



USDA Forest Service

GSD Update

Rocky Mountain Research Station
Grassland, Shrubland and Desert Ecosystems Science Program

Year in Review: Spotlight on 2012 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 Ecosystem Science Program (GSD) that depict its strengths and focus areas. Significant results of recent research and science applications by GSD scientists are highlighted. We identify where program research lines up with the strategic priorities of the USDA Forest Service and the Rocky Mountain Research Station (RMRS). In particular, we spotlight accomplishments in:

- Understanding and controlling invasive plant species
- Assessing changes in ecosystems and landscapes caused by disturbances and stressors such as fire, climate change and their interactions
- Evaluating methods to monitor and recover rare native species and biodiversity
- Developing approaches for restoring ecosystems and landscapes to improve their resiliency.

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INVASIVE SPECIES

Unwanted Side Effects of Roads: Invasive Species

Burning and thinning treatments are being increasingly used in Western forests to manage insects, manage disease, and reduce wildfire hazards. "Unfortunately," says Dr. Justin Runyon, RMRS Research Entomologist, Bozeman, MT, "these tools can trigger the invasion and spread of invasive non-native plants which could thwart successful restoration efforts". Land managers need to be aware of this potential unwanted side-effect and need to be armed with the knowledge to best monitor and treat weeds following restoration. However, the effects of these activities on the introduction and spread of invasive plants are not well understood. A recently published, long-term RMRS study at Tenderfoot Experimental Forest in Montana helps shed some light on the issue. Study partners include Montana Conservation Corps and Montana Department of Agriculture.



Invasive Species and Roads
Photo: Justin Runyon



Hybrid toadflax detail, near Boulder, MT.
Photo: Sharlene Sing



Setting up a Montana replicate of a common garden study at the Bozeman Forestry Sciences Lab.
Photo: Sharlene Sing

In the study, the occurrences of noxious weeds were monitored following thinning and burning treatments in a lodgepole pine forest in central Montana. Surveys were made in the treatment units and along roads for two shelterwood-with-reserve prescriptions, each with and without prescribed burning, burned only, and untreated controls. Five species listed as noxious weeds in Montana were recorded: spotted knapweed (*Centaurea stoebe*), oxeye daisy (*Leucanthemum vulgare*), Canada thistle (*Cirsium arvense*), common tansy (*Tanacetum vulgare*), and houndstongue (*Cynoglossum officinale*). "With the exception of Canada thistle", says Runyon, "noxious weeds were confined to roadsides and did not colonize silvicultural treatment areas which highlights the importance of roads for weed distribution and spread, and it suggests that roadways should be considered when evaluating the potential for invasion of exotic plants following restoration treatments. In this forest, weed control along adjacent roads and in heavily disturbed areas such as slash piles may be a cost-effective and efficient tactic to limit exotic plant invasion."

Many questions remain and more research is needed on this topic. For example, the Montana forest studied here is relatively weed-free and it is unclear if these findings can be extended to more heavily invaded forests or forests containing other weed species. It is clear that monitoring invasive plants, within treated areas and along roads, should be a component of forest restoration.

Publication findings from this study can be found at: <http://www.treearch.fs.fed.us/pubs/37963>

How Bad Weeds Get Worse: Hybrid Toadflax

Dalmatian toadflax (*Linaria dalmatica*) and yellow toadflax (*L. vulgaris*) are aggressive and highly prolific invaders that are difficult to control. Both species are propagated via cross-pollination, by seed, and vegetatively, through root buds. Significant competitive advantages are conferred on these species by dual reproductive modes, abundant seed production, and broad ecological tolerances. Successful chemical control of these toadflaxes is significantly limited by accurate timing of application to vulnerable plant phenological stage, and further influenced by environmental conditions. So how much worse would things get if these species could hybridize and produce fertile offspring?

Naturally occurring hybridization between yellow and Dalmatian toadflax was first confirmed in 2008 in plants collected from two sites in Montana. A common garden experiment replicated in Colorado and Montana in 2009-10 was initiated by Dr. Sharlene Sing, RMRS Research Entomologist, Bozeman, MT in collaboration with Colorado State University (CSU) to compare the fitness of toadflax hybrids with that of the two parental species. A range of artificially produced hybrid genotypes was evaluated, in addition to the field-collected confirmed hybrids. CSU partner Dr. Sarah Ward generated hybrids through greenhouse hand-pollinations with either yellow or Dalmatian toadflax as the maternal parent. These hybrids were additionally back-crossed to one of the two parental toadflax species.



Sharlene Sing examining small patch of hybrid toadflax near Boulder, MT.
Photo: Sharlene Sing



Cheatgrass races from different environments flower at different times in the greenhouse (lefthand planter box: sagebrush steppe race; central planter box: mountain race; righthand planter box: warm desert race).

Credit: Susan Meyer

“Lack of a cheatgrass problem in the past is no longer a guarantee that an ecosystem is at low risk for future invasion.”

Total above-ground dry biomass, along with number of flowering stems and seed capsules were significantly higher for all hybrid classes than for yellow or Dalmatian toadflax. Moreover, the naturally-occurring hybrids from Montana were larger, with higher rates of seed germination and earlier emergence than all other hybrid or parental genotypes evaluated. Mortality in the Montana common garden over the two year study period was lowest among the hybrid plants originating from Montana field sites. Across all traits evaluated, hybrids performed as well or better than either parental species. The superior performance of the naturally occurring hybrids in the Montana common garden plot strongly suggests that fitness and performance of these individuals was further enhanced by adaptation to local environmental conditions. “Simply put, the implication of these findings to managers”, says Dr. Sing, “is that hybrid toadflax is decidedly more fit and therefore likely more competitive than either Dalmatian or yellow toadflax, especially where hybridization is naturally occurring”.

“These results clearly identify hybrid toadflax as a new type of aggressively competitive invader threatening Western rangeland”, asserts Sing. “Under the influence of climate change, heterosis (‘hybrid vigor’) may become an increasingly worrisome factor in the war on weeds.” The obviously superior fitness of hybrid toadflax suggests that forest and range visitors and stewards need to know that it is a force to be reckoned with. Identifying alternatives to herbicide application may be particularly important for maintaining native floral biodiversity under increasingly challenging environmental influences.

These results were initially reported by Dr. Marie Turner, CSU, in her doctoral dissertation, “Viability and Invasive Potential of Hybrids between Yellow Toadflax (*Linaria vulgaris*) and Dalmatian Toadflax (*Linaria dalmatica*)”.

Is All Cheatgrass Created Equal?

Cheatgrass (*Bromus tectorum*) has been a serious weed in sagebrush ecosystems of the interior West for more than a century, and is associated with greatly increased fire frequency and subsequent conversion to near-monocultures of this weedy annual grass. More recently, this invasive species has become

problematic in mountain ecosystems such as ponderosa pine forest and also in more extreme desert environments previously thought to be outside its range of adaptation. “Our studies on the population genetics of cheatgrass,” says Research Ecologist, Dr. Susan Meyer, Shrub Sciences Lab, Provo, Utah, “have shown the races that can invade these novel environments are often genetically distinct from the ‘cottage-variety’ cheatgrass that dominates in the sagebrush steppe”. Meyer’s collaborators include Craig Coleman, Brigham Young University; Elizabeth Leger, University of Nevada Reno; Steven Novak, Boise State University; Richard Mack, Washington State University; Keith Merrill, North Carolina State University

Comparisons with cheatgrass populations from across the native Eurasian range indicate that the new invaders of more extreme desert environments are not closely related to the northern European source populations where the first wave of invasion originated. Instead, their closest relatives are found in the warm deserts of Turkmenistan, Iran, and southern Afghanistan. Exactly when these new invaders arrived in North America is not yet known. The differences between cheatgrass races from northern Europe and warm desert races from southcentral Asia are dramatic, according to Meyer. For example, warm desert races are adapted to short, warm winters, and flower much earlier than their sagebrush steppe relatives. These findings are relevant to land managers throughout the interior Western region and will make an important contribution to our ability to predict cheatgrass invasion patterns in response to current and future climate. Meyer contends, “Lack of a cheatgrass problem in the past is no longer a guarantee that an ecosystem is at low risk for future invasion. This knowledge will enable management for cheatgrass control at the early stages of invasion, before massive ecosystem damage occurs”.

Publication findings from this study can be found at:

www.treesearch.fs.fed.us/pubs/39162

www.treesearch.fs.fed.us/pubs/40576

Working Together to Find Management Solutions for Invasive Brome Grasses

Scientists have formed a collaborative network to develop a basic understanding of the factors that determine the distributions and abundances of invasive brome grasses and to integrate that information into predictive modeling and management

Exotic grasses in the genus *Bromus* are among the most damaging invasive plants in the western United States. The most notorious is cheatgrass (*Bromus tectorum*) which is highly adapted to the cold-wet winters and long-hot summers of the Intermountain Region and can out compete native species for early season moisture. The fine fuels that it adds to these ecosystems promote fire spread, and can result in grass-fire cycles that provide positive feedbacks to its continued invasion. Red brome (*B. rubens*; syn: *madritensis*) has been expanding in the Mojave Desert with impacts similar to those of cheatgrass, and Japanese brome (*B. japonicus*) and smooth brome (*B. inermis*) pose increasing threats to native ecosystems in higher elevation and more mesic areas. Progressive conversion of native ecosystems to *Bromus* dominance is altering fire regimes, decreasing ecosystem services, and placing native species at risk.

To increase understanding of the causes of invasion and to develop restoration and management solutions", says Dr. Jeanne Chambers, Research Ecologist, Reno, NV, "we formed the *Bromus* Research, Education, and Extension Network (REENet), a USDA National Institute of Food and Agriculture Program that fosters communication and collaboration among *Bromus* experts." *Bromus* REENet uses a blend of cross-disciplinary syntheses, modeling and prediction to develop innovative research studies and extension activities. Questions being addressed by working groups include:

- How will *Bromus* species distributions change under current and future climates?
- Are there environmental or ecological conditions that make ecosystems resilient to disturbance and resistant to *Bromus* species?
- What are the most appropriate restoration and adaptive management tools?
- How can we best communicate this information?

A major emphasis is on developing and sharing information. A database has been constructed on the existing distributional, biological, and ecological information on invasive bromes. And syntheses are being prepared on the roles of environmental conditions, native plant communities, genetics, pathogens, and disturbance in mediating *Bromus* invasions and on viable restoration and management approaches for *Bromus* species. Networking and information sharing is accomplished via a website and internet chatroom, in-person meetings and symposia, and webinars. Both communication and multi-partner activities are greatly enhanced through close ties to regional collaborative organizations, like the Great Basin Consortium, (<http://environment.unr.edu/consortium>), regional research projects like the Sagebrush Treatment Evaluation Project (www.SageSTEP.org) and outreach efforts like the Great Basin Science Delivery Project (www.gbfireshci.org). Additional information on the *Bromus* REENet project can be found at <http://greatbasin.wr.usgs.gov/GBRMP/bwg.html>.

DISTURBANCES AND STRESSORS, FIRE AND CLIMATE CHANGE

Multi-century Fire Regime Forensics: The Past as a Guide for Restoring Landscape Resilience

A thorough understanding of historic disturbance regimes and their effects on vegetation is necessary for successful wildland management. Fire histories developed from analyses of tree-ring injuries, or fire scars, and tree establishment patterns provide an effective means to measure past variation in fire regimes at various scales of time and space. When tree-ring-based forest histories are constructed in concert with fire histories they allow examination of linkages between fire regimes and vegetation dynamics, according to Dr. Stan Kitchen, RMRS Research Botanist, Provo, UT. Dr. Kitchen teamed with Emily Heyerdahl (RMRS, FFS); Peter Brown (Rocky Mountain Tree Ring Research); Fishlake National Forest; USDI Bureau of Land Management, Utah Office; and USDI Great Basin National Park to use tree-ring evidence to develop multi-century fire and forest establishment histories representing

"To increase understanding of the causes of invasion and to develop restoration and management solutions we formed the *Bromus* Research, Education, and Extension Network (REENet)."



Multiple fire scars in a ponderosa pine stump used to calculate multi-century variation in surface fire frequency in what is presently a pinyon-juniper woodland

Photo: Stanley Kitchen

broad gradients in elevation and vegetation for 14 sites in Utah and eastern Nevada. Vegetation included pinyon-juniper woodland, mountain shrubland, and ponderosa pine, dry mixed-conifer, aspen, aspen-conifer and subalpine-conifer (spruce, fir and pine) forest types. Fire regime analysis included frequency, severity and extent. According to Dr. Stan Kitchen, RMRS Research Botanist, Provo, UT, "Results revealed that before 1900, fire frequency and severity varied significantly over short distances and through time." The variable, mixed-severity fire regime maintained shifting vegetation mosaics as fire-tolerant tree species responded to periods of high-frequency, low-severity fire while fire-sensitive species were restricted to areas of low-frequency (often high-severity) fire. The sharp decline in fire occurrence that began in the late 1800's resulted in an increase of fire-sensitive conifers, including an expansion of trees to previously non-forested mountain shrublands. These vegetative changes result in greater fuel loads and fuel continuity increasing risk for large, high-severity fires uncharacteristic of those documented for historic conditions. Managers use information from this study, including site-specific variation in fire frequency, severity and extent as well as historic vegetation composition and structure, for planning and implementation of the fire and fire-surrogate treatments necessary to restore resilient landscapes in Utah and eastern Nevada.

Publications are available at:

<http://www.treeseearch.fs.fed.us/pubs/41573>
<http://www.treeseearch.fs.fed.us/pubs/39737>
<http://www.treeseearch.fs.fed.us/pubs/36304>
<http://www.treeseearch.fs.fed.us/pubs/29486>

Why Are Sagebrush and Woodland Landscapes Changing?

Anthropogenic disturbance and its influence on vegetation, plus ongoing woodland expansion, have had a significant influence on the biogeochemical cycling and soil properties in Great Basin sagebrush and woodland ecosystems. Particularly important is an understanding of the effects of these successional changes on the above and below ground carbon and nitrogen levels, both before and after fire, and the resulting changes in carbon levels and dynamics.

Results from both local (Underdown Canyon, NV) and regional (SageSTEP Project sites in Nevada and Utah) studies show that on the sample plots with low tree cover about 90% of the estimated C and N was stored in the top ½ meter of the soil. After tree dominance was reached over 50% of the estimated ecosystem C and 13% of the estimated ecosystem N were in the above ground biomass. With tree dominance wildfire can convert these systems from carbon sinks to carbon sources. Given the potential future changes in climate, the increasing frequency of large wildfires, and the associated loss of native perennial vegetation most current estimates of potential future above ground and below ground storage of organic C and N should be viewed with skepticism.

Research results provide improved understanding of the dynamics over time in the above and below ground storage of C and N with successional changes in these ecosystems that are potentially useful for estimating the C source and sink tradeoffs in the Great Basin woodlands with different management scenarios. With better understanding of the C and N dynamics in these Great Basin ecosystems, decisions can be more effective for managing the long-term outcomes of carbon dynamics.

Relevant Publications include:

<http://www.treeseearch.fs.fed.us/pubs/39878>
<http://www.treeseearch.fs.fed.us/pubs/36179>





A flood dominated watershed characterized by a highly dynamic stream channel and disturbance-tolerant woody vegetation.

Photo: Jeanne Chambers

Shrub Expansion, Fire, Carbon and Climate Change in Southwestern Grasslands

In the Southwest, shrubs are expanding into grasslands, changing landscapes. Overgrazing, fire suppression, and climate change are causing this change, as shrubs move into grasslands. Fire is an important management tool in grassland ecosystems. Given the uncertainty of future scenarios for climate change and climate variability in the southwestern US we need to know how fire along with climate variability and climate change will affect ecosystem function. The consequences of shrub encroachment include loss of plant species diversity and altered soil C and N dynamics. Paulette Ford, Research Ecologist, Albuquerque, NM is collaborating with scientists at Long-Term Ecological Research sites to conduct a multifaceted research program that addresses the individual and combined impacts of fire, shrub encroachment, precipitation variability, and warming on arid grassland C and N dynamics. The goal is to use field experiments moving intact soil cores with blue grama across a climatic gradient to simulate climate change and measure carbon and nitrogen fluxes in arid grasslands across this geographic (climatic) gradient. Our study sites are arrayed along a latitudinal gradient from northeastern Colorado, to northeastern New Mexico (Kiowa National Grassland), central and southern New Mexico and are located on three Long-Term Ecological Research Sites. Thus far, 28 of 40 soil cores have been excavated (Photo).

Once all soil cores are created, pre-treatment data will be collected for an initial measurement of aboveground grass dimensions and soil enzyme activity. Soil collars will be installed within the cores to measure soil C and N fluxes. Cores will then be placed in assigned locations. Once transplanted, the team will monitor plant growth throughout the growing season, measure changes in soil enzyme activity via periodic soil collections for enzyme assays, and measure gas exchange from the soil. Ford says, "Ultimately this experiment will allow us to assess the impacts of a warmer and more variable climate across a latitudinal gradient from desert grasslands to shortgrass steppe."

Exploring the Past to Find Management Solutions for Riparian Area Degradation

Scientists have developed a basic understanding of the influence of past climates and geomorphic processes on the response of Great Basin riparian ecosystems to natural and anthropogenic disturbance, and used that understanding to devised effective strategies for their restoration and management.

Many of the riparian areas in the Great Basin have been severely degraded. In recent decades, stream down cutting or incision has resulted in lowered water tables, changes in the composition and abundance of riparian vegetation, and

Soil core extraction and an intact grassland core in shrubland on Sevilleta National Wildlife Refuge.

Photo: Sevilleta Long-Term Ecological Research





A fan-dominated watershed characterized by a large, side-valley alluvial fan and riparian meadow vegetation.

Photo: Jeanne Chambers

decreases in the overall extent of the riparian corridor. Although Great Basin riparian areas constitute less than 1% of the land area in this semi-arid region, they provide critical ecosystem services and serve as the foundation for much of the region's biological diversity. These riparian areas supply water for local communities, farms and ranches, provide forage and browse for livestock and wildlife, and attract a variety of recreational activities. Restoring and maintaining sustainable riparian ecosystems for current and future generations is of considerable importance to both land managers and the public. The recently completed Great Basin Ecosystem Management Project (GBEMP) for Maintaining and Restoring Sustainable Ecosystems, led by Dr. Jeanne Chambers, RMRS Research Ecologist, Reno, NV, sought to increase our understanding of the causes of riparian area degradation and to develop process-based management and restoration strategies for these ecosystems. The GBEMP was unique because it examined the interactions between geomorphic and hydrologic processes and riparian vegetation, and encompassed time scales that included the mid-late Holocene (last 5,000 years), post-settlement (last 170 years), and present (last 10 years). Study partners included University of Nevada, Reno; Western Carolina University; Lafayette College; and Humboldt-Toiyabe National Forest.

A major finding of the GBEMP is that Great Basin riparian areas are strongly influenced by the geomorphic characteristics of the watersheds and the legacies of past climates. The numerous, small upland watersheds are characterized by a diversity of geologies or rock types that weather differently and that produce varying runoff and sediment regimes. These differences result in three general types of watersheds – flood dominated, deeply incised, and fan dominated – that respond differently to flood events and that support varying types and amounts of riparian vegetation. Flood dominated and deeply incised watersheds are underlain by volcanic or intrusive rocks and have little sediment storage which results in high peak flows of short duration and dynamic stream channels. They are often dominated by disturbance tolerant woody vegetation like willows. In contrast, fan dominated watersheds are underlain by carbonate and meta-sedimentary rocks which results in larger and more gently sloping watersheds and, thus, longer water and sediment retention times. They are characterized by large, side-valley alluvial fans with riparian meadows

above the fans and woody riparian vegetation at and below the fans.

Past climate changes have significantly affected the rate and magnitude of stream down cutting and riparian area degradation in the different types of watersheds. Paleoecological records and stream bank profiles indicate that a major drought occurred in the region from approximately 2500 to 1300 YBP. During this drought, most of the available sediments were stripped from the hillsides and deposited on the valley floors and side-valley fans. Due to this erosion, streams are now sediment limited and have a natural tendency to down cut. Flood dominated and deeply incised watersheds are more sensitive to flood disturbances due to their sediment and runoff regimes and have exhibited the highest rates of change. In fan dominated watersheds, the side-valley alluvial fans have tended to act like base level controls resulting in less sensitivity to flood disturbances and stream degradation. However, human-caused disturbances, especially roads in the valley bottoms, have increased the rate and magnitude of stream down cutting and riparian area degradation. The current episode of down cutting is most evident in riparian meadows and has placed these ecosystems at high risk.

Developing effective management strategies requires recognizing that many streams and riparian ecosystems are functioning as nonequilibrium or unstable systems. Some streams have adjusted to the current geomorphic conditions, but others are still adjusting. Many of the streams that have down cut have crossed geomorphic and hydrologic thresholds, and thus vegetation thresholds. Returning to the predisturbance state of the streams and riparian ecosystems following degradation is an unrealistic goal, and process based approaches are necessary to maintain or restore sustainable ecosystems. At the watershed scale, we can use our understanding of geomorphic processes and watershed sensitivity to disturbance to prioritize management and restoration activities. At the valley segment/stream reach scale we can increase stability of stream reaches currently incising or at risk of incision. We also can restore riparian meadows following incision based on an understanding of the new site potential.

Publications from this study can be found at:
<http://www.treeseearch.fs.fed.us/pubs/38907>
<http://www.treeseearch.fs.fed.us/pubs/39012>
<http://www.treeseearch.fs.fed.us/pubs/41474>

Climate Change in Grasslands, Shrublands and Deserts

The USDA Forest Service, Rocky Mountain Research Station published a comprehensive report summarizing climate change research

and potential effects on grassland, shrub, and desert ecosystems. The report, "Climate Change in Grasslands, Shrublands, and Deserts of the Interior American West: A Review and Needs Assessment," highlights current knowledge and future research essential to mitigate the prospective detrimental effects of climate change. It addresses animal, plant, and invasive species models and responses, vulnerabilities and genetic adaption, animal species and habitats, and decision support tools for restoration and land management.

In 2010, RMRS Grasslands, Shrublands, and Deserts Ecosystems Science Program Manager, Dr. Deborah Finch, encouraged program scientists to

evaluate existing knowledge and research needs through the framework of climate change to ignite interest, develop new studies and add a valuable dimension to existing work. In response, 19 scientists and researchers from the Rocky Mountain Research Station collaborated across six states including New Mexico, South Dakota, Montana, Idaho, Nevada and Utah, and with colleagues from the University of New Mexico, University of Arizona, University of Wisconsin, and Dryland Institute, to summarize the current literature, conduct a needs assessment review, and develop decision support guidelines applicable for land management.

Findings from the report include:

- Transformations in native and invasive flora and fauna—by the turn of the century, climate in the western U.S. may be incompatible with current vegetation types, resulting in shifting patterns of terrestrial ecosystems.
- In arid and semi-arid shrublands and deserts, invasive grass species with higher flammability, like cheatgrass, will spread and increase both fire frequency and extent.

- Invasive species are one of the greatest threats to the health and sustainability of ecosystems worldwide—invasive species control costs the U.S. an estimated \$137 billion annually.
- Climate affects timing, migration, and reproduction cycles of plant and animal species—increased temperatures can affect insect development time and result in significant increases in generations per year/per habitat and expose new environments to colonization.
- Increasing water scarcity such as disruption of water flow regimes, and river and wetland drying, are likely to become overriding conservation issues.
- Native intact cold desert shrublands can store 30 percent more carbon than the average regional flora and be restored as an alternative source of carbon sequestration.

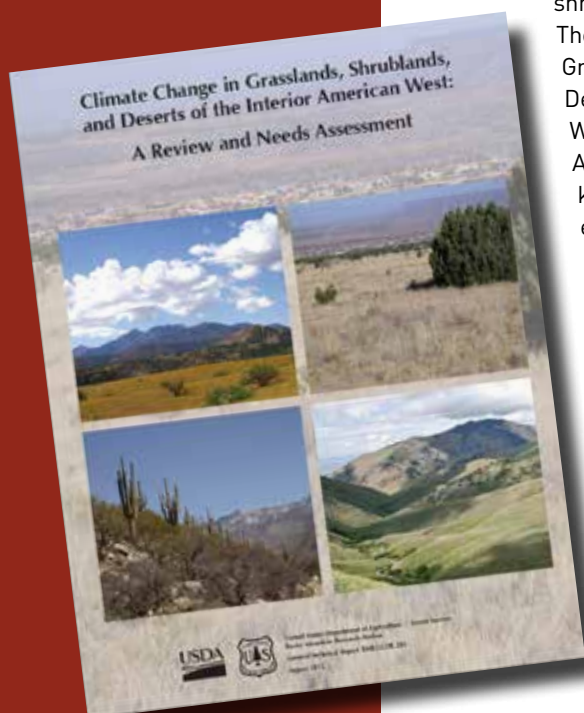
The published General Technical Report can be found at: [Climate change in grasslands, shrublands, and deserts of the interior American West: a review and needs assessment](#).

Mourning Doves, Invasive Species, and Wildfire: Lessons for Riparian Restoration

Mourning Doves are prolific nesters: a pair can raise up to six broods of young during a spring and summer nesting season. Their reproductive success, however, is limited by the availability of sites, such as trees or shrubs, that support nests and keep them hidden from predators.

In grassland, shrubland, and desert landscapes, riparian forests provide nest sites for large numbers of Mourning Doves and other breeding birds. Though riparian forests are dynamic in nature, humans have brought changes to rivers, such as the Middle Rio Grande in Central New Mexico, that have encouraged nonnative plant invasions and high-severity wildfire. In response, managers are conducting restoration treatments to control spread of nonnative plants and reduce wildfire risk.

Deborah Finch, GSD program manager, Dave Hawksworth, Biological Technician, and Max Smith, Contract Wildlife Biologist, evaluated effects of wildfire and fuel reduction treatments on reproductive success of Mourning Doves



Cover of RMRS-GTR-285



Mourning Dove nestlings
Photo: D. Max Smith



Top: Aerial view of the Rio Grande as it flows through downtown Albuquerque
Photo: Ron Reiring, Wikimedia

Bottom: New development in Las Cruces
Photo: Neomexicanus 1c, Wikimedia

Cities in the western U.S. are experiencing high rates of growth creating conflicts between traditional land use (e.g. agriculture), development and the needs of natural ecosystems.

along the Middle Rio Grande. They examined nest site selection and nest survival in plots that had been previously burned by wildfire, plots where nonnative vegetation and woody debris were mechanically removed to reduce fuel loads, and control plots that were unburned and untreated. They located and monitored 450 Mourning Dove nests, with 50% of these nests in post-wildfire plots, 33% in control plots, and only 17% in treated plots. The investigators found that most nests in control plots were constructed in small nonnative trees such as saltcedar and Russian olive, most nests in post-wildfire plots were placed atop pieces of woody debris that had fallen into resprouting vegetation, and the relatively few nests constructed in post-treatment sites were in the cottonwoods left behind during treatments. Nest survival did not differ between the different types of plots or nest sites.

Based on these results, the investigators recommend that future restoration treatments include the establishment of native understory trees and shrubs to ensure that nest sites are available for Mourning Doves and other birds. In the current phase of this study, data from the Middle Rio Grande and other rivers are being incorporated into long-term projection models of riparian vegetation. Riparian forest managers will use these models to prioritize restoration activities and conserve wildlife habitat.

Published findings can be found at:
<http://www.treeseearch.fs.fed.us/pubs/40060>

Urban Pressures on Open Space in the Southwest

Management of open space is increasingly challenged by pressures from growing populations and by threats such as wildland fire, drought, water shortages, and climate change. Managers of open space in or near cities are hindered in their ability to sustain public lands by inadequate knowledge of how urban pressures and agency policies and preferences shape decisions and actions. To address this, scientists from the Rocky Mountain Research Station (RMRS) and from three southwestern universities launched an "ULTRA-EX" project funded by National Science Foundation to evaluate land use decision-making practices across a gradient of city size from large (Phoenix, AZ), mid-size (Albuquerque, NM) to small (Las Cruces, NM).

Researchers began by reviewing current approaches and issues relating to studies of urban systems under changing climate and population growth. They identified the importance of comparative approaches that examine multiple cities and outline 5 types of studies to improve future information. Then, the RMRS led surveys of over 900 federal land managers to understand what influences agency decisions regarding open space management. Research indicated that these decisions were influenced by agency mission, adjacent city size and management level of those surveyed. Agencies with strong land management missions viewed providing and managing open space as one of their major focus areas. Managers in the Phoenix area, the largest and most urbanized city surveyed, agreed more with statements regarding the importance of open space and felt open space management was threatened by population growth and urbanization. Lower-level managers and employees agreed more than higher-level managers that open space should primarily serve conservation aims, whereas higher level managers felt more strongly that agency mission influenced management of open space and agreed that agencies were preparing for future demographic shifts. These trends may reflect the more local, field oriented experience of lower-level employees, whereas higher-level employees may be involved with agency missions at a broader level.

This research addressed a critical but understudied aspect of urban governance, and increased our understanding of how decision makers make land and water use decisions in the arid Southwest. Through this process, we gain a deeper understanding of the drivers, outcomes, and processes of land and water use, cover, and change that supports the long-term goals of managing and sustaining open space. The results of this research will assist decision makers at the city, county, state, and federal levels, concerned citizen groups, real estate developers, and tribal groups involved in land and water management in the Southwest.

Published findings can be found at:
<http://www.treeseearch.fs.fed.us/pubs/40752>



*Charleston ant safari led by
Burt Pendleton.*

Photo: USDA Forest Service

MONITORING AND SUPPORTING NATIVE SPECIES

Monitoring Biodiversity from Space

Biodiversity has been variously defined. One of the simplest measures of biodiversity is the total number of species present in a given area, community or landscape, i.e., species richness. This definition can relate to all living organisms present, or to a single class of organisms, e.g., plant species richness or plant biodiversity. While a seemingly simple concept, the determination of species richness can be problematic. Traditionally, ecologists have relied on field surveys to quantify the number of species present on a landscape. However, such methods are typically inefficient, costly, and subject to considerable error, leading to the conclusion that field measurements represent, at best, estimates rather than absolutes. Science could benefit greatly from more cost- and time-effective methods to estimate and monitor biodiversity, and identify biodiversity hotspots.

Dr. Steve Warren, RMRS Disturbance Ecologist, Provo, UT has been working for several years on a novel approach to detect and monitor biodiversity. Contemporary ecological thought suggests that habitat heterogeneity is the driving force determining species richness. While satellite imagery may not be able to precisely quantify plant biodiversity, it is capable of measuring habitat heterogeneity, which is, in turn, correlated to the diversity of plants and other organisms. The term Spectral Variability Hypothesis (SVH) has been coined, suggesting that the spectral heterogeneity of satellite imagery should be closely correlated with biodiversity. In conjunction with Colorado State University and the University of Bayreuth (Germany), Dr. Warren compared 168 measures of spectral diversity with on-the-ground plant diversity at the U.S. Army Grafenwoehr Training Area in Germany. They found that some of the simplest spectral diversity measures were among the best correlates of plant biodiversity.

A final report was submitted to the U.S. Army, Europe in 2011. This year, Dr. Warren met with his collaborators and outlined several potential manuscripts to publish in the next few years. The group is seeking further opportunities to expand the efforts.

The ability to detect and monitor biodiversity from satellite imagery has the potential to vastly



The U.S. Army's Grafenwoehr Training Area in Germany where remote sensing was tested as a measure of habitat heterogeneity and plant biodiversity.

decrease the cost and increase the ability of utilizing biodiversity as a measure of ecosystem health. While the technology is not anticipated to diminish the need for on-the-ground ecologist, it has promise for extrapolating such efforts across a much larger landscape than is currently practical when relying strictly on in-the-field efforts. It also has the potential to remotely detect changes in biodiversity resulting from fire, climate change, invasions of insects and exotic species, and other forms of disturbance. In addition, it has the potential to detect and monitor biodiversity hotspots on the landscape.

Where, Oh Where, are the Rare Butterflies, Snails, Mousetails, Moonworts, and Milkvetches...

RMRS is partnering with the Humboldt-Toiyabe National Forest and METI (Management and Engineering Technologies International, Inc.) to determine the distribution of rare species within the Spring Mountains National Recreation Area. The Spring Mountains National Recreation Area (SMNRA) includes approximately 316,000 acres of National Forest System lands managed by the Humboldt-Toiyabe National Forest in Clark and Nye Counties, Nevada. The Spring Mountains have long been recognized as an island of endemism, harboring flora and fauna found nowhere else in the world. Conservation of the species endemic to and resident in the Spring Mountains is a goal described in the Organic Act for the SMNRA.

Since the SMNRA's establishment, efforts to conduct inventory and monitoring have contributed to a greater understanding of the species' habitats and status. However, previous



ORV rider on trail next to fenced spring which is habitat for rare butterflies.

Photo: METI INC.

studies used a biological hotspot model, a model in which studies are concentrated in known locations where a number of species of management interest are located. The biological hotspot has several limitations as the information is only applicable to that location, and information on the distribution of species is not collected. "Given future changes in climate", says Dr. Burt Pendleton, RMRS Research Ecologist, Albuquerque, NM, "species may move up or down slope, outside of established hotspots." The current program seeks to examine rare species in an ecological context, i.e. how the species fit into their communities and how these communities influence the long term viability of the species. In addition, a complete picture of species' distribution provides for a better representation of their numbers and conservation status.

The 2011 Report contains the first full year of data collection and analysis for all program components outlined in the Spring Mountains National Recreation Area's Comprehensive Inventory and Monitoring Strategy. The report is divided into three major sections and appendices: 1) a description of the inventory and monitoring design and data collection of 2010 and 2011; 2) an evaluation of information collected from various sources and the SMNRA inventory and monitoring program with respect to ecological context, species conservation, and management interactions; and 3) recommendations regarding plans and programs. The appendices to the report present data analysis and findings for data collected during 2010 and 2011, including Species Fact Sheets (a summary of all information known about a species), GIS models of potential habitat, and data reports from a comprehensive sampling of all known spring sites in the SMNRA. A final report will be issued in 2013.

Reports can be found at:

www.treesearch.fs.fed.us/pubs/39015

www.treesearch.fs.fed.us/pubs/42158

Greater Sage-Grouse Winter Habitat Use on the Eastern Edge of Their Range

Greater sage-grouse (*Centrocercus urophasianus*) is a candidate species for listing as federally threatened or endangered. At the western edge of the Dakotas, it occurs in the transition zone between sagebrush steppe and the grasslands of the Northern Great Plains. These mixed sagebrush (*Artemisia* sp.)/grassland communities differ from those that comprise the central core areas of the sage-grouse range. Dr. Mark Rumble, Research Wildlife Biologist, Rapid City, SD partnered with Bureau of Land Management, North Dakota Game and Fish, South Dakota State University, U.S. Geological Survey and Dakota Prairie National Grassland to evaluate factors influencing greater sage-grouse winter habitat use in North Dakota during 2005–06 and 2006–07 and in South Dakota during 2006–07 and 2007–08. Sites selected by sage-grouse had about 15% sagebrush cover versus 7% sagebrush cover throughout the area. Our best resource selection model comprised sagebrush canopy cover, sagebrush height, and the interaction between sagebrush canopy cover and sagebrush height. The probability of selection by sage-grouse increased by 1.867 for every 1% increase in sagebrush cover (95% CI = 1.627 – 2.141) and by 1.041 for every 1 cm increase in sagebrush height (95% CI = 1.002 – 1.082). Management could focus on maintaining current sagebrush communities and identify areas of important winter habitat. Restoring sagebrush to grasslands where it previously existed would likely benefit sage-grouse populations along the eastern edge of their range.

The publication is available at:

<http://onlinelibrary.wiley.com/doi/10.1002/jwmg.484/full>



Tagging a male Greater Sage-grouse.

Photo: Mark Rumble.

RESTORING RESILIENT LANDSCAPES

Linking Climate and Plant Genetics Provides Tools for Desert Plant Restoration

An understanding of how climate defines the geographic distributions of plant species and populations is fundamental to successful ecological restoration. For many of the shrub-dominated desert and semi-desert ecosystems of the West, increased disturbance frequencies, mainly from wildfire, followed by the displacement of these native species by exotic annual weeds, creates a cascade of devastating impacts to ecosystems services, including loss of wildlife habitat and forage, increased fire risk, and poor air quality. Restoration projects designed to mitigate the conversion of native shrublands to invasive annuals require the use of site-adapted plant materials. Land management agencies use the information provided by seed transfer zones to assure seeds or seedlings used for restoration are adapted to local environments. Modern seed transfer zones are derived from measuring plant traits or physiological responses of different populations grown in common garden settings, followed by associating these responses with the climate (i.e., temperature and precipitation) at each plant collection site. By developing a model of temperature and precipitation variables that affect genetic traits, scientists are able to map these patterns on the landscape for our contemporary climate, and for future climates based on climate models and carbon dioxide emission scenarios.

Big sagebrush and blackbrush are two examples of shrub species that require post-fire restoration to mitigate habitat loss and prevent annual weed encroachment. Big sagebrush and blackbrush are widespread shrubs that occupy much of the landscape in the cold semi-deserts and northern Mojave Desert / Colorado Plateau, respectively. Without seed transfer zones, managers are left to make hard decisions as to how far they can move seed from their sources. To aid in the

decision process, scientists are investigating the adaptation of these species and populations to their climates in order to develop seed zones. For example, in blackbrush DNA markers and existing data from packrat middens have shown how past climates and topographical barriers have shaped the distribution and genetic structure of populations. More recently, data collected from common gardens show that blackbrush populations have different thresholds to winter temperatures. Colorado Plateau populations have better growth and much less mortality in colder environments compared to Mojave populations. This suggests that seed zone boundaries should be set to restrict blackbrush seed movement between Mojave and Colorado Plateau ecoregions under contemporary climates. However, for future climates these boundaries will likely change. Analyses of these potential changes are underway.

Partners/collaborators: Nancy Shaw, GSD-Boise; Stan Kitchen, Susan Meyer, GSD-Provo; Rosemary Pendleton, Burton Pendleton, GSD-Albuquerque. Outside partners: Joshua Udall, Brigham Young University; Matthew Germino, USGS.

Principal Investigator: Bryce Richardson, Research Geneticist, GSD Provo, Utah

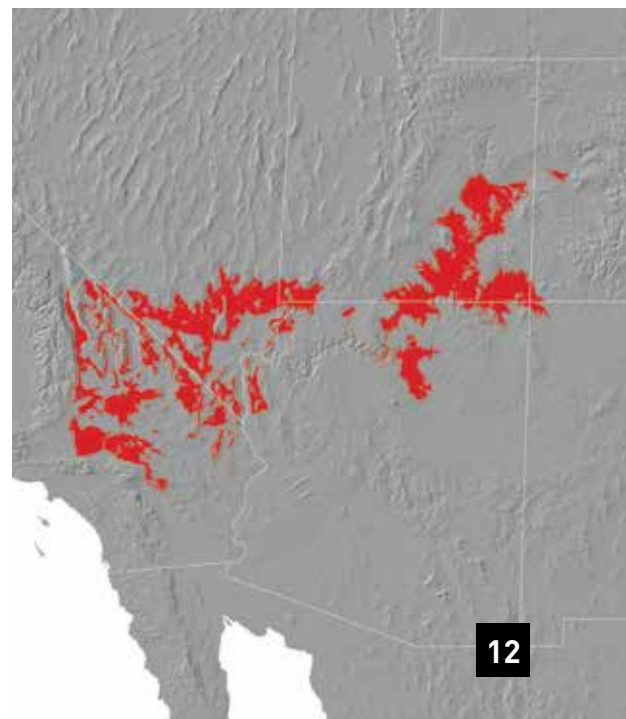
Published findings can be found at:

www.treesearch.fs.fed.us/pubs/40435

www.treesearch.fs.fed.us/pubs/41188

www.treesearch.fs.fed.us/pubs/39138

A predicted distribution of blackbrush (Coleogyne ramosissima) based on a climate.
Bryce Richardson.





Seeds are collected from plant populations throughout the Great Basin for studies of genetic variation, germplasm conservation and seed increase for wildland restoration.

Photo: USDA Forest Service



Hand collecting native seeds in the Black Hills National Forest.

Photo: Jack Butler

Native Seed - Conserving Genes and Providing Regionally Adapted Plants

Faced with extensive disturbances and climatological challenges that are rapidly changing ecosystems, scientists and land managers require the seeds of today if they hope to propagate the plants of tomorrow. Dr. Nancy Shaw, Boise, ID, and Scott Jensen and Dr. Bryce Richardson, Provo, UT, in partnership with the Bureau of Land Management's Seeds of Success Program, are providing the resources necessary to restore damaged grasslands, shrublands, and deserts, and especially the sagebrush ecosystem.

For commonly used restoration species, goals of the program are to ensure that there are genetically diverse, regionally adapted plants, especially forbs, for re-establishing degraded landscapes, and that there is sufficient knowledge and technology available to plant self-sustaining native communities on disturbed sagebrush rangelands. Researchers are currently studying more than 50 plant species, and knowledge gained from their efforts improves their ability to select the plants that are believed to be best adapted to current and future climate conditions. Also evaluated is a plant's likely contribution to improving habitat for more than 300 common and rare plant and animal species that depend on the sagebrush ecosystem. Along with cooperators, researchers have collected native grass and forb seed at more than 2,000 sites over the last 10 years. In addition to using the seed collections for research, when collection size permits, 10,000 seeds are provided to the Seeds of Success program for deposit in the Agricultural Research Service National Plant Germplasm System along with site details, photographs, and herbarium specimens. Preserving seeds has inherent value in the retention of the DNA of native plants at risk of loss because of ongoing disturbances, and provides a library of plant genetic material. This effort makes a variety of seeds available to plant materials developers who create seed supplies for future landscape.

For more information on this program see:
<http://www.fs.fed.us/rm/boise/research/shrub/greatbasin.shtml>

and refer to publications at:
<http://www.treeseearch.fs.fed.us/pubs/41192>
<http://www.treeseearch.fs.fed.us/pubs/40784>

Developing Plant Materials for the Black Hills National Forest

The Black Hills of South Dakota is an intensively managed area and has been for more than a century. Most management activities in the Black Hills National Forest are primarily concerned with timber production; however, management plans also include consideration for wildlife habitat, rangeland improvement, fire fuels reduction, recreation activities, and control of pests, disease, and invasive species. The unique vegetation assemblage of the Black Hills in conjunction with the frequent occurrence of natural and anthropogenic disturbances emphasizes the need to use locally adapted native species in a wide variety of restoration efforts. However, a general lack of information regarding germination and propagation requirements for most native plant species has restricted their usage.

Dr. Jack Butler, RMRS Research Ecologist, Rapid City, SD, partnered with South Dakota State University and the Black Hills National Forest to address this problem. The objectives of the study were to use hand-collected seeds of two common montane grassland species (prairie dropseed and hairy goldaster) from diverse, wild populations in the Black Hills to 1) evaluate germination under different temperature regimes, 2) examine the effects of cold-moist stratification on the response of seed germination to temperature, and 3) evaluate the year to year variation in germination. Results from our study indicate that patterns of germination observed for both are consistent for species inhabiting grasslands and meadows with a fluctuating environment and subjected to moderate seasonal disturbances. Hairy goldaster seeds readily germinated under a variety of temperatures less than 30° C. This temperature may define the upper metabolic limits for this species with respect to temperature, which appears to be ameliorated by stratification. When the species is used for restoration, the most suitable establishment method may be to cast seed in early spring.

They found that prairie dropseed has more than one optimal germination temperature, and that responses to both temperature and stratification are strongly influenced by seed collection year. Collection year variability emphasized the need to evaluate germinability of different seed lots, and offered an explanation as to why prairie dropseed sometimes establishes



Subirrigation offers benefits to native plant nursery growers and managers both in production and outplanting.

Photo: Jeremiah Pinto

poorly when directly seeded. The best approach for restoration may be to transplant mature individuals into established vegetation. This information is important in identifying the optimal environmental conditions to overcome dormancy and induce germination with the ultimate goal of increasing the availability, usability, and affordability of these species for restoration projects and promoting the use of locally adapted native species in landscaping.

For published findings, see <http://www.treesearch.fs.fed.us/pubs/41523>

Subirrigation for Success

A common problem nursery managers encounter while producing plants is increasing their production efficiency while reducing wastewater and pollution. Contributing to this problem is the production of broad-leaved native plants, which are subject to uneven water distribution from traditional overhead irrigation systems, and thus require even more fertilizer and irrigation inputs. Subirrigation technology, a method whereby water is allowed to move upward into the growing medium by capillary action, has been the focus of recent research in forest and conservation nurseries to address these problems. The reason for this interest is found in subirrigation's capability to reduce the amount of water needed for producing high-quality plants, control and limit discharged wastewater, and minimize the leaching of nutrients compared with traditional overhead irrigation systems.

Dr. Jeremiah Pinto, RMRS Research Plant Physiologist, Moscow, ID, in collaboration with Purdue University, University of Idaho, US Fish and Wildlife Service and State of Hawai'i, has recently conducted research showing that using subirrigation to produce native plants can not only improve irrigation efficiency (45% reduction in water use) but also improve seedling quality and outplanting success (larger seedlings with better survival and growth

post outplanting). Other benefits have been recorded such as increasing the survival rates during nursery production and increasing the fertilizer efficiency. Subirrigation also reduced moss and liverwort problems in one study, and it has been known to reduce foliar disease.

Thus far, research by Pinto and collaborators show promise for native plant nursery managers who are seeking improvements in production efficiency that also save costs. This production technique is helpful for managers in locales that face local water limitations or government regulations on wastewater discharge. Our work also gives solace to managers implementing this method by giving them data on improved seedling quality and outplanting performance. Small native plant nurseries in water limited areas (Arizona and Hawai'i) are successfully using this technique; a large Forest Service nursery is also using subirrigation for the production of broad-leaved riparian species.

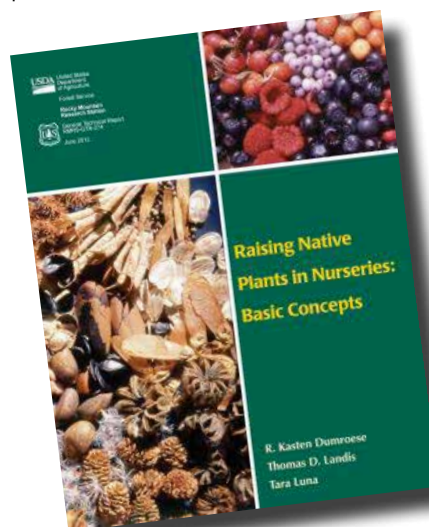
Publications can be found at:

<http://www.treesearch.fs.fed.us/pubs/38688>
<http://www.treesearch.fs.fed.us/pubs/39792>
<http://www.treesearch.fs.fed.us/pubs/39793>
<http://www.treesearch.fs.fed.us/pubs/30390>

How to Grow Your Own Native Plants at Home

Serving as the National Nursery Specialist, it is not uncommon for Kas Dumroese to get two or three calls every month; people want him to "send me everything you have" about growing native plants, especially conifers and oaks for reforestation. Most of these people were interested in growing seedlings as a hobby, or for use on their own land, although some are curious about starting their own nursery as a business. Unable to send folks "everything", Dumroese enlisted the help of retired USDA Forest Service National Nursery Specialist Tom Landis, and Tara Luna, a botanist with

extensive experience growing native plants at the Glacier National Park nursery to write an easy-to-read guide that addresses the most frequently asked questions about growing native plants. Published as RMRS-GTR-274,



The cover of RMRS-GTR-274, Raising Native Plants in Nurseries: Basic Concepts.

Program Manager

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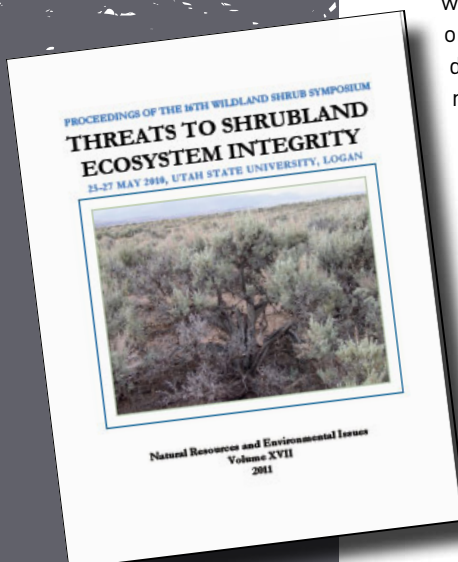
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this book, particularly the first chapter that introduces important concepts, is geared for the novice who wants to start growing native plants as a hobby, but can also be helpful to someone with a bit more experience who is wondering about starting their own nursery. The second chapter provides basic information about collecting, processing, storing, and treating seeds. Chapter three focuses on using seeds to grow plants in the field or in containers using simple but effective techniques. For those native plants that reproduce poorly from seeds, the fourth chapter describes how to start native plants from cuttings. The final chapter provides valuable information on how to successfully move native plants from the nursery and establish them in their final planting location. Several appendices expand on what has been presented in the chapters with more details and specific information about growing a variety of native plants; George Hernandez, USDA Forest Service Regeneration Specialist in Region 8, provided detailed information on eastern species to give the effort national relevance.

The publication is available at:

<http://www.treeseearch.fs.fed.us/pubs/40753>



Proceedings of the 16th Wildland Shrub Symposium

The 16th Wildland Shrub Symposium was held 25-27 June 2010, in Logan, UT. The symposium, entitled "Threats to Shrubland Ecosystem Integrity," focused on current issues facing land managers, including fire, invasive species, climate change, and energy development. RMRS Research Ecologist Rosemary Pendleton, Albuquerque, NM and Research Botanist Dr. Stanley Kitchen, Provo, UT who helped to edit the proceedings, say "The twenty-nine papers included in the proceedings cover such diverse topics as effects of historic land use, nitrogen uptake by invasive weeds, impacts of fire on sage grouse habitat, and synthesis of existing monitoring data."

Wildland Shrub Symposia are held under the direction of the Shrub Research Consortium (SRC), an organization begun in 1983 and composed of some 25 agency and university institutions. The symposia provide a forum for researchers and managers in the Interior West to learn about recent research findings and restoration projects, and to discuss issues related to shrubland management.

Shrublands make up over 30% of the land area in the Western United States, providing food and habitat for numerous species of wildlife, from big game mammals and pygmy rabbits, down to native bees and other insects. Despite their importance on the landscape, western shrub species received little attention prior to the 1970s. The Rocky Mountain Research Station's Shrub Sciences Laboratory, a founding member and driving force behind the SRC, is unique within Forest Service R&D for its focus on research and rehabilitation of shrub-dominated ecosystems. Maintenance and restoration of shrublands is an important component of Forest Service efforts to preserve biodiversity in the Interior West.

The publication is available at: www.treeseearch.fs.fed.us/pubs/39789

Cover of the 16th Wildland Shrub Symposium Proceedings.