USDA United States Department of Agriculture

Rocky Mountain Research Station

Grassland, Shrubland, and Desert Ecosystems Program

GSD Update

March 2015

IN THIS ISSUE

- Providing knowledge, technology, and availability of native plants across the Great Basin
- Helping native plants move in response to changes in climate
- Tribes seek to learn new strategies to restore their native lands
- Why does blackbrush persist as a dominant shrub?
- Resilience science - key to effective restoration of imperiled sagebrush ecosystems
- Science-based guidelines for restoration and conservation of sagebrush ecosystems
- Biological soil crust response to prescribed fire in a Great Basin juniper woodland
- Interactive impacts of climate change and fire on Southwestern riparian species
- Grassland to shrubland state transitions enhance carbon sequestration
- Climate change and grazing alter belowground bud growth of invasive and native grasses
- Forecasting the influence of climate change on invasive weeds and weed biological control
- Discover the amazing diversity of the long-legged flies

Year in Review: Spotlight on 2015 Research by the Grassland, Shrubland and Desert Ecosystems Science Program

In this issue of the GSD Update, we take a look back at selected studies of the Grassland, Shrubland and Desert Ecosystems Science Program (GSD) that depict its strengths and focus areas. Significant results of recent research and science delivery by GSD scientists are highlighted. We feature program research that lines up with the strategic research priorities of the USDA Forest Service and the Rocky Mountain Research Station (RMRS). In particular, we spotlight accomplishments in GSD research and technology that addresses:

- Conservation, restoration and resiliency of sagebrush ecosystems,
- Availability, adaptation, seed zones and deployment of native plant species.
- The role of climate in species adaptation, carbon storage, and land management.
- The effects of disturbances and stressors on ecosystems

A high elevation sagebrush hillside on the Uinta-Wasatch-Cache National Forest, Utah.

Photo by Teresa Prendusi, USDA Forest Service.

"Healthy ecosystems need diverse plant communities of grasses, forbs [herbaceous flowering plants other than grasses] and shrubs that are native species with traits adapted to the right climates, so they can establish successfully,"

– Dr. Francis Kilkenny, RMRS Research Biologist, Boise, ID

Providing knowledge, technology, and availability of native plants across the Great Basin

Background and Project Objectives

Demand for native plant seed is increasing especially in federal agencies including the USDOI Bureau of Land Management (BLM) and USDA Forest Service. The BLM is guided by Executive Orders and Congressional direction to increase, where feasible and practical, the use of native plant seed. Invasive species, shifting fire regimes, and rapid climate change increase the need for researchers and land managers to develop sound management and successful restoration practices.

The Great Basin Native Plant Project seeks to increase the availability of genetically appropriate native plant materials and to provide the knowledge and technology required for their use in restoring diverse native plant communities across the Great Basin. This multi-state, collaborative research project was initiated in 2001 by the Plant Conservation Program of the BLM and the Grassland, Shrubland, and Desert Ecosystem Research Program of the Rocky Mountain Research Station.

"Healthy ecosystems need diverse plant communities of grasses, forbs [herbaceous flowering plants other than grasses] and shrubs that are native species with traits adapted to the right climates, so they can establish successfully," said Francis Kilkenny, who leads the Great Basin Native Plant Project. To help managers restore landscapes with a holistic, biologically diverse ecosystem that benefits wildlife, agriculture and humans, Kilkenny and his colleagues are breeding native plant varieties, such as bluebunch wheatgrass, that fit well with local and regional climates.

There are more than 30 major cooperators in nine states currently working together to meet objectives of the Great Basin Native Plant Project, which include:

- Increase the availability of native plant materials, particularly forbs, for restoring disturbed Great Basin rangelands.
- Provide an understanding of species variability and potential response to climate change and develop seed transfer guidelines.
- Develop seed technology and cultural practices for producing native seed in agricultural settings.
- Collaborate with seed regulatory agencies and the private seed industry to improve native seed supplies.
- Examine interactions of native restoration species and exotic invasives to aid in formulating seeding prescriptions.
- Develop application strategies and technologies to improve the establishment of native seedings.
- Develop demonstration areas, manuals, popular publications, and websites to facilitate application of research results.

Researching Native Plants

Researchers with the Great Basin Native Plant Project focus on genetics, species-specific seed zones, rapid testing and provisional seed zones, and the establishment of a common garden network to assess the suitability of native seeds for

Biological Technician Matt Fisk, Boise, ID cleaning seeds. Photo: USDA Forest Service.

Collecting seeds. Photo: USDA Forest Service.

different climates. The most robust seeds become the foundation for restoration projects to rebuild ecosystems after big wildfires, such as those currently wiping out vast sagebrush expanses in Nevada, Idaho and Utah.

“Common garden studies” are a particularly valuable approach for comparing the performance of native seed. Researchers gather native seeds from different areas of the country with different climates and grow the seeds together in a single garden. The seeds experience the same environmental conditions in the common garden, allowing researchers to compare growth and performance of the different varieties. In other words, common garden studies for plants are similar to “twin studies” done on humans to separate the effects of nature versus nurture.

Another research focus is creating an adequate supply of different varieties of native seed mixes. Using one variety of a species during large, landscape-scale restoration projects raises monoculture concerns. Genetic diversity can ensure seeds have a variety of traits, such as drought tolerance, that can help the species establish and persist into the future.

Kilkenny’s lab also assesses the outcome of plantings 15 years after restoration. Long-term results from plantings are not well-studied, so it’s important to know under what conditions different planting techniques and seed mixes are more or less successful.

Delivering Knowledge

The Great Basin Native Plant Project also focuses on sharing knowledge about successful seeding of native species with land managers. Kilkenny and his colleagues report findings through publications such as annual reports, plant guides, journal articles, and brochures, as well as through face-to-face workshops and conferences with scientists and managers.

Success on a national scale will continue to happen through a nationwide network of native seed collectors, a network of farmers and growers working to develop seed, a network of nurseries and seed storage facilities to supply adequate quantities of appropriate seed, and a network of restoration ecologists who know how to put the right seed in the right place at the right time.

Please visit the website for the Great Basin Native Plant Project for additional information on the project, including research descriptions, publications, and updates on conferences and other events. The Great Basin Native Plant Project was also highlighted in a recent article in Live Science, *To prevent another dust bowl, the U.S. must sow the right seeds*.

Featured Publications

Great Basin Native Plant Project: 2014 Progress Report Kilkenny, Francis; Halford, Anne; Malcomb, Alexis, 2015

Great Basin Native Plant Project: 2013 Progress Report Kilkenny, Francis; Shaw, Nancy L; Gucker, Corey, 2014

Great Basin Native Plant Selection and Increase Project: 2012 progress report Shaw, Nancy L.; Pellant, Mike, 2013

Great Basin Native Plant Selection and Increase Project: 2011 Progress Report Shaw, Nancy L; Pellant, Mike, 2012

Great Basin Native Plant Selection and Increase Project: FY2010 Progress Report Shaw, Nancy L.; Pellant, Mike, 2011

[Great Basin Native Plant Selection and Increase Project FY08 Progress Report](#)
Shaw, Nancy L; Pellant, Mike, 2009

Principal Investigators:

Francis F. Kilkenny
Bryce A. Richardson
Scott L. Jensen

Forest Service Partners:

Bob Karrfalt - National Seed Laboratory

Andrew Bower - Olympic National Forest

Holly Prendeville and Brad St. Clair - Pacific Northwest Research Station

Charlie Schrader-Patton - Remote Sensing Applications Center

External Partners:

Matt Germino, Todd Esque, Daniel Shyrock, Lesley Defalco - U.S. Geological Survey

Keirith Snyder, Doug Johnson, Beth Newingham, Shaun Bushman, Kirk Davies, RC Johnson, Thomas Monaco, Matt Madsen, Jim Cane, Tom Jones – USDA Agricultural Research Service

Derek Tilley - Natural Resource Conservation Service

Berta Youtie - Eastern Oregon Stewardship Services

Kevin Gunnell and Jason Vernon - Utah Division of Wildlife Resources

Robert Cox - Texas Tech University

Jeremy James - University of California

Marie Ann DeGraaf and Marcelo Serpe - Boise State University

Mark Kimsey, Anthony Davis, and Kent Apostol - University of Idaho

Beth Leger and Kent McAdoo - University of Nevada

Kari Veblen, Kris Hulvey, and Eric Thacker - Utah State University

Clint Shock, Matt Orr, and Kathryn Alexander - Oregon State University

Kevin Grady, Troy Wood, Paul Dijkstra, Catherine Gehring, Egbert Schwartz, and Hillary Cooper - Northern Arizona University

Mikel Stevens and Jason Stettler - Brigham Young University

Erica David - Perth, Australia

College of Western Idaho

Plant Conservation Alliance

Private contractors and land owners

Native seed industry

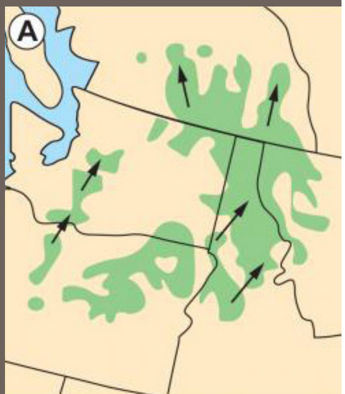
Truax Company, Inc.

U.S. Army Corps of Engineers

USDI Bureau of Land Management

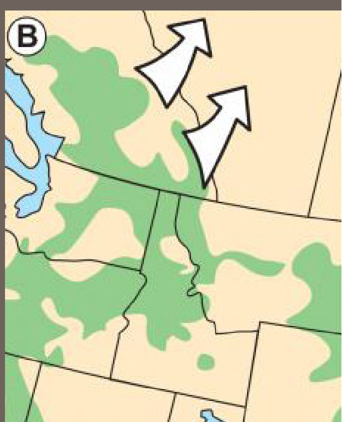
Researchers with the Great Basin Native Plant Project collecting native seeds in the field.

Photo: USDA Forest Service.



Assisted Population Migration

Lanx occentalis Nutt



Assisted Range Expansion

Pinus ponderosa Douglas ex C. Lawson

Assisted Species Migration

Torreya taxifolia Arn.

Illustration of assisted population migration, range expansion, and species migration (from Williams and Dumroese 2013).

Helping native plants move in response to changes in climate

Background

With the current rate of climate change, many landscapes in the United States will have climates that are incompatible with current vegetation by the end of the century. One adaptation strategy at the nexus of native plant transfer guidelines and climate change is assisted migration, also known as managed relocation, defined as the intentional movement of plants in response to climate change. Although researchers propose frameworks and guidelines on how to apply assisted migration of native plants, there is no consensus on implementation in the U.S. because of ecological and economic concerns and lack of supporting data.

Key Findings

To identify knowledge gaps and provide a central foundation for collaboration, researchers compiled information about native plant transfer guidelines, climate change, and assisted migration. The resulting database connects all pieces of information from peer-review journal articles to decision-support tools.

This database can help inform scientists, land managers, and university students about the intersection of traditional plant transfer guidelines, climate change and assisted migration and in particular the historical, biological, social, legal, and ethical aspects of assisted migration.

Featured Publications

Foundational literature for moving native plant materials in changing climates Williams, Mary I.; Dumroese, R. Kasten; Pinto, Jeremiah; Jurgensen, Martin F, 2015

Assisted migration: What it means to nursery managers and tree planters Williams, Mary I.; Dumroese, R. Kasten, 2014

Contemporary forest restoration: A review emphasizing function Stanturf, John A.; Palik, Brian J.; Dumroese, R. Kasten, 2014

Role of climate change in reforestation and nursery practices Williams, Mary I.; Dumroese, R. Kasten, 2014

Climatic change and assisted migration: Strategic options for forest and conservation nurseries Williams, Mary I.; Dumroese, R. Kasten, 2013

Preparing for climate change: Forestry and assisted migration Williams, Mary I.; Dumroese, R. Kasten, 2013

Principal Investigator:

Kasten Dumroese

Forest Service Partners:

National Center for Reforestation, Nurseries, and Genetic Resources

Rocky Mountain Research Station

External Partners:

Mary Williams, Martin F Jurgensen - Michigan Technological University

Tribes seek to learn new strategies to restore their native lands

The Forest Service's Reforestation, Nurseries, and Genetic Resources Team provides an important forum for Native American tribes to network regarding native plant production and restoration. Team leaders have worked with nearly 80 tribes and one-on-one with more than 500 tribal members across the United States and Canada, teaching them how best to propagate culturally significant plants for their own uses.

Native peoples are seeking out expertise on native plant propagation as they increasingly work to restore their lands with culturally significant native plants. Scientists at the agency's Rocky Mountain Research Station are currently working on writing nearly 300 native plant propagation protocols requested by different tribes. Several awards have recognized the quality and effectiveness of the team's efforts, including the Earle R. Wilcox Award from the Intertribal Timber Council.

Forest Service scientists helped conduct a native plant nursery planning workshop in Wisconsin. Attendees came from the College of the Menominee, Menominee Tribal Enterprises, the Oneida Tribe, the Keweenaw Bay Indian Community, the Sault Tribe of Chippewa Indians, and the Redlake Band of Chippewa Indians. Several of these tribes are in the beginning stages of native plant nursery production and are eager to learn new strategies for planning, implementing, and conducting their own programs. The two-day workshop included lectures and tours on nursery planning, implementing agroforestry programs, and greenhouse operations. The event was well-received among tribal participants, with open discussions promoting the use of native plant nurseries for tribal restoration projects, reforestation, education, cultural preservation, and science.

"[The scientists] fill an important role by helping the Forest Service direct its expertise and resources dealing with forestry and native plants to areas where we need help," said Priscilla Pavatea of the Hopi Office of

Tribe members attending a native plant nursery planning workshop.

Photo: Chris Hoag, USDA Natural Resources Conservation Service.

Range Management in Kykotsmovi, AZ. “We trust them to provide us quality information. Their help is not directed only to Hopi. Many tribes are participating in the Intertribal Nursery Council they organize and taking home knowledge on how to produce native plants for reforestation, cultural, medicinal, and spiritual needs.”

Media and YouTube Stories

[Highlights: The 2015 Intertribal Nursery Council Meeting]

[2015 Intertribal Nursery Council Meeting, Western Forestry and Conservation Association]

[Tribes, Pueblos Explore Native Plants]

[Seneca Nation - First U.S. Tribe to Establish Native Plant Policy]

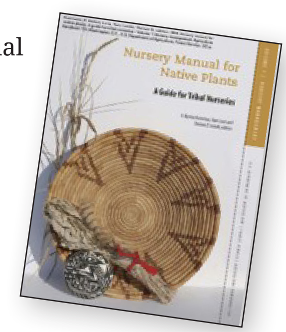
[USDA Forest Service Botany in the News]

[Compass Issue 8: Restoring Native Plants and Tribal Traditions in Arizona]

[Intertribal Nursery Council Slideshow - YouTube]

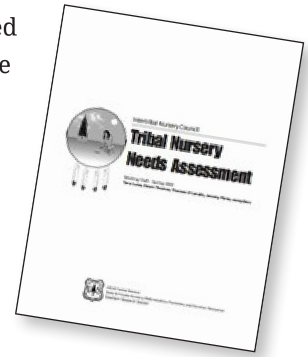
Featured Publications

Tribal Nursery Manual



This handbook covers all aspects of managing a native plant nursery, from initial planning through crop production to establishing trials to improving nursery productivity into the future. It was written to assist Native Americans in growing native plants and draws extensively on tribal activities for the many photos and specific examples in the text. Click here to view or download the manual.

Tribal Nursery Needs Assessment



Using funding provided by USDA Forest Service State and Private Forestry, Native Americans associated with the Intertribal Nursery Council were asked to provide information about their native plant production needs. The information was compiled into this needs assessment which forms the basis for some new and ongoing Forest Service outreach projects to Native Americans. Click here to view the Assessment.

Principal Investigators:

Jeremiah R. Pinto

Kasten Dumroese

Forest Service Partners

National Center for Reforestation, Nurseries, and Genetic Resources

Rocky Mountain Research Station

External Partners

Native American Tribes

Why does blackbrush persist as a dominant shrub?

Background

Blackbrush (*Coleogyne ramosissima*: Rosaceae) is a slow-growing, non-clonal shrub that is regionally dominant on xeric, shallow soils in the North American Mojave Desert-Great Basin transition zone and southern Colorado Plateau. Blackbrush seed production is concentrated in mast years, and most seeds are cached and later consumed by heteromyid rodents. Vegetation histories show that blackbrush stands can persist apparently unchanged for over a century.

Approach

Scientists used dendrochronological techniques to examine plant age distributions, recruitment patterns and growth rates, to ascertain how blackbrush achieves this long-term population stability. Their study addressed the following questions: (1) What is the role of within-clump recruitment in long-term patterns of clump persistence? Do blackbrush clumps accrue new cohorts through time? (2) How does recruitment vary temporally, specifically in relation to years of mast seed production and climate variability? (3) What impact does intra-specific competition have on plant growth rates? To address these questions, we aged stems from 208 clumps in five Mojave Desert and four Colorado Plateau populations.

Findings

Individual plant age estimates ranged from 3 to 122 years. Clumps comprised of multiple-aged cohorts were ubiquitous. Within clumps, plant and cohort number increased with clump age, suggesting a steady accumulation of new cohorts over time. Clumps in Colorado Plateau populations accumulated cohorts at a significantly faster rate than clumps in Mojave Desert populations.

Recruitment occurred in relatively frequent pulses. It was only partially synchronized with mast years, with some seedling establishment following years of low seed production. Individuals that recruited into established clumps averaged half the radial growth rate of individuals that recruited into openings. Blackbrush recruitment is bimodal, with initial colonization of open spaces from rodent caches but with long-term clump persistence a product of periodic, within-clump recruitment of new plants. This dual recruitment strategy provides a mechanism for continued community dominance in an abiotically stressful environment under low levels of disturbance.

Blackbrush plant community in the Arches National Park, Utah.

Photo: Rhean Pendleton, Independent Photographer

Further Research

In another study, investigators followed flowering and seed production in 16 populations of blackbrush from contrasting environments across its range over an 11-year period to determine patterns of interannual reproductive output variation. The premise of the study was that the evolutionary drivers and proximal regulators of mast-seeding were well understood for species of mesic environments, but how these regulators interact with high spatial and interannual variability in growing-season precipitation for a masting species in a desert environment had never been examined.

Patterns of reproductive output in blackbrush did not track current growing season precipitation, but instead were regulated by prior-year weather cues. The strength of the response to the masting cue depended on habitat quality, with higher mean reproductive output, shorter intervals between years of high seed production, and lower population coefficients of variation at more favorable sites. Wind pollination efficiency was demonstrated to be an important evolutionary driver of masting in blackbrush, and satiation of heteromyid seed predator-dispersers was supported as an evolutionary driver based on earlier studies.

Both the evolutionary drivers and proximal regulators of masting in blackbrush are similar to those demonstrated for masting species of mesic environments. Relatively low synchrony across populations in response to regional masting cues occurs at least partly because prior-year environmental cues can trigger masting eff orts in years with resource limitation due to suboptimal precipitation, especially in more xeric low-elevation habitats.

Featured Publications

Mechanisms for maintenance of dominance in a nonclonal desert shrub Kitchen, Stanley G.; Meyer, Susan E.; Carlson, Stephanie L., 2015.

Evolutionary drivers of mast-seeding in a long-lived desert shrub Meyer, Susan E.; Pendleton, Burton K., 2015

Seedling establishment in a masting desert shrub parallels the pattern for forest trees Meyer, Susan E.; Pendleton, Burton K., 2015

Blackbrush (Coleogyne ramosissima Torr.): State of our knowledge and future challenges [Chapter 10] Pendleton, Rosemary L.; Pendleton, Burton K.; Meyer, Susan E.; Richardson, Bryce A.; Esque, Todd; Kitchen, Stanley G., 2015

Adaptive responses reveal contemporary and future ecotypes in a desert shrub Richardson, Bryce A.; Kitchen, Stanley G.; Pendleton, Rosemary L.; Pendleton, Burton K.; Germino, Matthew J.; Rehfeldt, Gerald E.; Meyer, Susan E., 2014

Principal Investigators

Stanley G. Kitchen

Susan E. Meyer

Burton K. Pendleton, Emeritus

Forest Service Partners

Bryce A. Richardson

Rosemary L. Pendleton

Gerald E. Rehfeldt, retired

External Partners

Matthew Germino, Todd Esque - U.S. Geological Survey

Resilience science - key to effective restoration of imperiled sagebrush ecosystems

Background

Progressive expansion of invasive annual grasses and larger and more severe fires in sagebrush ecosystems underscore the importance of vegetation management treatments that can reverse these trends. In sagebrush ecosystems, vegetation treatments focus on reducing woody species (shrubs and grasses) to reduce fuel loads, and thus fire severity and extent, and on post-fire rehabilitation. Overarching management objectives are restoring and maintaining ecosystem services such as clean air and water by (1) increasing resilience to disturbance or recovery potential, and (2) decreasing the longer term risk of conversion to invasive annual grasses and an annual/grass fire cycle.

Research

Resilience science has been used to develop management guides for selecting appropriate treatment and restoration strategies for sagebrush and piñon-juniper ecosystems. The guides provide a framework with six key components for rapidly evaluating resilience to disturbance, resistance to invasive annual grasses, and plant community succession following wildfires and management treatments. The key components are:

- Ecological characteristics of the site;
- Vegetation composition and structure prior to treatment;
- Severity of the disturbance or treatment;
- Post-treatment weather;

A wildfire burning through a Wyoming big sagebrush community with the invasive annual grass, cheatgrass, in the understory. These types of communities have low resilience or recovery potential.

Photo: Doug Shinneman, US Geological Survey.

Piñon and juniper (PJ) species expanding into a mountain big sagebrush community. PJ expansion decreases the understory shrubs and grasses and lowers the resilience of these communities to wildfire and other disturbance.

Photo: Jeanne Chambers, USDA Forest Service.

Rehabilitation seeding after a wildfire to restore a Wyoming big sagebrush community

Photo: Chad Boyd, USDA Agricultural Research Service.

- Post-treatment management, especially grazing; and
- Monitoring and adaptive management.

Several tools are provided to aid in determining the most appropriate treatment. These tools include:

A conceptual model of the relationships between the key components and their effects on resilience and resistance,

Guides to evaluate disturbance and treatment severity, and

Aids for determining plant composition and structure after wildfires.

Importantly, evaluation score sheets are provided for rating resilience to disturbance and resistance to invasive annual grasses, and for evaluating the probability of treatment success. The approach is being widely adapted by managers seeking to increase treatment effectiveness.

Key Findings

This research provides:

- Information and criteria for evaluating resilience (recovery potential) following wildfire and management treatments in sagebrush ecosystems;
- Information and criteria for evaluating resistance to invasive annual grasses; and
- Score sheets for determining the suitability of areas for treatment and the need for post-fire or post-treating rehabilitation seeding.

Featured Publications

A field guide for rapid assessment of post-wildfire recovery potential in sagebrush and pinon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response Miller, Richard F.; Chambers, Jeanne C.; Pellant, Mike, 2015

A field guide for selecting the most appropriate treatment in sagebrush and pinon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses, and predicting vegetation response Miller, Richard F.; Chambers, Jeanne C.; Pellant, Mike, 2014

Resilience and resistance of sagebrush ecosystems: Implications for state and transition models and management treatments Chambers, Jeanne C.; Miller, Richard F.; Board, David ; Pyke, David A.; Roundy, Bruce A.; Grace, James B.; Schupp, Eugene W.; Tausch, Robin J. , 2014

Resilience to stress and disturbance, and resistance to *Bromus tectorum* L invasion in cold desert shrublands of western North America Chambers, Jeanne C.; Bradley, Bethany A. ; Brown, Cynthia S.; D'Antonio, Carla; Germino, Matthew J.; Grace, James B.; Hardegree, Stuart P.; Miller, Richard F.; Pyke, David A., 2014

Principal Investigators:

Jeanne C. Chambers

External Partners:

Richard F. Miller - Oregon State University

Mike Pellant - Bureau of Land Management
Joint Fire Science Program

Great Basin Fire Science Exchange

Science-based guidelines for restoration and conservation of sagebrush ecosystems

Background

Sagebrush communities are the cornerstones of arid ecosystems in the West, mitigating soil erosion, fostering plant and animal biodiversity, storing carbon, and providing cover and forage for wildlife, such as the greater sage-grouse. However, these ecosystems are being compromised by increased fire frequency and climate change, coupled with encroachment of invasive plants. Subsequently, post-fire restoration has become a fundamental component for maintaining ecosystem function and resiliency in these communities. Knowledge of how plants are adapted to their environments is fundamental to ecological restoration and mitigating impacts of climate change.

Winter mortality of big sagebrush not adapted to colder areas of the species distribution

Photo: Bryce Richardson, USDA Forest Service.

Sagebrush communities are the cornerstones of arid ecosystems in the West, mitigating soil erosion, fostering plant and animal biodiversity, storing carbon, and providing cover and forage for wildlife, such as the greater sage-grouse (*Centrocercus urophasianus*). However, these ecosystems are being compromised by increased fire frequency and climate change, coupled with encroachment of invasive plants. Subsequently, post-fire restoration has become a fundamental component for maintaining ecosystem function and resiliency in these communities. Knowledge of how plants are adapted to their environments is fundamental to ecological restoration and mitigating impacts from climate change.

Research

This research focuses on ecological genetics of big sagebrush (*Artemisia tridentata*), which is under threat principally from wildfire and exotic weed encroachment. Conserving and restoring big sagebrush is critical for the recovery of sage-grouse and other sagebrush-dependent wildlife species. Our goal is to provide management tools to promote successful restoration by: 1) predicting the geographic areas where contemporary and future climates are suitable for this species, 2) developing empirical seed transfer zones, and 3) developing subspecies diagnostic tests to improve seed purity.

Findings

Climate change is projected to have a large impact on sagebrush ecosystems. Projections show that approximately one-third of the climatic niche of Wyoming sagebrush will be lost by 2050.

The aftermath of a late-season prescribed fire in the Onaqui Mountains, Utah show the remains of a juniper understory, and minimal effect on the few mosses or lichens.

Photo: Steven D. Warren, USDA Forest Service.

Populations of big sagebrush are adapted to local climates, specifically cold temperatures. Movement of seed should be restricted to prevent maladaptation.

Seed weight can be used to differentiate co-occurring subspecies of big sagebrush. Weighing can be used as a seed certification step for evaluating subspecies composition of seed intended for restoration.

Featured Publications

Genetic and environmental effects on seed weight in subspecies of big sagebrush: Applications for restoration Richardson, Bryce A.; Ortiz, Hector G.; Carlson, Stephanie L.; Jaeger, Deidre M.; Shaw, Nancy L., 2015

Projections of contemporary and future climate niche for Wyoming big sagebrush (Artemisia tridentata subsp. *wyomingensis*): A guide for restoration Still, Shannon M.; Richardson, Bryce A., 2015

Deep sequencing of amplicons reveals widespread intraspecific hybridization and multiple origins of polyploidy in big sagebrush (*Artemisia tridentata*, Asteraceae) Richardson, Bryce A. ; Page, Justin T.; Bajgain, Prabin ; Sanderson, Stewart; Udall, Joshua A., 2012

Principal Investigators:

Bryce A. Richardson

Forest Service Partners:

Francis F. Kilkenny

Nancy L. Shaw

Stewart Sanderson

External Partners:

Joshua A Udall, Lindsay Chaney - Brigham Young University

Matthew J Germino - U.S. Geological Survey

Biological soil crust response to prescribed fire in a Great Basin juniper woodland

Approach

Expansion of juniper on U.S. rangelands is a significant environmental concern. Prescribed fire is often recommended to control juniper. To that end, a late season prescribed burn was conducted in a Great Basin juniper woodland. Conditions were suboptimal; fire did not encroach into mid- or late-seral stages and was patchy in the early-seral stage. This study evaluated the effects of the burn on biological soil crusts of early-seral juniper.

Research Findings

Fire reduced moss cover under sagebrush and in shrub interspaces. Mosses were rare under juniper; their cover was unaffected there. Lichens were uncommon under juniper and sagebrush and therefore not significantly impacted there. Their cover was greater in shrub interspaces, but because the fire was spotty and of low intensity, the effects of burning were minimal. Compared with unburned plots, the biomass of cyanobacteria was diminished under juniper and sagebrush; it was reduced in the interspaces in both burned and unburned plots, presumably in response to generally harsher conditions in the postburn environment. Nitrogen fixation rates declined over time in juniper plots and interspaces but not in sagebrush plots.

Although fire negatively affected some biological soil crust organisms in some parts of the early-seral juniper woodland, the overall impact on the crusts was minimal. If the intent of burning is to reduce juniper, burning of early-seral juniper woodland

Fire in the Rio Grande Bosque.

Photo: Albuquerque Fire Department.

Riparian habitat along the Rio Grande, New Mexico.

Photo: Wikipedia.

is appropriate, as most affected trees were killed. Control of sagebrush can likewise be accomplished by low-intensity, cool season fires without eliminating the crust component. Intense fire should be avoided due to the potential for greater encroachment into the shrub interspaces, which contain the majority of biological soil crust organisms. Burning early-seral juniper may be preferred for controlling juniper encroachment on rangeland.

Featured Publications

Biological soil crust response to late season prescribed fire in a Great Basin juniper woodland Warren, Steve D.; St.Clair, Larry L.; Johansen, Jeffrey R.; Kugrens, Paul; Baggett, Scott; Bird, Benjamin J., 2015

Polyphasic characterization of *Trichocoleus desertorum* sp. nov. (Pseudanabaenales, Cyanobacteria) from desert soils and phylogenetic placement of the genus *Trichocoleus* Muhlsteinova, Radka; Johansen, Jeffrey R.; Pietrasiak, Nicole; Martin, Michael P.; Osorio-Santos, Karina; Warren, Steve D., 2014

Role of biological soil crusts in desert hydrology and geomorphology: Implications for military training operations Warren, Steve D., 2014.

Principal Investigator

Steven D. Warren

External Partners

Brigham Young University, Provo

John Carroll University, University Heights, Ohio

Colorado State University

University of South Bohemia, Czech Republic.

Universidad Nacional Autonóma de México

Interactive impacts of climate change and fire on Southwestern riparian species

Background

The interaction of fire, climate change, and invasive species is predicted to have extreme effects for ecosystems in the interior western United States. Wildlife species that rely on riparian habitats are likely to be particularly hard hit. Climate will drive changes to river flows through modified precipitation regimes and higher temperatures. These changes will, in turn, increase the risk of severe fires within riparian woodland habitats, affecting wildlife communities.

The potential for severe changes due to climate and fire threatens our capacity to develop successful strategies to manage for the species, habitats, and natural resources of our western water ecosystems.

Rocky Mountain Research Station scientists have developed a coupled approach that combines species distribution models, predictions for future fire regime, and climate change vulnerability assessments to estimate the interactive impacts of climate change and fire on species that reside within riparian habitats in the Southwest.

Approach

Resource managers need tools that identify the likely future of riparian habitats under various climate and fire scenarios, not only to focus limited resources on the most critical needs for wildlife species, but to find opportunities for promoting natural regeneration of riparian woodland and wetland habitats. Building upon a risk matrix method developed by the Northern Research Station and vulnerability assessment tools

Northern Chihuahuan Desert.

Photo: Sevilleta Long-Term Ecological Research Site Program.

developed by RMRS, this project quantifies the effects of fire and climate change on native and nonnative species residing within New Mexico riparian, wetland, and associated upland habitats.

Deliverables

- Species vulnerability pamphlets
- Maps of habitat suitability under future climate scenarios
- Project reports

Featured Publications

Vulnerability of riparian obligate species to the interactive effect of fire, climate and hydrological change Friggens, Megan M., Loehman, Rachel A.; Holsinger, Lisa M.; Finch, Deborah M., 2014

Implications of Climate Change for Bird Conservation in the Southwestern U.S. Friggens, Megan M.; Finch, Deborah M., 2015.

Principal Investigator:

Megan M. Friggens

Forest Service Partners:

Deborah M. Finch

Lisa M. Holsinger - RMRS Human Dimensions Program
RMRS Fire, Fuels and Smoke Program

External Partners:

Southern Rockies Landscape Conservation Cooperative

Desert Landscape Conservation Cooperative

Rachel Loehman, US Geological Survey, Alaska Science Center

Grassland to shrubland state transitions enhance carbon sequestration

Background

The replacement of native C4-dominated grassland by C3-dominated shrubland is considered an ecological state transition where different ecological communities can exist under similar environmental conditions. These state transitions are occurring globally, and may be exacerbated by climate change. One consequence of the global increase in woody vegetation may be enhanced ecosystem carbon sequestration, although the responses of arid and semiarid ecosystems may be highly variable.

Findings

During a drier than average period from 2007 to 2011 in the northern Chihuahuan Desert, scientists found established shrubland to sequester 49 g C m-2 yr-1 on average, while nearby native C4 grassland was a net source of 31 g C m-2 yr-1 over this same period. Differences in C exchange between these ecosystems were pronounced - grassland had similar productivity compared to shrubland but experienced higher C efflux via ecosystem respiration, while shrubland was a consistent C sink because of a longer growing season and lower ecosystem respiration.

At daily timescales, rates of carbon exchange were more sensitive to soil moisture variation in grassland than shrubland, such that grassland had a net uptake of C when wet but lost C when dry. Thus, even under unfavorable, drier than average climate conditions, the state transition from grassland to shrubland resulted in a substantial increase in terrestrial C sequestration.

Belowground buds are attached at the base of a stem. This belowground bud of Western Wheatgrass has not grown out. It is still covered by its prophyll, a protective outer leaf.

Photo: USDA Forest Service.

These results illustrate the inherent tradeoffs in quantifying ecosystem services that result from ecological state transitions, such as shrub encroachment. In this case, the deleterious changes to ecosystem services often linked to grassland to shrubland state transitions may at least be partially offset by increased ecosystem carbon sequestration.

Featured Publications

Grassland to shrubland state transitions enhance carbon sequestration in the northern Chihuahuan Desert Petrie, M. D.; Collins, S. L.; Swann, A. M.; Ford, Paulette L.; Litvak, M. E., 2015

Climate change impacts on future carbon stores and management of warm deserts of the United States Thomey, Michell L.; Ford, Paulette L.; Reeves, Matthew C.; Finch, Deborah M.; Litvak, Marcy E.; Collins, Scott L., 2014

Review of climate change impacts on future carbon stores and management of warm deserts of the United States Thomey, Michell L.; Ford, Paulette L.; Reeves, Matt C.; Finch, Deborah M.; Litvak, Marcy E.; Collins, Scott L., 2014.

Principal Investigator

Paulette L. Ford

Forest Service Partners

Matt C. Reeves

Deborah M. Finch

External Partners

Matthrew D. Petrie; Scott L. Collins; Amaris M. Swann; Marcy E. Litvak, Michell Thomey, University of New Mexico

Climate change and grazing alter belowground bud growth of invasive and native grasses

Background

Most stems of North American Great Plains grasses come from belowground vegetative buds rather than from seeds. Therefore, grassland biomass production depends on bud outgrowth into stems. Climate change and grazing can alter the amount of bud outgrowth of both invasive and native grasses. Invasive species could expand under climate change, especially if their bud outgrowth is superior to bud outgrowth of native species under a range of environmental conditions.

Research

Our research examined the bud outgrowth of the native western wheatgrass (*Pascopyrum smithii*) and the invasive smooth brome (*Bromus inermis*) under a range of environmental conditions including multiple temperatures, drought, and clipping.

Findings

- Smooth brome had more buds per stem than western wheatgrass. A greater proportion of smooth brome buds became stems under all temperature and moisture conditions. Western wheatgrass bud outgrowth was reduced at temperatures above 72°F.
- Short-term drought did not significantly impact bud outgrowth of either species.
- Clipping increased western wheatgrass bud mortality and temporarily reduced its bud outgrowth.

A Western Wheatgrass bud has started to grow out from the base of its parent stem. The tip of this new stem has grown past its prophyll.

Photo: Jacqueline Ott, South Dakota State University/USDA Forest Service

- The robust bud outgrowth of smooth brome under a range of environmental conditions is a key mechanism enabling its expansion into northern mixed-grass prairie in North America.

Featured Posters and Publications

Temperature, clipping and drought effects on belowground bud outgrowth on invasive *Bromus inermus* and native *Pascopyrum smithii*. Ott, Jacqueline P.; Jack L. Butler; Yuping Rong; and Lan Xu, 2015

Bud-bank and tiller dynamics of co-occurring C3 caespitose grasses in mixed grass prairie

Ott, Jacqueline P.; David C. Hartnett, 2015

Vegetative reproduction and bud bank dynamics of the perennial grass *Andropogon geradii* in mixedgrass and tallgrass prairie

Ott, Jacqueline P.; David C. Hartnett, 2015

Principal Investigators:

Jack L. Butler

External Partners:

Jacqueline P. Ott, Lan Xu - South Dakota State University;

Yuping Rong, China Agricultural University

Research Location:

Buffalo Gap National Grasslands, South Dakota

Forecasting the influence of climate change on invasive weeds and weed biological control

Background

Invasive plants are a major threat to natural ecosystems, with global climate change predicted to further intensify the negative impacts of weeds on native species. Classical biological control of invasive plants using host specific insects from invaders' native range is a powerful and highly selective tool for mitigating weed spread and impacts. However, climate change may affect multiple factors that determine the efficacy of this important management tool.

Future environmental conditions likely include elevated atmospheric levels of carbon dioxide (CO_2) and temperatures, coupled with reduced or altered patterns in precipitation. Such environmental factors can profoundly affect the growth, physiology and phenology of invasive plant species and their co-evolved specialist herbivore insects. A mechanistic approach to understanding how climate change may impact interactions between invasive plants and their biocontrol agents is essential for realistically addressing management needs under likely future field conditions.

Research

The first step in this research is gaining a greater understanding of how invasive weeds respond to climate change, namely to elevated atmospheric CO_2. The impact of elevated atmospheric CO_2 on the growth of Dalmatian toadflax (*Linaria dalmatica*), yellow or common toadflax (*L. vulgaris*), and their hybrids (*L. dalmatica* x *L. vulgaris*)

Dalmatian toadflax is an aggressive invader of western rangelands.

Photo: Steve Dewey, Utah State University, Bugwood.org.

is not currently known but is being experimentally determined by monitoring plants grown under differential levels of CO_2.

Initial experiments are being conducted in three reach-in growth chambers (Percival® model PGC-6L fitted with optional CO_2 enrichment package). The purpose is to determine if different CO_2 levels (ambient – 480 ppm; low – 580 ppm; and high – 780 ppm) induce differential growth responses in toadflax. Plants used in this experiment were clones generated from molecularly confirmed toadflax genotypes. Manipulated, reciprocal crosses were initially supplied by Colorado State University plant geneticist Dr. Sarah Ward, and have been used in a number of related experiments.

Subsequent experiments will measure the interactive effects of elevated CO_2 on host plant-herbivore interactions. These will initially focus on determining if and how host plants grown under elevated CO_2 might influence the biology and efficacy of approved and candidate weed biocontrol agents. Phenological milestones, fitness correlates, and reproductive success of agents belonging to different feeding and injury guilds – defoliators vs. stem miners vs. root gallers - will be compared. Interactions of agent feeding and injury guilds and elevated CO_2 on host plant primary metabolic responses (gas exchange, photosynthetic rate, transpiration), growth, above- and below-ground biomass will also be evaluated to rank agent biocontrol efficacy under one of the most significant predicted influences of climate change.

See the webinar series *Invasive Plants — Issues, Challenges, and Discoveries* from the RMRS Grassland, Shrubland, and Desert Ecosystems for more information about invasive plants.

Featured Publications

Toadflax stem miners and gallers: The original weed whackers Matonis, Megan S.; Sing, Sharlene E.; Ward, Sarah; Turner, Marie F. S. ; Weaver, David; Tosevski, Ivo; Gassmann, Andre; Bouchard, Patrice, 2014

Invasive species and climate change (Chapter 7) Runyon, Justin B.; Butler, Jack L.; Friggens, Megan M.; Meyer, Susan E.; Sing, Sharlene E., 2012

Growth inhibition of Dalmatian toadflax, *Linaria dalmatica* (L.) Miller, in response to herbivory by the biological control agent *Mecinus janthinus* Germar Schat, Marjolein; Sing, Sharlene E.; Peterson, Robert K. D.; Menalled, Fabian D.; Weaver, David K., 2011

Principal Investigator:

Sharlene E. Sing

Forest Service Partners:

Deborah Finch

Richard Reardon – Forest Health Technology Enterprise Team (FHTET)

FHTET Biological Control of Invasive Native and Non-Native Plants funding

RMRS climate change funding

External Partners:

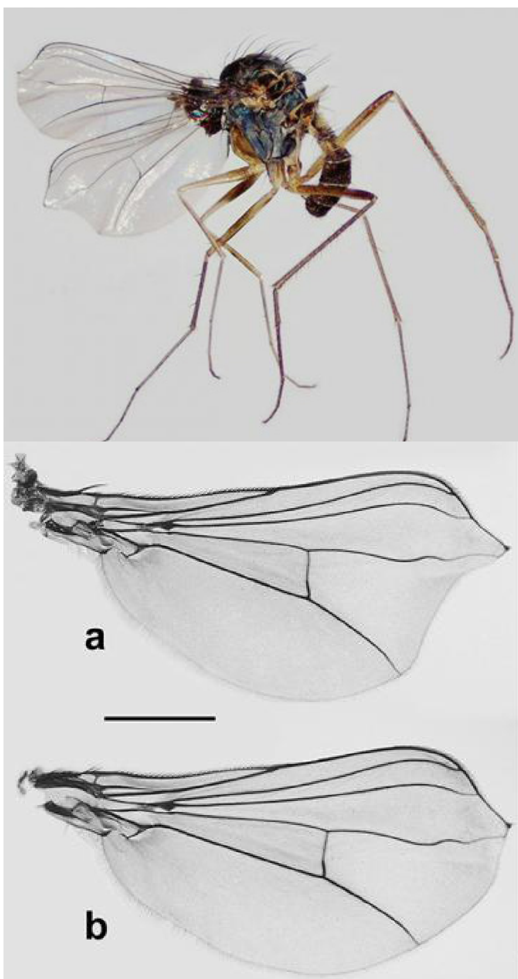
Norma Jean Irish, Robert K.D. Peterson, Jeff Littlefield, and David K. Weaver – Montana State University

Sarah Ward – Colorado State University

Discover the amazing diversity of the long-legged flies

Background

The fly family Dolichopodidae, commonly called long-legged flies, is an extremely abundant and diverse group of insects with more than 1,200 species in North America and more than 7,500 species worldwide. Many undescribed species await discovery. Most adults are smaller than a house fly and of a metallic green or bronze color. Adults and larvae are predators and play important roles in the ecosystems in which they occur.



Approach

The goals of this research are to collect, identify, and describe species and to synthesize relationships and distributions of these flies. Scientist are also providing identifications of species for research collections and scientific studies.

This information is essential if we are to monitor, conserve, and successfully manage public lands – how can we successfully manage lands if we don't know what species occur there, or if we cannot identify them? Further, this taxonomic research and collections are particularly critical in today's era of rapid ecological and climate change and is essential to fully understand and address the effects of invasive species, human use, and climate change on forests and grasslands.

Key Findings

- The long-legged fly *Erebomyia exalloptera* is only known from two places in the Coronado National Forest in Arizona. This unique species has two different shaped wings (Fig. 1).

*Figure 1: Left. The long-legged fly (*Erebomyia exalloptera*).*

Figure 2: Above. Liancalus pterodactyl *is a new species described in 2015.*

Photos: Justin Runyon.

Program Manager Grassland, Shrubland and Desert Ecosystems Science

Deborah Finch, Ph.D.

USDA Forest Service Rocky Mountain Research Station

333 Broadway SE, Suite 115
Albuquerque, NM 87102

voice 505-724-3671
fax 505-724-3688
cell 505-401-0580

http://www.fs.fed.us/rmrs/

http://www.fs.fed.us/rmrs/science-program-areas/grassland-shrubland-and-desert-ecosystems

Writer/Editor
Deborah Finch
dfinch@fs.fed.us

Design/Layout
Andrew Schlabach andrew@alloneplanet.com

- *Liancalus pterodactyl* is a new species collected on waterfalls in the Gallatin National Forest in Montana and described in 2015 (Fig. 2).
- *Liancalus sonorus* is a new species collected on waterfalls in the Coronado National Forest in Arizona (Fig. 3).
- *Hurleyella* is a new genus of long-legged flies discovered in the Jefferson National Forest in southwest Virginia (Fig. 4). Species in this genus are extremely small–a dozen of them can fit on a grain of rice!

Featured Publications

A revision of the Nearctic species of *Liancalus* (Diptera: Dolichopodidae) Runyon, Justin B.; Hurley, Richard L., 2015

Liancalus Loew, 1857 and *Scellus* Loew, 1857 (Insecta, Diptera, DOLICHOPODIDAE): Proposed conservation of the names by designation of *Dolichopus regius* Fabricius, 1805 as type species for *Anoplomerus* Rondani, 1856 [Case 3681] Runyon, Justin B.; Ivie, Michael A.; Evenhuis, Neal L., 2015.

Haromyia, a new genus of long-legged flies from Dominica (Diptera: Dolichopodidae). Runyon, Justin B., 2015.

The Nearctic species of *Telmaturgus* (Diptera: Dolichopodidae) Runyon, Justin B., 2012

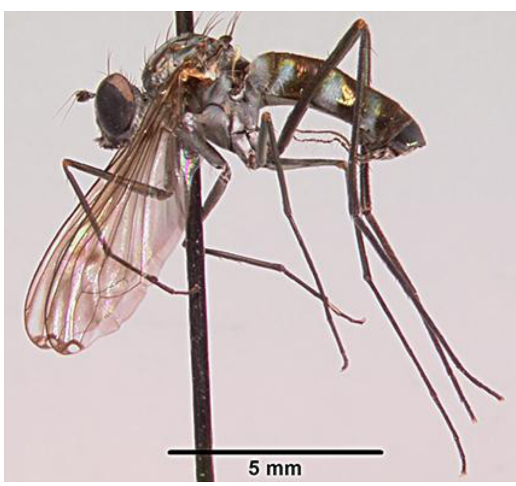


Figure 3: Above. Liancalus sonorus *is a new species of fly discovered in Arizona.*

Figure 4: Right. Hurleyella *is a new genus of long-legged flies. Adults of this species are incredibly small.*

Photos: Justin Runyon.

Principal Investigator:

Justin B. Runyon

External Partners:

Richard L. Hurley - Montana State University

Harold Robinson - National Museum of Natural History-Smithsonian Institution