavior and production responses to wolf activity as wolves migrate into eastern Oregon from neighboring Idaho, and livestock temporal and spatial use of riparian areas.
2) Weed (invasive species) ecology and management.
3) Developing methods to more efficiently and accurately determine diets based on plant DNA analysis.
4) Arid plant physiology in the context of restoration/reclamation of disturbed sites.

Respectfully submitted:

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Colorado State University
September 2009
Rangeland Ecology Degree Program, Department of Forest, Rangeland and Watershed Stewardship

Fall 2009 Undergraduate enrollment is approximately 21 majors and 9 minors.

There are over 40 MS and PhD students in Rangeland Ecology, and many students in the Graduate Degree Program in Ecology advised by Range Ecology faculty.

Range Ecology faculty at CSU are: Dennis Child, Maria Fernandez-Gimenez, Julia Klein, Mark Paschke, Paul Meiman and Roy Roath. In addition, many senior scientists at the Natural Resources Ecology Laboratory work in rangeland systems and our RE faculty collaborate with faculty in Soil and Crop Sciences, Bioagricultural and Pest Sciences and Biology, among other departments.

CSU's Undergraduate Range Management Exam team has placed in the top five teams three of the past five years.

Colorado Agricultural Experiment Station Projects in Rangeland Resources

PIs: Brown, CS

Title: Impacts and Mechanisms of Plant Invasions: Insights from Bromus tectorum

Objectives: My invasive species and restoration ecology research program includes three primary goals: A. Goal 1: Increase our knowledge of how invasive plants and management of invasions affect native plants and animals and the functioning of ecosystems. Objective 1. Measure effects of fire and IPM practices (imazapic application, seeding of native herbaceous species, and simulated grazing) on Bromus and C and N cycling. B. Goal 2: Evaluate biotic and abiotic mechanisms responsible for the establishment of invasive plants to provide the basis for sound, long-term integrated management of invasive species. Objective 2. Evaluate propagule pressure, local adaptation to high elevation, and environmental change as mechanisms underlying increases in Bromus at high elevation. Objective 3. Study the role transgenerational plasticity (maternal effects) may play in Bromus invasions.

PIs**:** Brummer, JE

Title: Management of Forages in Colorado for Improved Yield and Quality

Objectives: 1.) Evaluate yield and quality of forage species and/or cultivars potentially adapted to Colorado's varied environmental conditions and unique management needs. 2.) Evaluate various management practices for improving forage yield and quality. 3.) Evaluate techniques for interseeding grasses and legumes into existing stands of perennial forages to improve yield, forage quality, and/or extend stand life.

PIs: Paschke, MW ; Binkley, D ; Rhoades, C ; Dawson, JO ; Hahn, D

Title: Actinorhizal Shrubs in Forests and Rangelands of Colorado

Objectives: The objective of this study is to provide unique and crucial information regarding the basic ecology of actinorhizal shrubs in forest and rangeland habitats in Colorado. Specifically, we will provide the first estimates of the contributions of biologically-fixed nitrogen by actinorhizal shrubs to a variety of forest and rangeland habitats in Colorado. Despite the ecological importance of the actinorhizal symbiosis in Colorado forests and rangelands, there is a paucity of research on the actinorhizal shrub species characteristic of the Interior West. The purpose of our research is to provide a baseline understanding of actinorhizal symbioses in a variety of managed ecosystems of Colorado. This research represents the first attempt to broadly determine rates of N2-fixation for these keystone shrubs. The knowledge derived from this work will allow for better management and restoration of these ecosystems, which would result in improved forest and rangeland health. For example, knowledge of the basic mechanics of nitrogen cycling in these

systems will allow managers to make informed decisions regarding promoting or removing actinorhizal shrubs in order to alter successional trajectories of plant communities. Information that we obtain regarding N fixation by various Frankia strains might allow managers to inoculate sites or planted shrubs with appropriate Frankia strains. Additionally, information regarding differences in N2-fixation rates between various species, or the same species in various habitats would allow for better management of livestock grazing and the wildlife resources that are a vital part of Colorado's ecosystems and economy. The knowledge derived from these studies will be transferred to managers and scientists in the form of peer-reviewed publications and presentations at scientific meetings. Additionally, personnel in the Colorado Forest Restoration Institute that are associated with this project will be able to disseminate information to forest managers via the Institutes regular activities. Where appropriate, we will disseminate our finding via Colorado AES publications, such as Technical Bulletins or Technical Reports in order to reach land managers more directly. The project would result in the training of one graduate student (MS), one post-doc, and numerous undergraduate students.

PIs: Beck, KG

Title: Ecology, Biology, and Management of Invasive Weeds in Colorado

Objectives: Yellow toadflax sub-project: a. Determine the genetic variability within and among yellow toadflax populations from five Colorado locations (Field sampling by Dr. George Beck; laboratory genetic determination by Dr. Sarah Ward, Dept. of Soil and Crop Sciences, CSU); b. Determine whether there is an association between genetic variability and susceptibility to management with herbicides or whether the previously observed variable susceptibility is only environmentally oriented; c. Determine whether yellow toadflax displays a seasonal pattern of root bud development; d. Determine whether timing of application can overcome the varied response to herbicides previously observed and whether optimum timing is correlated to phenology of vegetative reproduction. Noxious weed seed burial sub-project: a. Determine the soil seed longevity of selected A-list and B-list Colorado designated noxious weed species; b. Determine the seed decay rate for selected A-list and B-list Colorado designated noxious weed species; c. Determine the response to accelerated aging for selected A-list and B-list Colorado designated noxious weed species; d. Determine whether insects play a role in seed loss from the soil bank for selected A-list and B-list Colorado designated noxious weed species.

PIs: Meiman, PJ ; Bright, AD ; Brummer, JE ; Cooper, DJ

Title: Interpretation of Hummocks Relative to the Condition of Riparian Areas and Wetlands

Objectives: The objectives of this project are to: 1) Characterize how natural resource

specialists and private and non-profit stakeholders in Colorado interpret the presence of hummocks in riparian and wetland systems and determine the basis for those interpretations. 2) Compile a historical review of hummocks (presence/absence, types and land use implications) in riparian areas and wetlands of the western U.S., based on information available in historical documents and photographs. 3) Identify and describe the edaphic, climatic, topographic and vegetative characteristics of riparian areas and wetlands that do, and do not support hummocks; and 4) Describe and compare key edaphic, microclimatic, hydrologic and vegetative characteristics of hummocks and interspaces, and interpret those characteristics relative to different theories of hummock formation (including differential freeze/thaw, domestic livestock grazing, erosion and differential litter accumulation). Expected Outcomes: The results of this project will be of significant interest to a wide variety of individuals and organizations engaged in natural resource conservation, research, education and land use management. The principal investigator has discussed the proposed project with a variety of natural resource specialists (State and Federal Agencies), scientists (academia and Federal Agencies) and Cooperative Extension Educators and Specialists. All have expressed considerable interest in the results of this project. The results of this project will be published in a M.S. thesis and peer reviewed journal articles. We anticipate that the results of this study will be incorporated into procedures used to assess the condition and function of wetlands and riparian ecosystems (land management agency publications, workshops and operating procedures) and educational efforts (courses taught by investigators, their colleagues and Cooperative Extension workshops). The results of this project are expected to affect natural resource conservation and land use management decision making processes on public and private land in Colorado and throughout the West.

PIs: Fernandez-Gimenez, ME ; Rocca, M ; Thompson, J

Title: Building Technical and Institutional Capacity for Collaborative Adaptive Management of Colorado Rangelands

Objectives: The goal of this project is to generate knowledge and develop practical tools that will increase landowner, agency and community capacities to manage Colorado rangelands using a collaborative adaptive management approach. Three interlinked research and capacity-building objectives support the project's broad goal. 1) Develop ecological state-and-transition (S-T) models as a practical technical tool to facilitate adaptive management. 2) Evaluate the ecological and social processes and outcomes of community-based collaborative resource management (CBCRM) in Colorado. 3) Use the knowledge and tools produced in objectives 1 and 2 to build community, agency, and stakeholder capacities for successful collaborative adaptive management. Expected outputs include S-T models for at least 3 ecological sites in NW Colorado, evaluation of the strengths and weaknesses of S-T models based on ecological data and local knowledge, guidelines for developing S-T models that integrate ecological data and local knowledge, research publications on S-T models and the social and ecological outcomes of CBNRM, and outreach materials and training workshops on S-T models and

collaborative adaptive management.

Other Related Research

Project Title: Linking Ecological and Economic State-and-Transition Models for Adaptive Management of Rangeland Ecosystems
PI: Maria Fernandez-Gimenez

Project Objectives: The goals of this integrated project are: 1) to develop an effective adaptive management decision-making tool by creating a linked ecological and economic state-and-transition model, and by quantifying ecosystem services associated with different vegetation states in the model, and 2) to promote adoption of S-T models by ranchers and other land managers as an adaptive management decision-making tool. Our goal will be accomplished through 5 research and outreach objectives: 1) identify states and transition s for key ecological sites within the sagebrush steppe biome of NW Colorado and quantify and value selected ecosystem services associated with each state. 2) Create and validate a linked ecological and economic S-T model. 3) Develop an innovated outreach program to help ranchers and land managers become familiar with S-T models and the feedback between ecosystem services and economic decisions. 4) Promote adoption of S-T models by ranchers and other land managers through a combination of participatory research, extension workshops, integration of curriculum units into existing Cooperative Extension and related short courses and workshops, and delivery through web media including Rangelands West website and eXtension. 5) Evaluate the effectiveness of the extension component by assessing changes in stakeholder knowledge, attitudes, management and monitoring practices, and their adoption of non-adoption of linked S-T models as decision making tools for adaptive management.

Project Title: Participatory Development of Ecological State-and-Transition Models: Integrating Scientific and Local Knowledge for Rangeland Sustainability (NRCS Conservation Incentive Grant)
PI: Maria Fernandez-Gimenez

Project Objectives:

1) Develop S-T models based on ecological field data and professional and local knowledge, using qualitative and quantitative analysis techniques.

2) Use a participatory stakeholder process to compare and evaluate the accuracy and utility of S-T models based on different knowledge sources and data analysis approaches, and to develop "best-fit" models that combine local knowledge and field data. 3) Promote adoption of S-T models through a) direct stakeholder participation in workshops to develop and evaluation S-T models, b) partnerships with local and state-wide organizations to integrate S-T models into existing producer and manager workshops, short-courses, and publications, c) incorporation of

S-T models into NRCS site descriptions, and d) publication of the S-T models and a handbook describing their development and use on the Colorado Rangelands and Rangelands West websites.

Project Title: Development of a Data-based Validation Network for State-and-Transition Models (CSREES)
Project Collaborator: Maria Fernandez-Gimenez (PIs David Briske and Ben Wu at Texas A&M)

Project Objectives: This project seeks to underpin the state-and-transition model framework, which represents the primary technology for rangeland assessment, with a network of long-term empirical data. Research objectives are to 1) explore new protocols to construct STMs that are based on empirical ecological data, 2) investigate the ecological validity of existing qualitative STMs by comparing them with data-based models, and 3) evaluate the decision rules and assumptions that various authors utilize to construct STMs.

PI: Paul Meiman
Project Title: Riparian Shrub Growth and Plant Metal Concentrations in Fluvial Mine Tailing Deposits

Fluvial mine tailing deposition has caused extensive riparian ecosystem damage throughout the West. Willows are often used for fluvial mine tailing revegetation but some species accumulate excessive metal concentrations. In a greenhouse experiment, Geyer willow (Salix geyeriana Andersson), Drummond's willow (Salix drummondiana Barratt ex Hook.), planeleaf willow (Salix planifolia Pursh.), Bebb willow (Salix bebbiana Sarg.), thinleaf alder [Alnus incana (L.) Moench spp. tenuifolia (Nutt.) Breitung], water birch (Betula occidentalis Hook.), red-osier dogwood (Cornus sericea L. spp. sericea), and shrubby cinquefoil [Dasiphora fruticosa (L.) Rybd.] growth and metal accumulation were screened for potential revegetation use. Bare-root shrubs were grown in three acidic, metal-contaminated (Cd, Cu, Pb, and Zn) tailings deposits (collected along the upper Arkansas River near Leadville, Colorado) amended with only lime (8.0, 21.1, and 39.1 g kg-1 added to deposit 1, 2, and 3, respectively) or lime and composted biosolids (42.3 g kg-1). Results showed that composted biosolids had little effect on plant biomass or metal concentrations. Following two months of growth, aboveground biomass increased between 268% and 1,091% with all species surviving. Most species accumulated Pb and Cu in roots. Compared to other species, alder and cinquefoil accumulated Pb in aboveground growth but concentrations were below animal toxicity thresholds. Dogwood, alder, and cinquefoil contained low Cd concentrations in aboveground new growth, whereas willows contained zootoxic concentrations. Dogwood, alder, and cinquefoil are three promising candidates for mine tailing revegetation, especially where fluvial tailing deposit Cd concentrations are elevated.

PI: Paul Meiman
Project Title: Mechanisms and Impacts of Integrated Pest Management for Sustainable Dalmatian Toadflax Control I\in The Western US

Dalmatian toadflax is a highly invasive weed that threatens rangelands throughout the Western U.S.; this exotic forb is classified as a noxious weed in almost every western state and impacts both private and government land managers. Dalmatian toadflax is very difficult to control. Cultural control is largely ineffective and impractical on many invaded rangelands. Chemical control has shown promise, though herbicides can have detrimental effects on non-target plants. Biological control of Dalmatian toadflax with the weevil, Mecinus janthinus, has also shown promise but suppression is slow or insufficient under some conditions. Very little is known about IPM (integrated pest management) of Dalmatian toadflax, though this approach is clearly warranted. We sought to evaluate IPM strategies for Dalmatian toadflax control using commercial or reduced-rate applications of the herbicides currently used for toadflax control (imazapic or picloram) and releases of the Dalmatian toadflax stem mining weevil (Mecinus janthinus). The overall objective of our approach is to minimize risk to non-target species, while achieving long-term and economical Dalmatian toadflax management.

PI: Paul Meiman
Project Title: Canada Thistle (Cirsium Arvense [L.] Scop.) Response to Mowing, Herbicide, Competitive Grasses, and Soil Amendments on Wetland, Upland, and Mesic Sites

Canada thistle (Cirsium arvense [L.] Scop.) is one of the most problematic weeds of temperate regions and found throughout the United States, Canada , Europe, Africa, and across central Asia to Japan (Moore 1975). Its' ability to spread quickly and resist most control methods leaves land managers with few tools for successfully reducing this invader. Herbicide application can be effective, but mixed results, toxicity concerns, and the need for re-application demand new strategies that are more efficient and reduce herbicide use. A greenhouse study tested effectiveness of clipping and grass seeding for Canada thistle control. Grasses used included two natives (western wheatgrass [Pascopyrum smithii {Rydb.} A. Löve], streambank wheatgrass [Elymus lanceolatus {Scribn. & J.G. Sm.}Gould ssp. lanceolatus]) and one sterile hybrid (common wheat [Triticum aestivum L.] x tall wheatgrass [Thinopyrum ponticum {Podp.} Z.W. Liu & R.C. Wang]) called Regreen™. Grasses were seeded alone or in combination (Regreen + western wheatgrass) in pots with Canada thistle. Field Study I tested combinations of mowing, herbicide, and grass seeding across two habitats (wetland, upland) and three different local climatic regimes for control of Canada thistle. Grass treatments involved seeding western wheatgrass (upland sites) or prairie cordgrass (Spartina pectinata Bosc ex Link) (wetland sites) alone or in combination with Regreen (upland and wetland sites). The six sites (three wetland sites, three upland sites) were paired geographically across Colorado with each wetland/upland pair in close proximity to each other. Field Study II tested Canada thistle control on a Colorado mesic site using combinations of mowing, herbicide, soil amendment addition (organic matter or manganese), and grass seeding (native western wheatgrass or the exotic intermediate wheatgrass [Thinopyrum intermedium (Host) Barkworth & D.R. Dewey]. In greenhouse trials, clipping inhibited Canada thistle growth, while grass seeding did not. In Field Study I, herbicide application produced effective control. In Field Study II, tilling enhanced herbicide effectiveness. Organic matter or manganese alone did not reduce Canada thistle growth. Manganese addition reduced herbicide effectiveness. In both field studies, neither mowing nor

grass seeding enhanced Canada thistle control above herbicide application alone, and tilling did not increase Canada thistle biomass.

PI: Mark Paschke
Project Title: Reclamation of Energy Development Impacts
Study Site Location: Piceance Basin, Rio Blanco County, Colorado.

The overall objective of this project is to study the long-term effects of various reclamation practices on ecosystem development associated with disturbed oil shale lands in the Piceance Basin of northwestern Colorado. In 1976 a large interdisciplinary research project was initiated in the Piceance Basin in order to provide basic and applied information that would aid in the reclamation of land disturbances associated with energy development. This effort was under the direction of Edward Redente and C. Wayne Cook at the Department of Range Science at Colorado State University. The project involved approximately ten independent field studies, which were established on a 20-ha site located near what was then the focal point of oil shale activity in the Piceance Basin. The site is at an elevation of 2042m, receives approximately 33 cm of annual precipitation, and encompasses shrubland and woodland plant communities typical of the Piceance Basin.

Since this study was established, over 35 articles in peer-reviewed scientific journals have resulted. Results from these studies have led to many practices currently used in the restoration of disturbed lands. In addition, dozens of thesis and dissertations have been produced. Many of the graduate students that have worked on studies at this site have advanced to become leaders in the fields of reclamation and restoration science.
In recent years, the Piceance Basin study site has become valuable as a unique source of long-term data on ecosystem development resulting from a variety of reclamation approaches. Many insights have been gained regarding the utility or futility of various approaches. These insights were either unapparent early on, or contradict earlier results. Both the initial and long-term findings have proven useful for making management recommendations regarding reclamation practices in semiarid ecosystems throughout the world.
Despite the value of these long-term observations, only three of the seven main studies have inventoried in recent years. There are three studies remaining that have the potential to yield additional information regarding long-term ecological dynamics. REL staff is revisiting these studies during the 2008 and 2009 growing seasons in order to retrieve this information. Results from these studies will be compared to earlier published findings and new publications describing long-term trends will be published. In addition, at the conclusion of these field studies, REL staff will co-host (along with Shell Oil Company) a special symposium on reclamation of oil shale lands in the western US featuring results from the Piceance Basin study site.

PI: Mark Paschke
Project Title: Natural Gas Well Pad Reclamation
Study Site Location: In the vicinity of Parachute, Colorado.

Natural gas exploration and extraction has experienced a flurry of development in Western Colorado in recent years. The construction activities associated with well pads, access roads, and pipeline right-of-ways remove existing vegetation and fragments wildlife habitat. The Colorado Oil and Gas Conservation Commission requires that natural gas pads on private and state land be reclaimed within 3-12 months after drilling operations have ceased and that the vegetation composition consist of species that are consistent with the surrounding plant community (COGCC, 2006). The Bureau of Land Management regulates its public lands and requires similar reclamation standards (WORG, 2006). These standards were promulgated to try to mitigate the impacts of the oil and gas industry on the natural environment, including air and water resources. Williams Production RMT Company is a natural gas extractor operating in the Piceance Basin in western Colorado, specifically the Grand Valley area surrounding Parachute, CO.

Williams, like most gas companies in the area, have had difficulty meeting the requirements of the COGCC and the BLM, which led to the funding of this research project in 2004. The overall objective for this research is to identify techniques that will improve the success of reclamation efforts of natural gas well pads on the western slope of Colorado.

PI: Mark Paschke
Project Title: N Fixing Shrubs in Colorado
Study Site Location: Mountains of Northern Colorado.

The objective this study is to provide unique and crucial information regarding the basic ecology of actinorhizal shrubs in forest and rangeland habitats in Colorado. Specifically, REL staff is currently working on providing the first estimates of the contributions of biologically-fixed nitrogen by actinorhizal shrubs to a variety of forest and rangeland habitats in Colorado. Actinorhizal shrubs and trees are a group of species capable of forming a symbiosis with N2-fixing soil actinomycetes of the genus Frankia. Many actinorhizal species are capable of fixing ecologically significant amounts of N2 in perennial woody root nodules. This ability allows them to flourish in soils where low levels of available N may preclude the growth of other species. With their Frankia symbionts, many actinorhizal shrubs play crucial roles in the successional development and restoration of disturbed ecosystems. In Colorado, actinorhizal species of Ceanothus and buffaloberry are important early colonizers in post-fire forest habitats. Similarly, species of bitterbrush and mountain mahogany play critical roles in Colorado rangelands. Once actinorhizal plants are established on a site, they can fix considerable amounts of N and add it to the soil as either leaf or root detritus. In so doing, actinorhizal plants build the soil organic matter pool and create a more favorable habitat for other plants and soil organisms. However, much of what is known about actinorhizal taxa is based upon studies conducted in the Pacific Northwest and the ecological role of similar actinorhizal species in the Rocky Mountains remains largely unknown.
Actinorhizal shrubs are keystone plant species in Colorado forests and rangelands. Despite this recognition, we know surprisingly little about the symbiosis between these shrubs and their

Frankia symbionts. Current studies by REL staff are the first attempt to estimate N inputs by actinorhizal shrubs to forests and rangelands of Colorado

PI: Mark Paschke
Project Title: Gold Mine Reclamation
Study Site Location: In the vicinity of Del Norte, Colorado.

Reclamation at the Summitville Superfund Site Faculty and staff in the REL have been working at the Summitville Mine Site for over 10 years. Our initial work was to produce a successful and executable design for the reclamation of the Summitville Mine Superfund Site. This objective was met by evaluating site characteristics followed by greenhouse and field studies to identify appropriate plant species and soil treatment combinations that would produce a productive and self-sustaining plant community. These studies resulted in the formulation of a plan for site wide reclamation. Currently, the REL is monitoring the development of the vegetation at the mine.

PI: Mark Paschke
Project Title: Rehabilitation of Post Fire Plant Communities
Study Site Locations: Craters of the Moon National Monument, Idaho; Rural Southern Idaho; and two sites in Western Colorado.

The central idea to be tested in these studies is that a mismatch of seeded plant species to site conditions opens the door to invasion by non-native species. We are exploring the possibility that establishing native early-seral species, and in particular annual species, will facilitate the establishment of native perennial plant species. Furthermore, these native annual species will compete with invasive annual species, such as cheatgrass more effectively than seeded native perennial species. We speculate that native annual species, which naturally colonize severe disturbances, will facilitate natural transitions to later seral native plant communities thus avoiding altered stable states. If this hypothesis is supported, then seeding native annual species could be an inexpensive and effective method for restoring native species and suppressing exotic invaders.

PI: Mark Paschke
Project Title: Allelopathy as an invasion pathway

We are exploring if the allelochemicals produced by some invasive plant species can be used as herbicides in the control of other exotic invaders. We are also examining the production of allelochemicals under various control strategies and the persistence of these allelochemicals in soils to determine if residual allelochemicals pose a problem for revegetation once allelopathic weeds are removed from a site. We are integrating basic ecological and biological knowledge of allelochemistry in invasive weeds with current and developing control and revegetation strategies to help slow the invasion of noxious weeds.

PI: Mark Paschke
Project Title: Tamarix Restoration
Study Site Location: Canyon de Chelly National Monument, Arizona.

Removal of non-native invasive trees (saltcedar and Russian olive) along riparian corridors in the Western U.S. often results in reinvasion by these same exotic species or other weedy species, such as cheatgrass. The REL is working to identify effective approaches for restoring native plant communities following removal of exotic tree species in Canyon de Chelly, including seeding techniques with native species and using the harvested tree residue as a mulch.