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Rocky Mountain Research Station

Grassland, Shrubland and Desert Ecosystems Science Program

Ushering in a New Age of Genetics to Restore Lands and Conserve Species

Plant genetic information provides critical knowledge necessary to mitigate the impacts of climate change through ecological restoration. The first step in restoration is recognizing and delineating genetic boundaries at different taxonomic and spatial hierarchies (e.g., species, subspecies and populations). The second step is an assessment of the genetic diversity found within and among populations of a species. "For many of the plants that occupy western North American, little population genetic information is available," says RMRS Director Sam Foster, "which can lead to imperfect matches of plants to environments." These data provide guidance on the health and evolutionary potential of species by understanding the characteristics of their populations, fundamental units of evolution.

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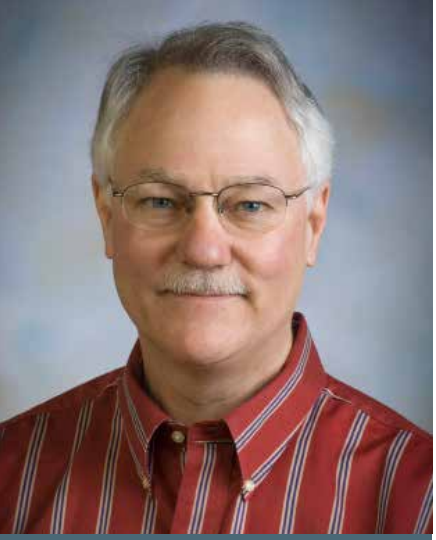
Finally, an evaluation of adaptive traits in common garden trials provides the information needed to infer climatic adaptation and delineate seed transfer zones. Because of the relationships between climate and adaptive trait responses within a species, researchers are able to assess how plant populations could be affected by future climates.

One of the hurdles in restoring big sagebrush is that a disproportionate amount of seed production is from diploid plants, while the disproportionate amount of land that requires restoration is suited for tetraploids. For example, the big sagebrush and clematis stories alert us that successful restoration may depend on the genetic history and climate adaptability of stock which varies greatly among species and subspecies.

As we listen and respond to the call for seeding and restoring big sagebrush ecosystems and other environments after devastating wildfires and to recover populations of greater sage-grouse and other vulnerable species, an important lesson learned from these stories is that the genetics and adaptive responses of species to climate must be factored in when taking landscape restoration actions and in conserving plant and animal species.

Sagebrush ecosystems cover 62 million ha, yet they are in need of restoration to help recover species like Greater Sage-Grouse.

Photo: U.S. Fish and Wildlife Service



G. Sam Foster, RMRS Station Director.
Photo: Forest Service

George "Sam" Foster has been the Director of the Rocky Mountain Research Station since 2008. Dr. Foster oversees the Forest Service's research and development work conducted by more than 90 research scientists in the 14-state area of the Interior West with its headquarters in Fort Collins. Sam is a native of Tennessee and earned his Baccalaureate and Master's Degrees at the University of Tennessee. He earned his Doctorate in Forest Genetics and Silviculture from Oregon State University. Sam began his research career with the forest products industry, working for Weyerhaeuser, Crown Zellerbach, and International Forest Seed Company. He began government service as a research geneticist with the Forest Service's Southern Research Station in Huntsville, AL. Foster's work as a research geneticist took him to 18 foreign countries, and he worked for Hilleshog AB Company headquartered in Sweden, providing seeds for planting new forests in China, India, and the United States. Sam spent three years as the Dean of College of Forest Resources at Mississippi State University in Starkville, and then moved to Washington, D.C., to oversee the Forest Service's silviculture and genetics research.

Conversation with RMRS Director Dr. G. Sam Foster

Is genetics important in restoration?

Absolutely! The genetic makeup of an organism, whether plant or animal, determines how well they will grow, survive and thrive in their environment. If a plant used in restoration is maladapted to its environment, its growth may be inhibited or it may not survive. To ensure successful restoration and healthy populations, matching the genetic constitution of organisms to their environment is very important.

Genetics knowledge has been applied in forestry for many years. What lessons have been learned?

Much knowledge has been developed for trees, and more lessons can be learned as we test new methods and concepts! We have learned that the genetic backgrounds of organisms vary within and between populations of a species, and that it is possible to model survival and growth in new environments based on this variation. In particular, common garden studies and seed source trials are essential methods for identifying adaptive traits of different populations and subspecies. Results of these studies are not intuitive, that is, we can't just know how organisms will respond if grown in a new environment. Also, for long-lived organisms, we know that testing their resiliency over many years is important to determine whether and how well they adapt to drought, frost and rare events. How long the test should be conducted depends on the longevity of the plant.

How can these lessons be applied to restoration practices using native grasses, forbs, shrubs and non-commercial trees?

The field of genecology started in the early 1900's with native species. Foresters adapted methods such as seed source trials to target high priority tree species. The trick is to conduct studies evaluating the entire range of environmental variation across the distribution of the species in question. Genetic diversity of a species across the landscape is critical to its ability to adapt to environmental stressors. For example, chestnut blight wiped out our native chestnut because its populations were not resistant to the exotic disease, and the lack of resistance was linked to low genetic diversity in the specific genes for resistance to the disease.

What are some important restoration goals relative to native species?

Relevant goals include applying science to predict the likelihood that a native species used in restoration can adapt to future environments; understanding and matching the genetic variation and proper seed sources of species to appropriate environments; using such information to conserve rare and endangered species; understanding and conserving the genetic makeup of disjunct populations; and developing knowledge and methods for promoting migration across barriers and preventing extinctions as environments and climates change.

Agronomically developed cultivars are widely used in restoration. Are there concerns about their use?

Well, many cultivars are non-native species which have the potential to replace native plant species. The introduction of cultivars can change the ecology of the system and affect habitat quality. Cultivars typically lack genetic diversity (as they are selected for specific environments) which would likely affect how well they respond to changing conditions.

What are seed transfer guidelines and why are they important?

Seed transfer guidelines are developed from experimental common garden studies and seed source trials that result in models matching genotypes, including adaptive traits, to environments. They enable one to gauge how far a population can be moved and still be well-adapted. After researchers develop these models and seed zones, guidelines are handed off to restorationists for application and to seed growers for commercial use. With the addition of molecular genetic information, seed zone models and transfer guidelines are better than ever.

How do researchers pick species to test?

It is impossible to conduct such studies on all species because there are so many. Criteria for determining which species to study depend on what they are needed for, how useable they are, what environment they will be used in, whether they are commercially important, whether other species need them for survival, or if they are threatened and endangered. The scope of the research project and number of species selected will depend on how critical, economical, widespread, or geographically important the needs and interests are.

"Common garden" experiments are used to assess genetic variation among and within populations. Because plants are grown at the same location - the common garden - the environmental variation is removed or greatly reduced so that the trait and physiological differences expressed in the garden are solely genetic as opposed to a genetic-by-environmental interaction. Typically, multiple populations of species are included in each garden and several gardens in different environments are established to evaluate changes in the organisms' traits according to these environments. A **reciprocal transplant** is a specific type of common garden experiment where each population included in the experiment is transplanted into the all population locations.

Above: Planting bottlebrush squirreltail in a Pacific Northwest Research Station common garden experiment, Powell Butte, OR. Courtesy of Francis Kilkenny

Photo: Matt Horning.

*RIght: Sagebrush showing trait differences (size) due to ploidy. In the background is the diploid (*A. tridentata tridentata*) and in the foreground the tetraploid (*A. tridentata wyomingensis*).*

Photo: Bryce Richardson

Big Sagebrush: Genetic Details Make the Difference

Big sagebrush (*Artemisia tridentata*) is one of the most widespread and abundant plant species in western North America. The ability of this species to occupy sites with a wide climatic and ecological spectrum is partially due to the formation of subspecies, but probably more importantly is its capability to form polyploids (genome doubling). While rare in animals, polyploidy in plants is relatively common. However, the effect of polyploidy on a plant's traits and physiology varies considerably. For many herbaceous species, polyploidy results in a larger plant, but in most woody plants, like big sagebrush, plants are often smaller. For desert plants, reduced size can be a valuable adaptive trait where water is limited. In the case of big sagebrush, polyploids (tetraploids) typically occupy areas with lower rainfall and shallow soils. These characteristics describe many of the basins of the Intermountain West, and may explain why tetraploids are typically more prevalent than their diploid progenitors.

One of the hurdles in restoring big sagebrush is that a disproportionate amount of seed production is from diploid plants, while the disproportionate amount of land that requires restoration is suited for tetraploids. Diploids are frequently found along roadsides where the road grade provides a microclimate for these plants, whereas away from the road tetraploids dominate and produce fewer seed. "These roadside diploid plants are tempting picks for seed collectors", says **Bryce Richardson**, Research Geneticist, Provo, UT "yet the seed industry has had no means of differentiating diploid and tetraploid seeds".

"Understanding the genetic relationships between diploid and tetraploid populations is a fundamental research question that needs to be addressed," says Richardson, "before applications can be designed to distinguish subspecies and populations." Recent research by Richardson and his colleagues have shown that tetraploid populations are likely derived from local or regional diploids and in some areas the tetraploids appear to be of hybrid origin between subspecies tridentata and vaseyana. In this case the taxonomy is misleading, since most tetraploids are considered a single subspecies (*A. tridentata* ssp. *wyomingensis*). Currently, research is focused on using this genetic knowledge to develop a rapid diagnostic test to differentiate between ploidy levels. One potential tool is the use of an electronic nose. This instrument uses sensors that analyze volatiles (smells) from plant samples. Previous research has shown that big sagebrush subspecies, besides being very aromatic, differ in the amount and types of volatiles.

Along with distinguishing subspecies of big sagebrush, understanding how this species is shaped by climate can greatly influence management decisions for current and future restoration, says Richardson. Populations are a fundamental unit of evolution, and it is essential for restorationists to align a plant population's adaptive capacity to its climate niche. Analyzing adaptive traits in common gardens and assessing genetic diversity and structure of populations provide the information to reach this goal. Ongoing work in big sagebrush suggests that tetraploid populations vary in their adaptive capacity to cold temperatures and precipitation. When planted in a cold dry site, plants from warmer and higher precipitation areas performed poorly and had higher mortality than plants from colder drier sites. This ongoing research suggests movement of seed will have to be evaluated to ensure successful restoration.

For more information, see the following publication:

Richardson, Bryce A.; Page, Justin T.; Bajgain, Prabin; Sanderson, Stewart C.; Udall, Joshua A. 2012. Deep sequencing of amplicons reveals widespread intraspecific hybridization and multiple origins of polyploidy in big sagebrush (*Artemisia tridentata, Asteraceae*). American Journal of Botany. 99(12): 1962-1975.

Top: Clematis sibirica
Middle: Clematis songorica

Photos: H. X. Zhang

Bottom: Native stand of bluebunch wheatgrass, Little Jack's Creek Research Natural Area, southern Idaho.

Photo: Bureau of Land Management

Established plant communities with high bluebunch wheatgrass abundance have been shown to resist invasion by cheatgrass, which reduces diversity and leaves communities more fire-prone. At present, bluebunch wheatgrass is seeded on thousands of acres annually, using only a small number of seed sources that represent a subset of the species-wide genetic diversity.

Retreat or Stand: How Two Species Face Climate Change

Climatic change is expected to affect individual taxa in different ways, as exemplified by the contrasting behaviors of two Clematis (virgin's bower) species from northwest China in Central Asia, under past and present, and projected future climates. *Clematis sibirica* is an understory species found in montane conifer forest areas, while *C. songorica* is a species of steppe (arid grassland). They were studied by a combination of molecular phylogeography and species distribution modeling. Phylogeography is the use of information about the genetics and phylogeny of a species to cast light on its past geographic expansions and contractions.

"*Clematis sibirica* was found to show a significant phylogeographic signal," says **Stewart Sanderson**, a GSD volunteer, co-investigator and co-author on the resulting journal article, "with genetic evidence of having experienced demographic contractions and expansions during the Pleistocene. In contrast, *C. songorica* has had a stable range distribution during the same time period."

Under a projected future climate with higher temperatures and more variable precipitation, responses indicate moderate range reductions for the understory montane species, but continued stability for the drought adapted steppe plant. In a warmer and sometimes drier climate, the montane species, which is more moisture dependent, would therefore be restricted to higher altitudes owing to its greater vulnerability to climate change than the steppe species. These results suggest that increased management attention should be paid to *Clematis sibirica*.

For more information, see the following publication:

Zhang, Hong-Xiang; Zhang, Ming-Li; Sanderson, Stewart C. 2013. Retreating or standing: Responses of forest species and steppe species to climate change in arid eastern central Asia. PLoS ONE. 8(4): e61954. doi:10.1371/journal.pone.0061954. http://www.plosone.org/article/info:doi/10.1371/journal.pone.0061954

Testing Seed Zones for a Key Restoration Species: Bluebunch Wheatgrass

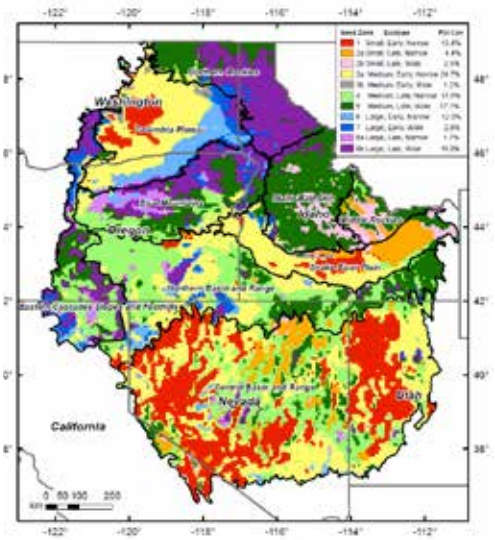
The use of native plants in wildland restoration is critical to the recovery and health of fire-prone ecosystems and to enhance ecosystem resilience in the face of climate change. Seed zones and seed transfer guidelines developed from common garden studies ensure that adapted plant material is seeded and may be particularly important for the long-term resilience of re-established native plant populations. Seed transfer guidelines can also help land managers select plant material that is most likely to be adapted to future climates.

Recently completed research by Brad St. Clair and Francis Kilkenny, USFS PNW (the latter soon RMRS) and their collaborators (RC Johnson, ARS; **Nancy Shaw**, RMRS; and George Weaver, OSU) provided seed zones for bluebunch wheatgrass (Pseudoroegneria spicata), one of the most widespread bunchgrasses in rangeland and forested ecosystems of the interior western United States and the most widely used native grass in restoration seedings. They used a common garden approach to explore genetic variation in adaptive traits. Bluebunch wheatgrass populations from arid source environments were smaller with earlier phenology and narrower leaves than those from more mesic environments. Later phenology was generally associated with populations from colder climates. Differences among native populations associated with source climates indicated that genetic variation across the landscape is adaptive and should be considered during restoration. Their results were used to delineate seed transfer zones and population movement guidelines to ensure adapted plant materials for restoration activities.

Seed zones have been used extensively and successfully in forestry. Genecology research with herbaceous plants is recent and its application limited, in part because managers lack experience and confidence in the use of seed zones for the selection of native plant materials. To test the effectiveness of the proposed seed zones, Francis Kilkenny, Brad St. Clair and Bryce Richardson (RMRS) have initiated a reciprocal planting study of bluebunch wheatgrass in the Great Basin and Interior Pacific Northwest. Results will

evaluate adaptation of plant populations to their local environments. Inclusion of extreme environments will determine how plants will respond to future climate change.

St.Clair, J.B.; Kilkenny, F.F.; Johnson, R.C.; Shaw, N.L.; Weaver, G. Genecology and seed transfer zones for *Pseudoroegneria spicata* (bluebunch wheatgrass) in the inland northwestern United States. Evolutionary Applications in press.



Bluebunch wheatgrass seed zone map (St.Clair et al. in press).

Bluebunch wheatgrass common garden experiment at the Lucky Peak Forest Service Nursery near Boise, Idaho.

Photo: Nancy Shaw

Symposium Announcements

Paulette Ford, RMRS-GSD and Justin Derner, ARS will be hosting a special symposium titled, "**Challenges and opportunities for Western rangeland restoration under a changing climate,"** at the upcoming Society for Ecological Restoration: 5th World Conference on Ecological Restoration- Reflections on the Past, Directions for the Future, Madison, Wisconsin, USA, October 6-11, 2013.

Speakers will address key challenges and opportunities for restoration of Western rangelands in terms of ecosystem changes and management practices, drought and interactions with grazing, use of genetic information to mitigate negative effects of a changing climate, modifications in wildlife population and distribution, responses to wildfire and post-wildfire restoration efforts, and changing plant-herbivore interactions that impact biocontrol of invasive plants.

Jeremy Pinto (RMRS-GSD) will be hosting a symposium session, **"Using target seedlings to maximize restoration success,"** at the upcoming Society for Ecological Restoration: 5th World Conference on Ecological Restoration- Reflections on the Past, Directions for the Future, Madison, Wisconsin, USA, October 6-11, 2013.

This symposium focuses on the Target Plant Concept (TPC) and provides a research-based, restoration-focused means of overcoming critical barriers to seedling establishment and growth after outplanting. Examples will draw upon past experiences, research results, and case studies to help participants effectively use the TPC for future restoration challenges.

Megan Friggens, RMRS-GSD **and Deborah Fi**nch, RMRS-GSD will be hosting a special symposium session, "**Predicting disturbance impacts under climate change,"** at the upcoming The Wildlife Society 20th annual conference in Milwaukee, Wisconsin, October 5-9, 2013.

The purpose of the symposium will be to highlight recent advances to predict future conditions and impacts arising from the interaction of climate change and disturbance processes and identify how these methods and new knowledge improve wildlife species management and conservation.

Prepping for planting: University of Idaho students learn about the cultural and ecological value of native plants being used for restoration on Mauna Kea.

Photo: Jeremy Pinto

Dr. Peng Zhang, Northeast Forestry University, Harbin, China, is a visiting professor at the RMRS Moscow Lab.

Photo: Kas Dumroese

People and Events

Native Hawaiian Culture and Ecology, a Service Learning Experience

Research Plant Physiologist **Jeremy Pinto** (RMRS, Moscow), was recently invited for the second year, and had all expenses paid, to co-instruct a 6-day-long University of Idaho (UI) class on Native Hawaiian Culture and Ecology. Jeremy was selected because of his expertise in native plants, research experience in Hawaii, Director of the Intertribal Nursery Council as part of the National Reforestation, Nurseries, and Genetics Resources Team, and because he is a member of the Navajo Nation. Anthony Davis (UI Assistant Professor) and Art Taylor (UI Tribal Liaison; Nez Perce Tribal member) were also instructors for the course held on the Big Island of Hawaii. The class was designed as a service learning experience for Native American students giving them the opportunity to participate in restoration projects while simultaneously learning about Hawaii's unique ecology, climate, and culture. Upon returning from the trip, students gave a well-attended, public presentation sharing their journey of learning, volunteering, self-exploration, and cultural exchange from mauna (the mountain) to makai (the sea). Several returning students from last year's course emotionally shared how transformational their previous experience was, and how they are now pursuing undergraduate and graduate degrees in natural resource areas and working with native plants.

RMRS Moscow Hosts International Scientists

Jeremy Pinto and **Kas Dumroese**, research plant physiologists, RMRS Moscow, hosted Katri Himanen, a seed researcher at the Finnish Forest Research Institute, Suonenjoki, for 10 days in early April. Katri presented their collaborative seed research at the National Native Seed Conference in Sante Fe, and then visited tribal facilities in New Mexico and Arizona before touring the Forest Service Bend Seed Extractory in Bend, Oregon. In addition, Dr. Peng Zhang, Professor of Silviculture at Northeast Forestry University in Harbin, China, arrived in late March and will work with Pinto and Dumroese for a year in their research facility. Dr. Zhang's focus is on improving reforestation efforts in China, working on collaborative research with Pinto and Dumroese, learning their techniques for physiological assessment of nursery plants produced for restoration, and improving his language skills.

Pinto, Williams, and Dumroese Co-organize Assisted Migration Workshop

Jeremy Pinto and **Kas Dumroese**, research plant physiologists, RMRS Moscow, and **Mary Williams**, post-doc ecologist with Michigan Technological University but stationed with RMRS Moscow, co-organized a recent workshop with Dr. Anthony S. Davis at the University of Idaho Center for Forest Nursery and Seedling Research. Held February 21 in Portland, Oregon, the one-day international workshop, **Assisted Migration: A Primer for Reforestation and Restoration Decision Makers**, was co-hosted by the University of Idaho, the Western Forestry and Conservation Association, and RMRS Science Applications. Topics included the ethical ramifications and legality of employing assisted migration, the process of deciding when and where to (and not to) actively migrate plant materials, landscape variation in adaption and implications for managing ecosystems for future climates, practical application of assisted migration through adjustments to seed transfer guidelines, and landscape genomics. Dumroese and Pinto served as moderators, and Pinto also facilitated a lively audience-panelist discussion. Because of time and travel restrictions, the program was also recorded and is available on-line.

Left to right: Marcus Warwell (RMRS), Mary Williams (Michigan Technological University and RMRS), Jeremy Pinto (RMRS), Kas Dumroese (RMRS) and Olga Kildesheva (University of Idaho) discuss the morning presentations.

From Left to Right: Nancy Shaw, RMRS-GSD, Peggy Olwell, BLM and Wayne Padgett, BLM.

Photo: Olivia Kwong

CCRC Takes on Grasslands

RMRS Scientists Karen Bagne, Paulette Ford, and Matt Reeves prepared the new topic page "Grasslands" for the USDA Forest Service Climate Change Resource Center (CCRC). The Climate Change Resource Center is a reference Web site for resource managers and decisionmakers who need information and tools to address climate change in planning and project implementation. The CCRC addresses the manager's question "What can I do about climate change?" by providing information about basic climate sciences and compiling knowledge resources and support for adaptation and mitigation strategies. Click here: http://www.fs.fed.us/ccrc/topics/grasslands/index.shtml.

Restoration Genetics Was Big at the National Native Seed Conference

RMRS was a major participant in the National Native Seed Conference held April 8-11, 2013 in Santa Fe, New Mexico. The event focused on restoration genetics, seed zone delineation and application, options for adapting seed zones for climate change, and ecological restoration technologies and strategies for re-establishing native communities with resistance to weed invasion and resilience following disturbance. About 260 attendees represented research, land management and private sector native seed industry and restorationists. Twelve members of the Grassland, Shrubland and Desert Ecosystems Science Program made oral or poster presentations, including: Bryce Richardson, Stan Kitchen, Rosemary Pendleton, Burt Pendleton, Susan Meyer, Nancy Shaw, Matthew Fisk, Jeffrey Ott, Kas Dumrose, Mary Williams, Jeremiah Pinto and Scott Jensen. In addition, Nancy Shaw, Team Leader for the Great Basin Native Plant Selection and Increase Project, was honored by stakeholders with a special gift, a pueblo handmade pot.

From Ashes to Education and Desert Restoration

RMRS-Boise, Idaho staff of the Grasslands, Shrublands, and Desert Ecosystems Science Program is assisting the U.S. Bureau of Land Management and private, local, and state agencies with a unique demonstration project in the Boise area. The Healthy Hills Initiative (http://healthyhills.org) is working to restore a native desert sagebrush site of a 2009 fire that burned 200 acres of the northwestern Boise foothills. With educational lessons and restoration advancement in mind, the RMRS collaborator with this effort, Alexis Malcomb, with assistance from Robin Bjork, has focused on kid energy. Local school and church groups from diverse backgrounds, cultures, and education levels are brought to Healthy Hills where first they are given a talk about wildfire, the importance of native plant communities, and how to plant the delicate little seedlings. Then, with a little adult oversight, they spend part of a day with hoe and spade in-hand working in teams to plant the seedlings across a delineated area. While experiencing fresh air and exercise in the foothills, to date, 32 kids ranging from 12 to 17 years of age have participated in planting over 1300 native grass, forb, and shrub seedlings on two planting days. In the future, these kids and their families can return to the Healthy Hills for recreation and with satisfaction in remembering they were a part of the restoration. Healthy Hills can also be found on Facebook (https://www.facebook.com/pages/Healthy-Hills-Initiative/212602768776916).

Healthy Hills volunteers planting shrubs to restore a sagebrush site.

Photo: Alexis Malcomb

Dr. Francis Kilkenny has accepted a Research Biologist position at the RMRS Boise Lab.

Photo: USDA Forest Service

Jeff Ott, new postdoc Research Geneticist, RMRS Boise Lab.

Photo: USDA Forest Service

New Scientists in the Great Basin Native Plant Selection and Increase Project

Dr. Francis Kilkenny has accepted the GSD Research Biologist position and will start in June 2013. He received his Bachelor's in Environmental Studies with Honors from the University of California at Santa Cruz, CA; his Certificate of Study in Geographical Information Systems and Remote Sensing from Humboldt State University, Arcata, CA, where he was a Mark B. Rhea Fellow; and his Ph.D. in Biology from the University of Virginia in Charlottesville, VA, where he was a Presidential Fellow. His research interests have included impacts of climate change on native and invasive plant species; the evolution of local adaptation in native and invasive plant species; pollination biology of herbaceous and long-lived clonal plants; evolutionary consequences of density and intraspecific competition; fundamental niche modeling and the projection of species range shifts due to climate change. His Ph.D. focused on the evolution and population genetics of the invasive vine Japanese honeysuckle in eastern North America, where he found that populations at the northern margin of the invaded range are evolving faster growth rates. As a post-doctoral Research Geneticist with the Forest Service Pacific Northwest Research Station from 2011-2013, he studied the adaptation of native grass populations to local climates.

Dr. Jeff Ott, Research Geneticist, joined the RMRS Boise lab recently as a post-doc working with Dr. Nancy Shaw, Research Botanist. Jeff has a broad background in plant ecology and has worked in the Southeast U.S. and Brazil as well as the Intermountain West. He previously worked intermittently at the RMRS Provo lab where he carried out his master's research on the effects of seeding and chaining following wildfires in Utah. He subsequently earned a PhD from the University of North Carolina where he developed novel techniques for multivariate analysis of vegetation data. Jeff is currently researching the effectiveness of rangeland drill techniques for seeding native plants in sagebrush communities, and will be participating in a pending study evaluating seed-transfer zones for bluebunch wheatgrass.

New Books and Reports

Forest Landscape Restoration: Integrating Natural and Social Sciences was recently published by Springer. This book provides an integrated and multidisciplinary view of forest landscape restoration, which has emerged in developing countries because the approach is both large-scale and focused on meeting human needs. John Stanturf (SRS) was lead editor of the book that brings together experts in landscape studies, natural resource management and forest restoration, together with those experienced in conflict management, environmental economics and urban studies. Dr. Kas Dumroese (GSD) co-wrote "Challenging a Paradigm: Toward Integrating Indigenous Species Into Tropical Plantation Forestry" with Dr. Anthony Davis at the University of Idaho and Dr. Douglass Jacobs at Purdue University. The book reflects information presented at an International Union of Forest Research Organizations (IUFRO) meeting held in Seoul, South Korea, that was organized by Stanturf with funding from the Korea Forest Research Institute and Forest Service Research and Development. All together 105 authors from 12 countries were involved.

Shaw, N. L., and M. Pellant. 2013. Great Basin Native Plant Selection and Increase Project 2012 Progress Report. USDA Forest Service and USDI Bureau of Land Management, Boise, ID. 259 p. http://www.fs.fed.us/rm/boise/research/shrub/GBNPSIP/GBNPSIPAnnualReports.shtml

Research progress in the areas of genecology, cultural practices for native seed production, and ecological restoration is described in 35 reports submitted by collaborators on this project. Aims of the USDI Bureau of Land Management funded program are to improve the availability of native plant materials and provide the knowledge and technology required for their use in restoring diverse native plant communities in the Great Basin.

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New Publications Available Online

Boiling water scarification plus stratification improves germination of *Iliamna rivularis* (Malvaceae) seeds. Himanen, Katri; Nygren, Markku; Dumroese, R. Kasten. 2012. Native Plants Journal. 13(3): 244-254. Online: http://www.treesearch.fs.fed.us/pubs/42762.

Breeding system and interaccessional hybridization of *Purshia tridentata* plants grown in a common garden. Rosemary L. Pendleton, E. Durant McArthur, and Stewart C. Sanderson. 2012. Western North American Naturalist 72(2): 241–249. Online: http://www.treesearch.fs.fed.us/pubs/41388

Ecosystem resilience despite large-scale altered hydroclimatic conditions. G.E. Ponce Campos, M.S. Moran, A. Huete, Y. Zhang, C. Bresloff, T.E. Huxman, D. Eamus, D.D. Bosch, A.R. Buda, S.A. Gunter, T.H. Scalley, S.G. Kitchen, M.P. McClaran, W.H. McNab, D.S. Montoya, J.A. Morgan, D.P.C. Peters, E.J. Sadler, M.S. Seyfried & P.J. Starks. 2013. Nature 494: 349-353. Online: http://www.treesearch.fs.fed.us/pubs/43187.

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Developing a model framework for predicting effects of woody expansion and fire on ecosystem carbon and nitrogen in a pinyon-juniper woodland. Rau, B. M.; Tausch, R.; Reiner, A.; Johnson, D. W.; Chambers, J. C.; Blank, R. R. 2012. Journal of Arid Environments. 76:97-104. Online: http://www.treesearch.fs.fed.us/pubs/39878.

Extreme precipitation patterns and reductions of terrestrial ecosystem production across biomes. Y. Zhang, M.S. Moran, M.A. Nearing, G.E. P. Campos, A.R. Huete, A.R. Buda, D.D. Bosch, S.A. Gunter, S.G. Kitchen, W.H. McNab, J.A. Morgan, M.P. McClaran, D.S. Montoya, D.P.C. Peters, and P.J. Starks. 2013. J. of Geophysical Research: Biogeosciences 118: 1–10. Online: http://www.treesearch.fs.fed.us/pubs/43259

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