July 2011

GSDUpdate

From the Rocky Mountain Research Station
Grassland, Shrubland and Desert Ecosystem Science Program

Checking the Range for Signs of Climate Change
In the Past, Present and Future

Imagine *you have access to a machine that can make particles move faster and faster until they approach the speed of light, and essentially travel through time. The machine might look like the Large Hadron Collider—the particle accelerator below ground in Switzerland—but instead of producing teeny, tiny, short-lived, exotic particles no one's ever seen before, it transports you, a person of ample curiosity, into the future. You disembark your time travel machine, look around, and though you believe you're in the same geography, things don't look quite the same. If you began your trip somewhere in the interior American West where familiar grasslands, shrublands, or deserts were found, you have reason to be perplexed. The ecosystems of the future world have changed. What does that future world look like? Scientists in the Grassland, Shrubland, and Desert Ecosystems Science Program (GSD) – a unit of the USDA Forest Service Rocky Mountain Research Station (RMRS) – are not waiting for the future to arrive to have a look*—**they are working on revealing the story to us now.**

IN THIS ISSUE

One of the areas where they are focusing their research has to do with understanding the role of climate in shaping the environment. How does variation in climate alter the types of plants and animals that are found in arid ecosystems of the American West? How will a long-term drought affect the composition of these ecosystems, and where will these ecosystems be able to exist in the future if the drought persists? How has human activity—past, present, and future—affected these natural communities? What do we know about invasive species, and how will future climate affect our ability to control them? What's the critical threshold, or tipping point, for a community of plants and animals before it loses stability? It's obvious there are a lot of questions that need to be answered, and if we hope to sustain or restore healthy ecosystems, and the services they provide us, we need to know how they will change over the next 20, 50, 100 years. This is a much better strategy than finding we've been snoozing while dramatic changes have taken place under our noses, and we don't recognize what we've lost until it's gone. To help us open our eyes and adjust to our changing world, the scientists share their findings. Here's what they tell us:

Photo: Kari Greer, USFS

Long-term drought fosters the spread of wildfires. Both drought and fire afflict the Southwest, as is evident by the 2011 Wallow Fire, the largest fire in Arizona's history.

Photo: Kari Greer, USFS


Photo: Bryce Richardson

Because it provides wildlife habitat and forage, excludes invasive weeds such as cheatgrass, catches snow and cycles nutrients, big sagebrush is one of the most ecologically important plant species in western North America, and a major focus for ecosystem restoration after disturbances.

Blackbrush, which lives in a narrow band between two major climate zones, is an ideal species for examining climate change.


Photo: Rose Pendleton

Big Sagebrush and Blackbrush: A Tale Of Two Shrub Types

With models predicting arid regions will grow ever drier, species will face challenges to their survival. Big sagebrush and blackbrush are so important for sustaining ecosystems in western North America, scientists are eager to discover how these two shrubs will cope with climate change.

By providing wildlife habitat and forage, excluding invasive weeds such as cheatgrass, catching snow and cycling nutrients, big sagebrush is an ecological powerhouse, and is a major focus for ecosystem restoration after disturbances. Bryce Richardson, research geneticist at the Provo Shrub Sciences Laboratory, and Nancy Shaw, research botanist, are hoping to uncover the genetic structure and traits that will allow big sagebrush to adapt to changing climate. "I realized at some point in my education that the fundamental interaction between organisms, or organisms and their environment, is through their genes," Richardson offers. "Understanding these genetic processes is critical to climate change research." By measuring adaptive traits in three different study plots of big sagebrush, the team will be able to develop seed zones for this critical species, providing important criteria for managing sagebrush in changing environments.

Growing across millions of acres, blackbrush is a regionally dominant species that occurs in a narrow band between two climate zones, marking the transition between North American warm and cold deserts. Because of blackbrush's unique niche, and also because it is representative of a large group of slow-growing desert shrub species, Stanley Kitchen, research botanist, Susan Meyer, research ecologist, Bryce Richardson, research geneticist all with the Provo Shrub Sciences Laboratory, Burton K. Pendleton, research ecologist, and Rosemary L. Pendleton, research ecologist, find it is an ideal model species for examining climate change response. The scientists want to integrate bioclimatological models so they can predict where blackbrush will be able to grow in the future—whether the plants can survive where they are, or "migrate" and survive in new locales because of changing climate.

Stressed Out: Piñon-Juniper Woodlands, "Barometers of Change"

It sounds like a pestilential scourge from classic literature: Enabled by severe drought, bark beetles, carrying blue stain fungi, have killed such massive swaths of piñon-juniper woodlands in the Southwest, that in some regions of Arizona and New Mexico, the die-off is close to a staggering 90%. Paulette L. Ford, research ecologist, and her University of New Mexico collaborators found the insects and fungi, with other environmental factors, are the main causes of tree death, and as yet, there is no biological control for either the bark beetles or the fungal tree pathogens that travel through life with them. They find that the damage to piñon-juniper woodlands—so critical in their habitat that they affect many other species—may be irreversible. Ford and others are trying to determine how much the fungal spores carried by bark beetles contribute to disease and death in these plants. Piñon-

"Southwestern ecosystems," Ford says, "are some of the ecosystems at greatest risk due to climate change."

Drought, bark beetle infestation, and blue stain fungi carried by beetles translate to stress of epic proportions for piñon pines and junipers. All this and then some: climate change is exacerbating challenges to this ecosystem.


Photo: Andrea Porras-Alfaro

Biochar, a by-product of burning biomass to create energy, could be used as a more economical growing medium additive for nursery-raised native plants.

juniper woodlands dominate the upland areas of the Middle Rio Grande Basin, and disease and death in these plants will have important consequences for the management of the region, she believes.

The Odyssey of Great Basin Meadow Ecosystems

Knowing the components that make up a place, how they change over time, and the processes that affect them is critical to grasping the character of that place and to planning for the future. The Great Basin Ecosystem Management Project is just such an undertaking. Jeanne C. Chambers, research ecologist, and David Board, ecologist and data analyst, are using an integrated, interdisciplinary approach in looking at the effects of climate change and disturbances caused by human activity on riparian areas. Their unique study examines changes on the landscape over time, stretching across the Holocene, or past 10,000 years, and over different-sized areas, ranging from places adjacent to streams to entire watersheds. They will monitor rainfall, stream flow and water tables over the long-term, and reveal the connections among watershed and channel processes. They will check how water moves through the landscape, whether in streams or underground. By measuring water table levels, they can learn how changes in those levels due to climate or human-caused disturbance will affect the types of plants that rely on this irreplaceable resource. Meadow plants such as grasses that grow in the central Great Basin meadows and also in other areas with shallow water tables are vulnerable to a drop in groundwater. In some areas, because of groundwater level change, meadow plant communities have been replaced by upland shrubs and trees. Chambers and Board hope that by understanding the processes that are causing meadows to decline, they can develop management and treatment options to help these important ecosystems.

Meadow plants, such as grasses, that grow in areas with shallow water tables are vulnerable to a drop in groundwater. In some areas, where the groundwater level has changed, upland shrubs and trees have replaced grasses and forbs.

Turning Char into Gold for Growing Native Plants

Burning biomass to create bioenergy produces biochar as a by-product. The charm in that fact is more than an alliterative sentence. R. Kasten Dumroese, plant physiologist, and Jeremiah R. Pinto, botanist and tribal nursery coordinator, are examining biochar to see if it can be added to the growing medium for nursery-raised native plants. They are testing biochar in its original powder form, and also looking at its effectiveness when it is pressed into high-density pellets, which will make handling this messy substance easier for growers. The team offers that if the pellet form works, it will make converting biomass to energy more efficient economically, because it will create an additional useful product. It will also help nurseries decrease their production costs because they will be able to use biochar instead of the more expensive substances they've been adding to the growing medium. As an added boon, biochar, which is mostly carbon, becomes part of the root plug and when planted belowground, the carbon is sequestered—and at no additional cost.

Photo: Stan Kitchen

For more than 130 years, the salt-desert shrublands of North America have served as open range, feeding cattle and sheep and providing livelihoods for people. They also provide habitat for wildlife. Mismanagement of livestock grazing, along with climate change, invasive weeds, altered fire regimes, and disturbance from mining and energy development, threaten these cold-desert plant communities.

Disturbances and Threats: The Saga of Salt-Desert Shrublands

Think of a desert, and the tendency of many people is to picture a scorching, sandblasted wasteland. But temperate deserts, also known as cold-deserts, stretch over large areas of western North America, covering intermountain landscapes in the Great Basin, Colorado Plateau, and Wyoming Basin, as well as large stretches in Asia. Cold winters, warm summers, and low amounts of precipitation that vary dramatically by season, year and decade, mean that plant communities have a wide range of conditions to endure. Within the temperate deserts, plant specialists that survive in dry, salty soils make up the salt-desert communities. These communities are dominated by shrubs, sub-shrubs, and perennial grasses. A variety of forbs add biodiversity. North American salt-deserts provide ecosystem services on which wildlife, and livelihoods depend, acting as open-range feed sources for sheep and cattle for more than 130 years. An array of threats challenge the integrity of salt-desert plant communities, including livestock mismanagement, invasive weeds, climate change, altered fire regimes, and disturbance to the land from mining, energy development, and recreation. Stanley Kitchen, research botanist, and a team of collaborators from various agencies and universities, are investigating the long-term effects of livestock management strategies, invasive weeds, and climate variability on the stability of salt-desert shrublands. Their research also includes development of strategies for restoring these degraded communities.

Grassland Snapshots from North to South

In the Southwest, shrubs are encroaching into grasslands and changing landscapes. Overgrazing, fire suppression, and climate change are causing this change, and as shrubs move into grasslands, they alter soil chemistry and microbes, and reduce the diversity of plant species. 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. To the possibility of greater drought and greater downpours, add a potential shift in when that rain comes. Changes in winter and summer rainfall patterns can affect how these ecosystems function, compromising their resilience to disturbance. Dr. Paulette Ford, research ecologist, and her collaborators are in the initial stages of looking at the individual and combined impacts of shrub encroachment, variation in rainfall, and warming temperatures on arid grassland soil nutrients and carbon storage through a multifaceted research program. The team's study sites, stretching from northeastern Colorado to southern New Mexico, will allow them to experiment with moving intact chunks of soil containing blue gramma grass across a climatic gradient. In this way, they hope to simulate the climate changes expected in this geography, and measure how carbon and nitrogen will fluctuate in arid grasslands.

Grasslands converting to shrublands is a shift that is happening in the Southwest, and will have consequences for people who rely on livestock grazing resources, as well as for wildlife who inhabit these areas. By moving chunks of soil containing blue gramma grass across study sites stretching from northeastern Colorado to southern New Mexico, scientists hope to simulate and study the climate change challenges that are expected in the region.

Photo: U.S. Fish and Wildlife Service - Sevilleta National Wildlife Refuge, NM

"By the end of the century, 55% of future landscapes in the west will have climates that are incompatible with the vegetation communities that now occur on those landscapes."

Sowing the Seeds:
GSD Prepares Climate Change Report

Climate is all the weather we've had, are having, and will have in the future. While weather and climate are made up of the same meteorological elements—humidity, rainfall, temperature, wind, atmospheric pressure—they are not the same thing. Weather is the condition of these elements over shorter periods, and climate is the long history. Climate affects the quality and chemistry of air, the water cycle, the amount of water trapped as global ice and permafrost, the surface of land, and the kinds of species that can live in a particular place. When the balance shifts over a shorter period of time, we have weather changes that will bring us dry years, or wet years. When the balance changes over a much larger area and longer time scale, we have a shift in climate and that will bring us new landscapes where the composition of plants and animals can be vastly different from where we're used to seeing them. Or those plant and animal communities may disappear altogether.

An assemblage of USDA Forest Service researchers working within the Rocky Mountain Research Station's Grassland, Shrubland, and Desert Ecosystems Science Program is striving to answer questions about climate change, and the alterations that will impact these types of ecosystems. Scientists predict that the interior American West will have drier summers, wetter seasons the rest of the year, and increases in extreme weather events such as heat waves. They are reviewing and assessing needs to plan for support, restoration, or acceptance of permanent ecosystem shifts, and making their findings available in a general technical report that will soon be published.

Climate will also affect the free labor of insects on which we rely, those pollinators, weed eaters, seed dispersers, and tillers of the soil.

The work is important to understanding what will happen to communities of the natural world, as well as to the needs of people, as natural ecosystems provide us with many services such as water, livestock forage, game and fish, recreational opportunities, and other resources we depend on. The timing is critical. As the scientists state in their report, "by the end of the century, 55% of future landscapes in the west will have climates that are incompatible with the vegetation communities that now occur on those landscapes."

This may be good news for species that can adapt to communities invaded by exotic plants, such as Buffelgrass and Lehmann lovegrass, which are expected to expand their range in the future climate, but bad news for native species that require the ecosystem compositions of plants, animals, and insects on which they are accustomed and depend. Many grasslands of the interior West are expected to shift eastward, or even decline in some areas as shrubs encroach. Shrublands in general don't have it any easier. Scientists expect these to decrease in the U.S., with sagebrush, Joshua tree, saguaro and

Scientists are concerned that warming temperatures will allow fire-adapted invasive plant species to spread further, causing more fires.

Photo: Larry Jones, USFS

Endemic plant species in the Sonoran and Mohave Deserts, such as saguaro and Joshua tree, may already be responding to climate change.

Natural resources managers wonder if endangered species like the Lesser-Prairie Chicken will be affected by climate change. The SAVS tool can help to address such questions.

Photo: US Fish and Wildlife Service

creosote bush shifting northwards. Species found in the Mojave Desert will probably migrate north into the Great Basin, and the secluded high elevation habitats, such as the Madrean forests of the Sky Islands of Arizona, are projected to decline and disappear.

Of course, changes from climate, invasive species, insect epidemics and other threats don't happen in isolation of each other. Multiple disturbances can occur simultaneously, and scientists are trying to understand what the collective, or synergistic, effects of these assaults will be for the ecosystems of today, and the future. Understanding what will drive change in grasslands will help managers plan land use for the future, such as grazing on rangelands. They can also develop management plans for cold-desert shrublands, which have lower production capabilities for livestock grazing, but more value as ecosystems that sequester carbon.

Plant communities will be challenged by expanding human development, and human communities along the wildland/urban interface will be challenged by growing threats from wildfire. Given the changing composition of plant communities—that will include more fuel, or more easily ignited fuels, and drier conditions—the potential exists for increased mega fires. These will burn hotter, and consume larger areas across the landscape. And while we strive to produce enough energy to meet current and future demands, ecosystems will face increased disturbance as we explore for natural gas, or plant wind farms, and develop solar arrays.

"Climate-related shifts in the distributions of plants and animals have the potential to affect people directly by changing what they see and use in the environment around them," says Deborah Finch, program manager for the Grassland, Shrubland and Desert Ecosystems Science Program. "These shifts will alter the ecosystem services available to people, and change the economic value and productivity of the land and its resources." Knowing what to expect, and working to adapt, we can avoid the shock of a rude awakening.

The Web-based SAVS Tool Prompts Critical Thinking About Species Responses to Climate Change

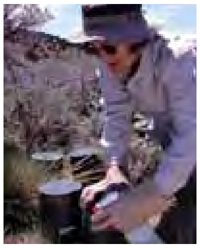
If you're a land manager tasked with planning, supporting, and implementing practices to help vulnerable species adapt to climate-related changes, and to identify which species are resilient, where do you start? How do you assess the complex connections between species and their environment, and discern how climate will affect the life histories of those species? Wouldn't it be wonderful to have a practical way to assess species at your fingertips, a guide that asks you a lot of questions to get you thinking so you could provide your own answers? Well, that's what Forest Service researchers have done—created an online tool known as The System for Assessing Vulnerability of Species to Climate Change, or SAVS. The SAVS tool poses 22 questions that managers can ask themselves about an animal, bird, amphibian, or reptile species, such as its preferred habitat; its physical and life history particulars (does it hibernate from heat or cold, for example, and does season and time of year affect reproduction?); its connection and interaction with other species (what will happen to the species if its food resources diminish or disappear?); and its ability to adapt to changes in its environment. Managers score six categories, which helps them assess whether the species they are examining is vulnerable or resilient, and where a species' potential struggles may lie. This in turn will help managers create land management practices that best serve their region, and the species within those management units. The tool that RMRS researchers Karen Bagne, Megan Friggens and Deborah Finch published in 2011 helps move abstract concepts about climate change and impacts to species into a very usable, understandable, and actionable tool. Though the SAVS tool can go a long way to prompting assessment, it is intended as a guide. The researchers urge managers to explore additional resources such as experts, literature and other assessment tools. The online tool can be accessed at http://www.fs.fed.us/rm/grassland-shrubland-desert/products/species-vulnerability/savs-climate-change-tool/

A message from the Program Manager

Climate Change is one of five focal areas of the Grassland, Shrubland and Desert Ecosystems Science Program (GSD). Our program mission is to develop and deliver knowledge and tools that will help to sustain and restore grasslands, shrublands and deserts threatened by invasive species, disturbances, urban pressures, and climate change. Scientists in our program study the physiological, behavioral, and demographic responses of plants and animals to climate change, especially in interaction with other stressors such as fire and invasive species. Our research also evaluates the capacity for species to adapt to environmental changes. We provide decision support by developing new plant materials for use in restoring ecosystems under stress, guidance for identifying species at risk from climate change, and assessments and tools for determining species and ecosystem vulnerability.

—Dr. Deborah Finch,
Science Program Manager

Meet Some of the GSD Scientists



Dr. Jeanne Chambers is a plant ecologist stationed at the RMRS Great Basin Ecology Lab in Reno, NV who works with physical scientists to study vegetation dynamics at a variety of scales. Her research focuses on global change processes with an emphasis on climate change, disturbance ecology and invasive species ecology. Her primary expertise is in alpine ecosystems, riparian and wetland ecosystems, and cold desert ecosystems including salt desert, sagebrush, and piñon and juniper.

Dr. Kas Dumroese is a research plant physiologist stationed at the Moscow Forestry Lab in Moscow, ID whose research focuses on propagating native plants and improving survival and growth of nursery stock after outplanting. He serves as National Nursery Specialist on the Reforestation, Nurseries, and Genetics Resources (RNGR) team, an intra-Agency group that transfers technology to managers engaged in reforestation and restoration of degraded ecosystems. He is the current editor of the Native Plants Journal, which publishes articles about the growing and outplanting of native flora.

Dr. Paulette Ford is a Research Ecologist stationed at the RMRS Albuquerque Lab in Albuquerque, NM. Her research interests include the roles of disturbance (i.e. fire, drought, infestations, pathogens) and climate change in structuring desert, grassland, and woodland communities, and methods for restoring degraded ecosystems. She is currently studying the effects of season and frequency of fire in shortgrass steppe of the southern Great Plains and she is working with university colleagues on the relationships between climate change and other stressors in southwestern US ecosystems.

Dr. Stanley Kitchen is a research botanist stationed at the RMRS Shrub Lab in Provo, UT who studies multi-century fire regime and climate change effects on Great Basin montane vegetation, as well as the ecological responses of cold-desert ecosystems to invasive plants and climate variability. He also works on post-fire succession for mountain sagebrush communities, long-term effects of livestock grazing practices, development of agronomic practices, and seed production for restoration plantings.

Dr. Bryce Richardson is a Research Geneticist stationed at the RMRS Shrub Lab in Provo, UT. His research interests are focused on population genomics, genecology, and phylogenetics of plants and plant pathogens. He is currently studying the genetic capacity of big sagebrush, blackbrush, aspen and other plants to adapt to changing climates and environments using common garden studies. He is the regional contact for the Western Forest Transcriptome Survey, a collaboration to identify climate-related genes from diverse species.

Dr. Karen Bagne is a Biologist working for RMRS via a joint venture agreement. She is currently developing products, workshops and tools aimed at assisting natural resource managers. Her research examines how populations of terrestrial organisms respond to climate change, fire and fuel reduction. Results will be useful in informing managment decisions regarding risks to and vulnerabilities of species in the face of environmental and climate changes.

Program Manager
Grassland, Shrubland and
Desert Ecosystems Science

Deborah Finch, Ph.D.

USDA Forest Service
Rocky Mountain Research Station

333 Broadway SE, Suite 115
Albuquerque, NM 87102

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

http://www.fs.fed.us/rm/grassland-shrubland-desert/

http://www.fs.fed.us/rm/albuq/dfinch.php

Writer/Editor

Lisa-Natalie Anjozian
lisanatalie@gmail.com
www.lisanatalieanjozian.com

Design/Layout

Andrew Schlabach
andrew@alloneplanet.com

Some Recent GSD Publications

Bajgain, P., B.A. Richardson, J.C. Price, R.C. Cronn, J.A. Udall. 2011. Transcriptome characterization and polymorphism detection between subspecies of big sagebrush (*Artemisia tridentata*). BMC Genomics. In press.

Bagne, Karen E.; Friggens, Megan M.; Finch, Deborah M. 2011. A System for Assessing Vulnerability of Species (SAVS) to Climate Change. Gen. Tech. Rep. RMRS-GTR-257. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

Brown, P.M.; E.K. Heyerdahl, EK; S.G. Kitchen; M.H. Weber. 2008. Climate effects on historical fires (1630-1900) in Utah. International Journal of Wildland Fire 17: 28-39.

Chambers, J.C. and M. Pellant. 2008. Climate change impacts on northwestern and intermountain United States rangelands. Rangelands 30: 29-33.

Chambers, J. C. and J. R. Miller, eds. 2011. Geomorphology, Hydrology and Ecology of Great Basin Meadow Complexes: Implications for Management and Restoration. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station, Gen. Tech. Rep. GTR-258.

Clifford, M J.; M. E. Rocca, R. Delph, P.L. Ford, and N.S. Cobb. 2008. Drought induced tree mortality and ensuing bark beetle outbreaks in southwestern pinyon-juniper woodlands. Proceedings RMRS-P-51. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. Pp. 39-51.

Dumroese, R.K, J. Heiskanen, K. Englund, A. Tervahaut. 2011. Pelleted biochar: chemical and physical properties show potential use as a substrate in container nurseries. Biomass and Bioenergy 35: 2018-2027.

Finch, D. M.; K.E. Bagne, M.M. Friggens, D.M. Smith, K.M. Brodhead. 2011. A review of climate change effects on terrestrial rangeland birds. In: IX International Rangeland Congress: Diverse Rangelands for a Sustainable Society; April 3-10, 2011; Rosario, Argentina. IRC 2001 Congress. p. 68.

Finch, D.M.; M. Friggens, K. Bagne. 2011. Case Study 3: Species vulnerability assessment for the Middle Rio Grande, New Mexico. In: Scanning the conservation horizon: A guide to climate change vulnerability assessment. Washington, D.C.: National Wildlife Federation. Pp. 96-103.

Floyd, L.M., M. Clifford, N.S. Cob, D. Hanna, R. Delph, P. Ford, D. Turner. 2009. Relationship of stand characteristics to drought-induced mortality in three Southwestern pinyon-juniper woodlands. Ecological Applications. 19: 1223-1230.

Kitchen, S.G., R.L. Pendleton, T.A. Monaco, J. Vernon, comps. 2008. Shrublands under fire: disturbance and recovery in a changing world. Proceedings RMRS-P-52. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

Richardson, B.A., G.E. Rehfeldt, K. Mee-Sook 2009. Congruent climate-related genecological responses from molecular markers and quantitative traits for western white pine (*Pinus monticola*). International Journal of Plant Sciences. 170: 1120-1131.

Publications are available online in TreeSearch http://www.treesearch.fs.fed.us/.