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

The West In Transition:
Costs and Unexpected Benefits of Disrupting Ecosystems

For centuries, the resilience of western ecosystems kept pace with changes in climate, native species and peoples, and other natural stressors. Droughts, winds, floods, insect outbreaks, bison, and wild fires periodically disrupted the ecosystem dynamics of America's grasslands, shrublands and deserts, and the changes would sometimes last a few years. Native plants and animals were adapted to ecological disturbances, though, and before long they bounced back or shifted to a new state of balance. Some ecosystems and species depended on disturbances such as fire and flooding for renewal. With the arrival of European settlers, however, the dynamics began to change. In today's western rangelands, bison have been replaced by cattle, river water is regulated, non-native plants are invading every state, and cities and transportation networks dot the land. Continuing new knowledge is needed to sustain healthy ecosystems as they undergo rapid changes to meet human needs. How much stress can arid lands tolerate? What knowledge is needed to maintain healthy, biologically diverse ecosystems as urban environments grow larger, as fires burn bigger and hotter, or when wind farms govern the landscape? What science is most helpful to meet the challenges of changing land use and climate? Scientists at USDA Forest Service Rocky Mountain Research Station's Grassland, Shrubland and Desert Ecosystem Research Program are investigating both natural and human-made stressors, and their results could help conserve native species and essential Western ecosystems.

IN THIS ISSUE

The USDA Forest Service manages 193 million acres of public forests and grasslands, an area the size of Texas, and the Bureau of Land Management manages 245 million acres more, many of them grasslands, shrublands and deserts. Much of this public land is actively managed for livestock production, oil, gas and energy, water, wood products, and recreation. "When lands are used beyond their limits, ecosystems become stressed, changing in directions that do not benefit either humans or the natural resources they depend on or care about", says Dr. Deborah Finch, Science Program Manager of Rocky Mountain Research Station's (RMRS) Grassland, Shrubland and Desert Ecosystems program. "The good news is that the negative consequences of many disturbances are preventable, and we can learn from past mistakes."

Aspen stands burn in the Johnson Fire, Fishlake National Forest, Utah.

Photo: USDA Forest Service.

Fire can benefit aspen by promoting regeneration as seen here after the Johnson Fire.

Photo: USDA Forest Service

"When we started doing this work a decade ago, there was very little knowledge about historic fire regimes for this part of the western United States"

In managing grasslands, we can learn from the Dust Bowl of the 1930s. After settlers plowed up huge swathes of grassland in the southern Great Plains to grow wheat, a multiyear drought dried up crops in the 1930s, setting the stage for the enormous dust storms of the Dust Bowl, which darkened noonday skies, buried homesteads and clogged the lungs of thousands with dirt. We know now that the farming and grazing practices of the late 1800s and early 1900s resulted in loss of topsoils which contributed significantly to dust storms and landscape desertification. That catastrophe delivered a hard lesson that "the consequences of drought and over use of arid lands can be disastrous, and managing such lands depends on knowing how lands respond to stress", Finch says. And we can learn that the deliberate introductions of invasive species like cheatgrass and salt cedar were a mistake, because they now threaten to crowd out native plants and increase fire risk, she says.

The USFS's Western Wildland Environmental Threat Center, which funds some of the RMRS grassland, shrubland and desert research projects, works on increasing knowledge about disturbances that threaten ecosystems and about methods to restore ecosystems to a healthy state. Several research projects featured in this issue of GSD*Update* are providing much-needed science to help land managers do just that. But natural disturbances like fire or flooding can also be viewed through a different lens, Finch says. As disruptive as they can seem to observers, they often benefit those native plants and animals that are adapted to disturbance. RMRS research botanist Stanley Kitchen, whose work is featured in this issue, investigates the essential role of fire in Western forest and sagebrush ecosystems to better understand when it helps ecosystems and when it hurts them.

As RMRS researchers deliver new understanding of rangeland ecosystems, public land managers and private stakeholders such as ranchers and energy companies can do a better job sustaining the health of the nation's valuable rangelands. Here's a sample of what RMRS researchers are discovering:

After the Fire: Post-Fire Recovery on Rangelands

When white settlers first moved into the mountain ranges of Utah and Eastern Nevada in the mid-19th century, they encountered a patchwork landscape: At mid-elevations sagebrush shrubland and grassland alternated with conifer forests. But over the past century and a half, forests have often marched into grassland and shrubland, and in forested areas, the composition of tree species has changed. The reasons for change are disturbances like fire, or the lack thereof. Fire-resistant grasses, shrubs and trees need periodic fire to beat back the fire-sensitive plants they compete with and to maintain open, resilient plant communities.

But how often is fire needed, and how intense should it be? To find out, RMRS research botanist Stanley Kitchen of RMRS's Shrub Science Lab in Provo, Utah, is using the past as a guide. A decade ago, Kitchen began studying how fire played out across mountainous landscapes of Utah and Eastern Nevada before Euro-Americans settled there. "When we started doing this work a decade ago, there was very little knowledge about historic fire regimes for this part of the western United States," Kitchen says.

To learn more about historic fire patterns, Kitchen collaborated with research forester Emily Heyerdahl of RMRS's Fire Sciences Lab in Missoula, Montana, and Peter M. Brown, director of Rocky Mountain Tree Ring Research, a nonprofit research organization based in Ft. Collins, Colorado. The trio selected 13 small watersheds scattered across Utah and one in eastern Nevada. They designated a grid of about 30 plots per watershed—from pinyon-juniper woodlands in the foothills up to subalpine spruce-fir forests near mountaintops. They cored or cut cross-sections from more than 11,000 trees in these plots, hundreds of which had been injured at least once by fire. By analyzing the annual tree rings of these trees, Kitchen and his colleagues first determined when and where forests were established and how they grew over time. Then, they noted in these cross-sections annual tree rings that had been scarred by fire. Together the two analyses revealed the year and even the season when the fire occurred. The two analyses enabled them to reconstruct historical fire patterns across the landscape and over the centuries.

Dr. Stan Kitchen develops multi-century fire chronologies by determing the location of fire scars in relation to annual growth rings on cross-scetions of fire-scarred trees. Chronologies are used to reconstruct historic fire regimes for forest-shrubland mosaics.

Photo: USDA Forest Service

"if conditions are dry that first year and you're out of seed, it can take 70 years or more for the stand to recover."

The trio found that fire was much more frequent before Euro-Americans settled the area, especially surface fires that burned through grass and shrubs and not through the crowns of trees. Past fires often were mixed in severity—in some areas they acted as surface fires, and in others they burned hot enough to devour entire patches of forest.

But what caused the more frequent fires is a subject of considerable debate, Kitchen says. Was it lightning and a lack of fire suppression, or did Native Americans burn areas intentionally when lightning failed to ignite them? To find out, Kitchen analyzed the time of year each fire occurred. He did this by examining the position of the fire scar within each annual growth ring. These days, fires in the region are most common in the mid- to late summer. But before European settlement, fires generally occurred early or late in the growing season, according to a detailed analysis of 378 fire scars from 110 trees in Mill Creek and Burnt Mill Canyons in Great Basin National Park. The results suggest that Native Americans intentionally set fires during the spring or fall, perhaps to improve hunting grounds or for other benefits. In support of this idea, fires burnt about every 10 years in Burnt Mill Canyon, while they only burned about every 27 years a short distance away in Mill Creek Canyon. Perhaps they burned the Burnt Mill Canyon area more often because it was better habitat for bighorn sheep, Kitchen speculates.

Researchers also used tree-ring data to investigate how fire was affected by the El Niño- La Niña oscillation—a natural climate cycle that lasts from 3 to 8 years and is caused by interrelated changes in the equatorial Pacific Ocean and the atmosphere. By analyzing those tree rings, Kitchen and associates documented more fires in dry La Niña years than in wet El Niño years for southern Utah. "We were able to tie fire patterns to climate variability," Kitchen says. As researchers understand in more detail how climate will change in coming decades, the results should help land managers predict when fire is likely to burn across the region.

More recently, Kitchen has turned his attention to fire patterns and effects in shrublands as well as forests. For one essential rangeland shrub, mountain big sagebrush, fires pose an intriguing paradox. This species is critical habitat for at risk species and thrives in rangeland landscapes that were historically dominated by fire, yet both the plant and its seeds perish easily in the flames. Kitchen is working with landscape ecologists Peter Weisberg of the University of Nevada, Reno, and Steven Petersen of Brigham Young University to understand the strategies the plant uses to survive and even thrive in a landscape that burns regularly.

First, Kitchen investigated past fire frequency in nine mountain big sagebrush communities in the eastern Great Basin, upper Colorado Plateau and intervening uplands by analyzing-fire scars from nearby injured trees. Kitchen and Weisberg also investigated how fast mountain sagebrush communities recover after fires today. They identified records of fires at 27 sites that burned between 1971 and 2007 by searching records kept by the USDI Bureau of Land Management, the National Park Service and the USDA Forest Service. For each site, they investigated vegetation recovery, using unburned areas for comparison.

Sagebrush on some sites had recovered completely in as few as 15 years, while other sites took many decades to bounce back. The researchers learned that mature mountain sagebrush stands usually produce an abundance of seed, enough that, despite its vulnerability to fire, a small percentage of seed usually survives to sprout the next year. However, seedlings survive only if there's enough rain or snow to support their growth the following summer. "If the seed has a chance to establish that first year you get a good stand right away," Kitchen explains adding. "But if conditions are dry that first year and you're out of seed, it can take 70 years or more for the stand to be recover."

In a follow-up study, Kitchen and Petersen are determining how quickly after a fire the new generation of sagebrush plants produces good quantities of sagebrush seed. They believe that a sagebrush stand may produce enough seed to regenerate a sagebrush stand even if the stand has not fully recovered. They're currently testing this idea at 14 sites. The results will be important in determining the effect of repeated fires.

With climate and fire regimes changing, will mountain big sagebrush stick around in Western landscapes over the long term, or will

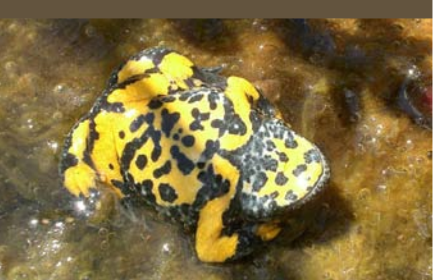
Pinyon pine encroaches into a mountain sagebrush community where fire has been absent for over 100 years.

Photo: USDA Forest Service

Above: The Yellow-bellied toad (Bombina variegata), an endangered species in Germany, responds positively to disturbance.

Below: The yellow-bellied toad gets its name from its bright yellow underside. Credit: Steven Warren

Photos: Reiner Buettner



other plants replace it? It's a delicate balance. Too much fire, and sagebrush gives way to fire-adapted grasses and shrubs that sprout from their roots. Too little fire, and trees move in to crowd out the shorter shrubs. To learn what the future might hold, Weisberg led an effort to build and test a computer model that incorporates data from the historical fire-scar analysis of nearby trees and from their work on sagebrush community recovery from fire. The model calculates what will happen to the vegetation on landscape over time with various fire frequencies and sizes and various levels of sagebrush seed survival.

They're still fine-tuning the model, but so far it looks like mountain big sagebrush has a fighting chance. If fires are small, and only occur about every 30 to 60 years, "we're probably OK," Kitchen says. Such knowledge can help land managers determine how often to conduct controlled burns, and keep sagebrush on the landscape for decades to come.

The Upside of Disturbance: Biodiversity on Military Lands

Ecologists and conservationists have often concluded that threatened and endangered species require untrammeled habitat for optimum success in recovering their populations, and the best way to preserve the species was to preserve large blocks of undisturbed land for them to inhabit. This is often true in the case of charismatic megafauna such as the polar bear and bighorn sheep, which has led many ecologists to conclude that all disturbances have negative consequences. "While for many of those species, disturbances may be bad, for others, disturbances are absolutely critical for their survival or reproductive success," explains Steve Warren, a disturbance ecologist from RMRS's Shrub Sciences Laboratory in Provo, Utah.

Warren began focusing on disturbance-dependent species a decade ago, when he was working as a research ecologist at U.S. Army training areas in Germany. For example, the yellow-bellied toad and the natterjack toad (*Epidalea calamita*) are red-list (endangered) species in Germany, and they can't reproduce where there's a lot of vegetation, Warren says. But after studying Army tank training sites, where tank tracks filled with rainwater, he found that the toads laid eggs in water-filled ruts created by the tanks, and tadpoles hatched and swam in them, he says. The US Army bases now support the largest populations of the toads anywhere in Europe. He found a similar dependence on disturbance for two endangered insects and four endangered plants.

To learn more about the phenomenon, Warren launched a project to examine the effects of military disturbances on the overall biodiversity on U.S. Army bases. He focused on plants because "they don't get up and run away, so they are easier to study." He collaborated with Anke Jentsch, an ecologist at the University of Bayreuth, to document plant biodiversity on 100 one-hectare plots in Grafenwöhr Training Area, eastern Bavaria, Germany. The researchers and Jentsch's graduate students surveyed each plot, counting how many plant species were present—a quantity that ecologists call "species richness." They also considered each of the plots as they might study a patchwork quilt, noting how many different patches of habitat it contained. One patch might be intact forest or grassland, while other patches in the plot were disturbed by tank traffic, forestry practices, or wild boars. They found that the more heterogeneous, or patchier, the landscape was, the more species were present. "It created a greater variety of habitats suitable for a greater variety of species," Warren explains.

But walking the land was a lot of work, and Warren wanted to find an easier way to study biodiversity across landscapes. He realized that different types of vegetation would create different shapes, shadows, and colors that could potentially be distinguished by satellite imagery. In the second phase of the project, Warren's team examined satellite images from the IKONOS satellite, which detects blue, green, red and near-infrared light reflected from the landscape. Each pixel of the satellite image represents a 4 by 4 meter square. Using statistical methods to analyze the satellite images, they examined 168 potential measures (metrics) of spectral diversity in image of their study site in Grafenwöhr Training Area. Then they correlated those metrics with the plant species richness they'd recorded on each plot, and found some metrics that were reliable gauges of plant biodiversity. "Now we can begin to estimate plant biodiversity with a satellite image. Ultimately that's easier than sending armies of graduate students—no pun intended," Warren says.

Suitable sites for wind farms include habitats occupied by the greater sage-grouse.

Photo: US Fish and Wildlife Service.

Wind turbines are becoming increasingly familiar sights on western landscapes.

Photo: National Renewable Energy Laboratory

Warren and Jentsch set out to determine if patchier landscapes indeed had higher biodiversity. They used a more definitive measure of plant biodiversity than they had used at first. If you have 20 species of plants on a plot, Warren says, "you could say it's really diverse. But if one species occupies 99 percent of that area . . . it's really not that diverse." Therefore, the researchers tapped graduate students again to measure both the number of species in each patch of land (species richness) as well how evenly each of those species are distributed (species evenness). According to work that is not yet published, the satellite imagery squared with biodiversity, as gauged by this more accurate measure, Warren says.

Ultimately, the work will help the Army and other agencies choose areas to conserve that are most important for biodiversity, and it will help them decide what types of disturbances those areas can endure and in which locations.

Energy Development and Sage-grouse Conservation: Collaborating to Improve Knowledge

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) were once distributed in 12 states and 3 provinces. Populations have declined substantially over the past 50 years, and sage-grouse currently inhabit only 56% of their pre-settlement habitat. In 2010, the U.S. Fish and Wildlife Service designated sage-grouse as warranted but precluded from protection under the Endangered Species Act because other species had higher priority for protection. This action, along with the long-recognized fact that sage-grouse populations are declining, have led land managers, scientists and industry to become more interested in gathering new information that will help conserve sage-grouse populations and improve habitat conditions for the species, while supporting clean energy development.

The emerging role of wind farms as an energy supplier in the western United States has led to questions on how to best manage sage-grouse populations and the resources these birds require in areas where wind farms are being developed, such as Wyoming. Wyoming already exports multiple forms of energy to urban areas throughout the U.S., and energy development in Wyoming often occurs within the extensive sagebrush ecosystems that provide habitat to a variety of species such as sage-grouse. While multiple studies are ongoing, no detailed studies have been completed to date that quantify the potential short term or long term effects specifically of wind energy on sage-grouse populations.

Rocky Mountain Research Station (RMRS) researchers are collaborating with other scientists to determine potential effects of wind energy development on sage-grouse. Scientists are studying varying aspects of the life history of sage-grouse including male behavioral ecology, breeding biology, habitat use, and seasonal movement patterns using a study design to detect changes before, during and after wind farm development. The research complements similar sage-grouse research programs in Idaho and Wyoming that are being coordinated by the Sage-grouse Research Collaborative of the National Wind Coordinating Collaborative, which includes a broad set of stakeholders supporting the development of environmentally and economically sustainable wind power.

As part of the effort, Dr. Mark Rumble, a wildlife biologist at RMRS's Rapid City Forest and Grassland Sciences Laboratory in Rapid City, South Dakota, and colleagues from University of Missouri, Wyoming Department of Game and Fish, Power Company of Wyoming LLC (PCW), and SWCA Environmental Consultants (SWCA) have launched a study looking at the potential effects on sage-grouse of a proposed wind farm to be constructed on portions of a 320,000-acre ranch in southwestern Wyoming. In the wind farm study, RMRS and project collaborators are monitoring the use patterns of male sage-grouse that have been tagged with solar-powered GPS transmitters. A similar study of female sage-grouse using GPS tags has been under way on the ranch since April 2010, conducted by SWCA and PCW, as part of PCW's sage-grouse conservation plan. This sage-grouse monitoring effort will continue more than five years, collecting data before, during and after the wind turbines are installed.

The Grassland, Shrubland and Desert Ecosystems (GSD) Program of the RMRS has been conducting sage-grouse research since 2005. During previous research in North Dakota

Plague contributes to the endangerment of the black-footed ferret (Mustela nigripes), a species that preys on prairie dogs and dens in their burrows.

Photo: US Fish and Wildlife Service

Rodents are brushed for fleas to gauge the relationship between rodent and flea species and flea community characteristics associated with increased disease transmission.

Photo: Megan Friggens

and South Dakota, Dr. Rumble and a research team from South Dakota State University investigated environmental factors that influence where sage-grouse build nests and how well the nests survive. They also studied the habitat of hens with broods and the winter ecology of sage-grouse.

In the current study, Rumble and his colleagues will be able to develop models that predict the quality of sage-grouse habitat across the landscape, which they believe can provide industry and government agencies with additional criteria to help ensure that wind energy can be developed while preserving or enhancing sage-grouse populations.

When Disturbing Ecosystems Can Spread A Disease

As humans disturb natural ecosystems around the world, are we more likely to see outbreaks of infectious diseases carried by animals? In the case of flea-borne diseases, the answer is yes, according to a recent study led by Megan Friggens, a research ecologist at RMRS's Albuquerque Forest Sciences Laboratory.

Friggens had spent several years investigating ways to improve management of prairie dogs, an essential species in grassland, shrubland and desert ecosystems. Plague, the same bacterial disease that caused the Black Death in Medieval Europe, can decimate a prairie dog town. To manage prairie dogs well, land managers need to better understand what leads to plague outbreaks, and in previous work, Friggens had attempted to isolate plague bacteria from prairie dogs and associated rodents to study the disease. But plague infections killed off the animals so quickly that it was hard to find living animals with signs of infection by plague bacteria. Friggens instead began studying fleas, which transmit the bacteria among prairie dogs, to get a handle on how plague bacteria move around in the field.

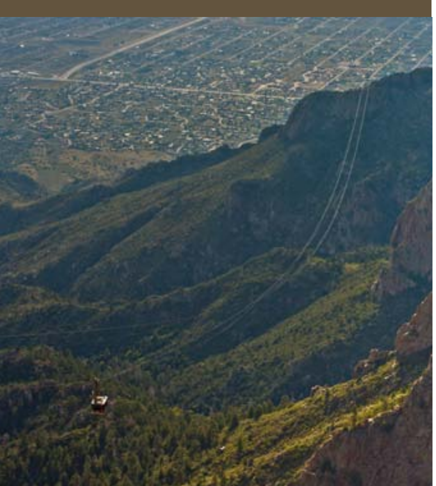
That work gave her a tool to look more broadly at how human-caused ecosystem disturbances were affecting the spread of fleas, which infest rodents and other small mammals and transmit plague, typhus, and other bacterial diseases to humans. Other researchers had shown that as cities grow and farms spread over formerly wild areas, zoonotic diseases—diseases carried in wildlife but also able to infect humans and domestic animals—often spread to new areas or become more common in areas where they're already established.

Friggens and her collaborator, conservation biologist Paul Beier of Northern Arizona University, knew that mammals with a high flea burden were more likely to transmit disease, and that just a few of the many species of fleas that exist actually transmit disease. So to learn something about their hypothesized link between disturbance and flea-borne disease, they needed to know which type of flea species were present at disturbed sites and how abundant they were. Friggens and Beier scanned the scientific literature for studies in which scientists had collected fleas from live-trapped animals, counted them and determined their species. They mapped the sampling locations from each study using Google Earth, and they determined in which of five biomes—forests, grassland/savanna, deserts, chaparral, or tundra—the site was located. Then they classified each of the 70 sampling sites which came from 63 separate studies as wild, agricultural, or urban, based on another research group's Google Earth map. To see if characteristics within the flea community associated with increased flea-borne disease was more common in disturbed sites, they used sophisticated statistical software to cross-check the disturbance level of the sampling site with data on fleas collected there.

At disturbed sites, more rodents had fleas, and the infested rodents had more fleas than rodents from more natural sites, the researchers reported in 2010 in *Oecologia*. "Disturbance was a significant influence," Friggens says. The results mean that disrupting natural ecosystems for agriculture or development could have consequences for zoonotic disease transmission. "If we don't try to preserve biodiversity, we are fostering an increase in likelihood of these outbreaks—both within wildlife communities and in ourselves," she concludes.

Above, Below and Right: Viewing the city of Albuquerque from Sandia Crest, Cibola National Forest.

Photo: Michael Marcus.



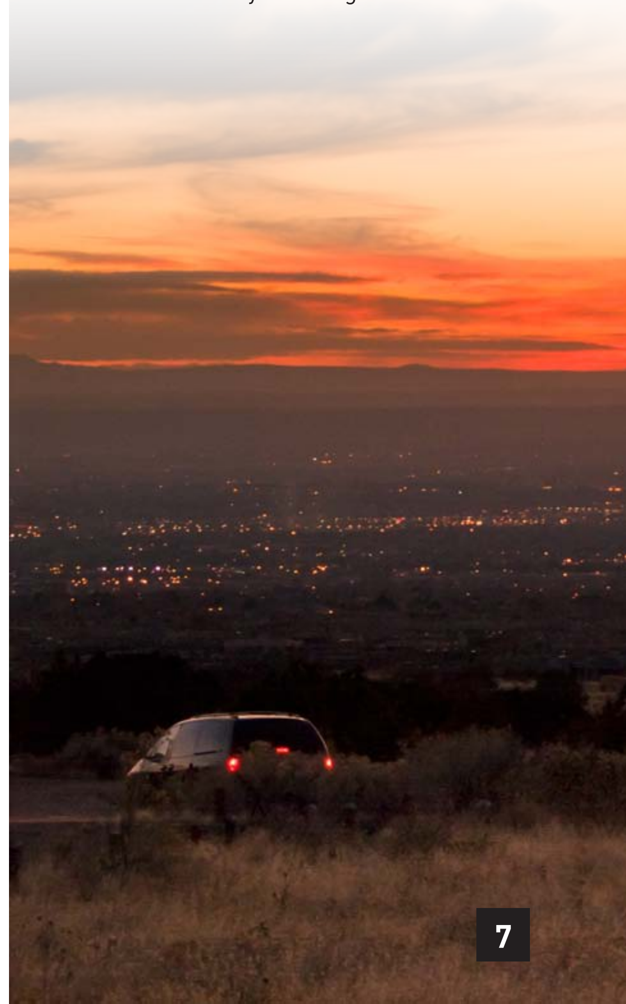
Getting to the Root of Urban Open Space Decisions

Urban residents value nearby natural areas for recreation, scenery, and quality of life, and increasingly want their cities to be sustainable. Yet cities can have a variety of impacts on nearby open space. Litter, vandalism, and accidental fires are common on federal lands near cities. Domestic cats prey on wild animals; city smog, heat and dust affect plants and wildlife; cities deplete water supplies, and housing developments fragment or displace open space. Federal agencies that manage open space in and around cities must make hard choices between competing interests while staying true to their agency mission. Sound agency decisions about open space matter in the lives of millions. So, it's no surprise that federal agencies—and employees within an agency—often have different views on how to manage a piece of land. Agencies increasingly need to collaborate in deciding how to manage large landscapes with multiple owners because many land-management issues, including fire, invasive species, habitat fragmentation and water shortages cross jurisdictional boundaries. To work well together in managing open space and the ecosystem services they provide, it helps if agencies and stakeholders get to the root of their differences and find common ground.

To resolve tensions arising from different approaches to land use, it's essential to understand the views and motivations of the federal employees who decide how federal lands are managed and used. That's the purpose of a new study initiated by Deborah Finch, manager of RMRS's Grassland, Shrubland and Desert Ecosystems Science Program and Carol Raish, a scientist in the RMRS Human Dimensions Program. Their study is part of a larger project done in collaboration with scientists at Arizona State University, University of New Mexico, and New Mexico State University.

With funding from a National Science Foundation program called Urban Long-Term Research Area Exploratory Awards (ULTRA-Ex), Finch, an ecologist, and Raish, an archaeologist, both of whom work at RMRS's Albuquerque Forestry Sciences Laboratory, surveyed more than 300 federal decision makers who manage national forests, rivers, parks, and military lands around a large, medium-sized and small Southwestern city: Phoenix, with a population of more than 2 million; Albuquerque, population 750,000, and Las Cruces, New Mexico, population 300,000. Researchers Dr. Megan Friggens and Alice McSweeney assisted in finding and contacting survey participants and administering the survey. Surveys were given to federal employees with varying levels of seniority, as measured by their position and pay scale. These federal employees work for the Departments of Agriculture, Interior, or Defense— organizations that each have lands on the urban fringe, but with different missions and ideas about how they should be used and managed.

The survey included questions such as: What is open space? Is livestock-grazed rangeland considered open space? How about farmlands? "We're trying to assess the full array of agency values, practices and views," Finch says. The survey data are just in, and Finch and Raish are beginning the analysis phase. But the results should help agencies understand how and why they decide what to do with urban open space and how to partner across boundaries, Finch explains: "And if they don't like the answers, they have the option of changing how they make decisions and how they work together."

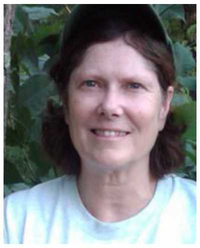


A message from the Program Manager

Disturbance Ecology 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, wild fire, disturbances, urban pressures and climate change. Scientists in our program evaluate how and to what extent natural and anthropogenic disturbances affect the functioning, composition, and integrity of natural ecosystems. Studies focus on plant and animal population and community responses to stress variation and assess resilience of ecosystems, communities, species and subspecies. Our research also evaluates the capacity for species to adapt to environmental changes. We provide decision support to managers in need of knowledge and tools for mitigating damage by disturbance. We also deliver information about the roles, challenges and benefits of natural disturbances.

—Dr. Deborah Finch, Science Program Manager

Meet Some of the GSD Scientists



Dr. Deborah Finch is the Science Program Manager of RMRS's Grassland, Shrubland, and Desert Ecosystems Science Program. An ecologist, she focuses much of her research on riparian environments. She focuses on the effects of fire and the removal of invasive plant species and fuel loads to reduce the risk of fire, and on determining how those measures affect threatened, endangered and sensitive species, water resources, soils, and how different elements of the ecosystem interact. She evaluates how processes and functions change and how managers can improve ecosystem conditions. She is collaborating with Dr. Carol Raish to explore views about urban open space, information that may help in establishing landscape-level collaborations.

Dr. Megan Friggens is a Research Ecologist within the USFS Rocky Mountain Research Station whose research activities include the development of species vulnerability assessments and climate change tools, climate change effects on southwestern vertebrate species and ecosystems, the ecology of prairie dogs and plague, disturbance ecology (fire, drought) in the southwestern U. S. ecosystems, and the management of urban open space. Megan's Ph.D. in Forest Science from Northern Arizona University focused on plague ecology, prairie dog conservation, and the effect of anthropogenic disturbance on the spread of flea borne disease.

Dr. Stanley Kitchen is a research botanist at the RMRS Shrub Sciences Laboratory in Provo, Utah. He conducts research on disturbance processes and restoration strategies in the Intermountain West. Major objectives of his research include: (1) characterizing historic fire regimes variability and associated vegetation dynamics for shrubland and forest vegetation; (2) exploring variability in post-fire succession to develop models of vegetation recovery; (3) investigating effects of climate variability, invasive species, and livestock grazing on the stability of temperate desert ecosystems; and (4) examining life-history attributes of intermountain shrub, grass, and forb species in order to develop cultural practices for native seed production for use in restoration plantings in Intermountain West shrublands.

Dr. Mark Rumble is a research wildlife biologist at RMRS's Forest and Grassland Research Laboratory in Rapid City, South Dakota. For the past 30-plus years he has been studying animal-plant community relations (habitat) for a variety of species in grassland and forest ecosystems of the Northern Great Plains. He currently is studying the relations between black-backed woodpeckers and recent wildfires, mountain pine beetle epidemics, and prescribed fire applications. He also is participating with a number of collaborators from universities, state agencies, and private industry to determine how wind energy development affects greater sage-grouse populations and movements.

Dr. Steve Warren is a research disturbance ecologist at RMRS' Shrub Sciences Laboratory in Provo, Utah. He joined RMRS recently after spending 13 years as a research ecologist with the U.S. Army and 11 years as Associate Director and then Director of the Center for Environmental Management of Military Lands at Colorado State University. He has a long track-record studying the effects of intensive and extensive disturbances on a variety of ecosystems, focusing on soil erosion modeling and control, biological soil crusts, disturbance-dependent threatened and endangered species, and related remote sensing applications. He has conducted research across the continental United States and Hawaii, Germany, Panama and Chile.

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Recent GSD Publications

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