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Forecast for the Great Basin

Elise LeQuire
US Forest Service, cygnete@mindspring.com

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Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Speyeria nokomis apacheana, a butterfly that occupies seeps, springs, and riparian areas in the central Great Basin. Credit: Erica Fleishman.

Forecast for the Great Basin

Summary

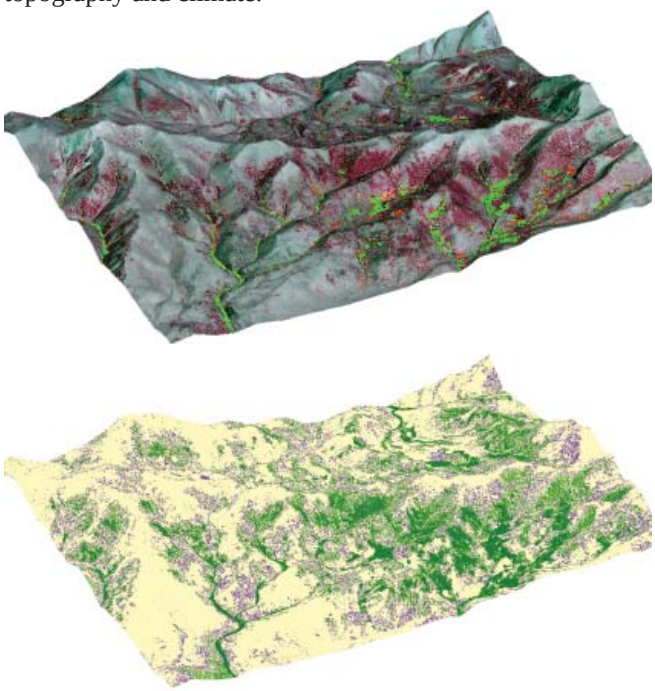
Across the Great Basin, human activity since the 19th century has altered fire regimes, land-cover patterns, and the distribution of animals and plants in ways that may be irreversible. Expansion of native pinyon and juniper trees and non-native cheatgrass into areas dominated by sagebrush is hypothesized to be increasing the frequency, extent, and severity of wildfire. Land uses such as grazing by domestic livestock and diversion of water for irrigation have greatly reduced the extent of riparian vegetation that supports many species of birds, butterflies, and other animals. For more than 20 years, changes in land cover have been documented via satellite remote sensing and, to a lesser extent, monitoring in the field. Research also has provided information on the distribution and population dynamics of birds and butterflies associated with pinyon-juniper woodlands and riparian vegetation. In a four-year study in the central Great Basin, researchers examined remote sensing data on land cover and as many as nine years of field data on the distribution and abundance of breeding birds and resident butterflies to infer how these taxonomic groups might respond to changes in land use, including fuels management approaches, and in climate. Because different species of animals are associated with different aspects of topography and vegetation structure and composition, it may be possible to project future responses of animals to alternative scenarios of vegetation change. This information adds to the regional knowledge base and provides resource managers with guidance on potential effects of fuels treatments on the habitat of animals.

Key Findings

- Field data on the distribution and abundance of breeding birds and resident butterflies—combined with field data on vegetation composition and structure, and satellite remote sensing data on changes in land cover over time—can be used to project the distribution of animals under different scenarios of fuels treatment and climate.
- Information gathered across four mountain ranges on the distribution and abundance of birds and butterflies that breed and feed in multiple land-cover types, including pinyon-juniper woodlands and riparian vegetation, serves as a baseline from which future research can expand.
- In the central Great Basin, year to year variation in weather patterns can be extreme. Abundances of three species of breeding birds associated with riparian vegetation were low during summer 2005, following a cold, wet winter and spring.
- Burning to curb expansion of pinyon and juniper trees into sagebrush may have undesirable effects on woodlands in which some species of birds breed.

Bird's eye view

With the Wasatch Range to the east and the Sierra Nevada and Cascade Mountains to the west, the Great Basin is a large region of internal drainage. Precipitation flows into streams or lakes that have no outlet to the ocean, and many of these are ephemeral. "Once you get into the canyons, you find small streams, springs, and seeps where vegetation is dense and diverse and supports many different animal species," says Erica Fleishman, a researcher at the Bren School of Environmental Science & Management, University of California, Santa Barbara. A riparian zone may be less than 330 feet (100 meters) wide, due largely to topography and climate.



(Top) Modeled location, derived from SPOT-5 data, of riparian vegetation (bright green, orange, and red) across 46 km^2 in the central Great Basin. (Bottom) Percent cover of woodland (darker green = higher percent cover) across the same area. Credit: Steve Sesnie and Brett Dickson, Northern Arizona University.

At the same time, pinyon and juniper woodlands are expanding into some areas once dominated by sagebrush and other shrubs, grasses, and forbs, and non-native cheatgrass has colonized extensive areas.

Pinyon-juniper woodland in Underdown Canyon, Shoshone Mountains. Credit: Erica Fleishman.

A four-year study funded by the Joint Fire Science Program has focused on the vegetation, birds, and butterflies in four mountain ranges in the central Great Basin: from west to east, the Shoshone Mountains and the Toiyabe, Toquima, and Monitor ranges (Lander, Eureka, and Nye counties, Nevada). The project is part of an ongoing collaboration among land managers and scientists with the Forest Service (Humboldt-Toiyabe National Forest and Rocky Mountain Research Station), the University of California, Santa Barbara, High Desert Ecological Research Institute, and Northern Arizona University.

The four ranges run roughly north to south. Precipitation is mainly in the form of winter snowfall with some summer rain. "The precipitation in a cold desert, as opposed to a hot desert, mostly comes as snow over the winter," says Fleishman, and flooding is unusual. "The main period of runoff is early June, though there is an occasional flash flood if there is a sudden downpour."

Because of its remote location, low human population, and documentation of the distributions of vegetation and animals dating back 20 to 25 years, the study area is valuable for research and for maintaining ecological resilience and connectivity. "We have a tremendous opportunity for landscape-level resource management in the central Great Basin because there are few people and relatively little resource extraction," says Fleishman.

Shrinking habitat

"The mountain ranges of the Great Basin comprise the last biological frontier in the lower 48 states," says David Dobkin, executive director of the High Desert Ecological Research Institute in Bend, Oregon. But the land is not pristine. "The impact of humanity is subtle, but very dramatic." In the 1870s, substantial herds of cattle, sheep, and horses were introduced to the Intermountain West. "In the four decades up until the 1910s, the impact of grazing by hoofed animals that previously had not been present profoundly altered the plant species composition and abundance, and that impact is still apparent."

The pattern of grazing has changed over time. In the middle decades of the 20th century, ranchers began to graze more cattle and fewer sheep. "Cows can't go as far as sheep from water sources, so they congregate along the riparian zones eating the vegetation," says Dobkin. There is general agreement that across the entire western United States, the current extent of riparian land cover is less than half its extent before the mid 1800s. "Riparian habitat is absolutely critical for breeding birds and during migration."

Cow grazing along the Reese River, Lander County, Nevada. Credit: Erica Fleishman.

In the past, a greater proportion of the river and stream systems in the Intermountain West had permanent flow. "Today many are ephemeral. There are riparian corridors where, if you walk up to a stream, you can't wiggle your toes in the water," says Dobkin. "The streams have cut down to bedrock. The upland areas are in better shape compared to a century ago, but the riparian zones are less healthy."

Birds, butterflies, and vegetation

Earlier in the 2000s, the researchers planned to conduct pre- and post-fire studies in Underdown Canyon, a watershed with substantial pinyon-juniper cover that is part of a Demonstration Watershed established by a partnership among the Humboldt-Toiyabe National Forest, the Rocky Mountain Research Station, and the Bureau of Land Management on lands managed by the Humboldt-Toiyabe National Forest. However, the total area ultimately burned in Underdown Canyon "was inadequate in its spatial pattern and acreage burned to draw robust conclusions about the responses of birds to fire," says Dobkin.

The researchers decided instead to continue gathering data from existing study sites in the four mountain ranges, and to use a 7,000 acre (2,800 ha) lightning ignited wildfire that occurred in Wall Canyon in the Toiyabe Range in 2000 as a "natural" treatment. They also collected data from a human-ignited fire approximately 10 miles (16 kilometers) to the northeast of Austin, Nevada.

Sampling points for birds were chosen to include the major vegetation types in the mountain ranges, such as pinyon-juniper, willow, sagebrush and other shrubs, and smaller shrubs, forbs, and grasses. Surveys were conducted in calm weather between dawn and 3.5 hours after dawn. A total of 376 points were monitored at elevations ranging from 6,280 to 10,320 feet (1,915 to 3,145 meters).

David Dobkin and Gabriel Markoff identify birds in riparian vegetation, San Juan Canyon, Toiyabe Range. Credit: Erica Fleishman.

Bird surveys were conducted during the breeding season, late May through June, from 2005 to 2009, but existing data gathered with identical methods in the same sites were included in the analyses. "Our results are built on a data set going back to 2001, an almost unprecedented information base for birds in the Great Basin," says Dobkin.

The number of species in the order Passeriformes is one of the greatest among the class Aves. Passerines, which include songbirds such as thrushes, warblers, and finches, account for more than 50 percent of all avian species. Eight migratory passerines were selected for one analysis in part because of their close association with pinyon and juniper woodlands: Gray Flycatcher, Blue-gray Gnatcatcher, Green-tailed Towhee, Chipping Sparrow, Mountain Chickadee, Black-throated Gray Warbler, Spotted Towhee, and Brewer's Sparrow. Also, "these are species that are sufficiently abundant to work with statistically," says Dobkin.

Migratory birds are of particular interest because they are the subject of international treaties dating back to the Migratory Bird Treaty Act of 1918. Resource

managers therefore must consider the distribution and resource requirements of these species when manipulating vegetation. The decisions of whether, where, and when to apply fire must take into account knowledge of the timing of the breeding season and type of vegetation with which specific species are associated. Curbing the expansion of pinyon-juniper woodland, for example, may benefit sagebrush and the animals associated with sagebrush-dominated vegetation, but burning mature pinyon and juniper trees causes loss of habitat for species that nest and forage in these woodlands.

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Other analyses focused on data for three migratory, riparian obligate species detected during point counts in the Shoshone Mountains and Toiyabe and Toquima ranges: MacGillivray's Warbler, Broad-tailed Hummingbird, and Song Sparrow. The vegetation at the bottom of the canyons where data were collected was primarily aspen, willow, pinyon and juniper, and sagebrush.

Broad-tailed Hummingbird (*Selasphorus platycercus*). Credit: Bill Ratcliff, National Park Service.

Management of riparian vegetation often focuses on overstory; the researchers found that different species of birds are associated with different plants in both the overstory and the understory. The occurrence of Broad-tailed Hummingbird, for example, is associated with water birch, a common tree along stream banks in canyon bottoms, and with a complex understory of shrubs and herbaceous plants that provide floral nectar for the hummingbirds. Song Sparrow is generally associated with a willow canopy and a diverse understory including wild rose, currant, and snowberry. MacGillivray's Warbler is associated with low riparian shrubs in the understory. Although latitude and elevation explained some variation in the occurrences of these three species, some year-to-year changes in abundance also were associated with weather. Abundances of the three species, especially Song Sparrow, were lowest in 2005. Total precipitation during the plant growing season was greatest—and mean temperatures during March, April, and May of the reporting year the coldest—of the six years examined for this analysis. These results establish a baseline of variation over time in distribution and abundance of birds in the absence of fire.

MacGillivray's Warbler (*Oporornis tolmiei*). Credit: Sarah Beckwith, National Park Service.

While surveys of birds are definitely for the early bird, research on butterflies may appeal more to the sleepy head. "Butterflies keep bankers' hours," says Fleishman, so field data are collected between approximately 9:00 a.m. and 3:00 p.m. and when there is little wind or cloud cover. "Butterflies need time to warm up in the morning."

Data on the distribution and abundance of butterflies were collected throughout treated and untreated areas in the Underdown Canyon Demonstration Watershed and in a control watershed, Riley Canyon, where there was no wildfire or prescribed fire for the duration of the project. Butterfly surveys were conducted repeatedly between June and August, which encompasses the flight season for most species. "We recorded approximately 45 species of resident butterflies," says Fleishman. Depending on the species, larvae feed on different trees, shrubs, grasses, and forbs. Adults of some species of butterflies feed on nectar, and some obtain nutrients from mud puddles.

Many species of butterflies in Underdown Canyon moved freely between treated and untreated sites, reflecting the small size of the treatments and the mobility of adult butterflies. Fleishman is still processing the butterfly data and data on vegetation from the same locations, but previous research in the Great Basin has allowed scientists to make some predictions about the response of butterflies to climate change. Many of the species present in the Great Basin may be able to adapt to climate change by retreating to higher elevations or different slopes and aspects.

The larvae of *Plebejus saepiolus* feed on *Trifolium*, a plant that grows primarily in riparian areas. Credit: George T. Austin.

Evolving technology

When Dobkin began his research in the central Great Basin, the basic technique for recording the locations where point counts were conducted was well established. "In the early 1980s, our ability to locate study sites depended on physical topo maps. We used meter tapes and marked our study plots with numbered metal tags, fence posts, or pieces of rebar." But even after just one year, it was often impossible to determine the exact location of the original points. Notes were recorded with pencil and paper. Today, researchers use portable global positioning systems that can pinpoint the location of each study site with horizontal accuracy of 3 to 10 feet (1 to 3 meters).

Fleishman, Dobkin, and researchers from Monash University, Australia, used computationally intensive methods to analyze data on guilds of birds defined on the basis of on riparian vegetation and nest location. They modeled the responses of six putative guilds to latitude, longitude, and elevation as well the structure and composition of vegetation and primary productivity. These data were derived from digital information on topography, field measurements, and satellite remote sensing.

Ironically, in spite of the advances in technology, research in the Great Basin is hampered by the paucity of weather stations. "We know that even without climate change, bird and butterfly populations are sensitive to weather," says Fleishman, "and weather stations are few and far between."

Adapting to change

For resource managers with an eye to the future, one thing is certain: changes are in store for the Great Basin. As temperature and precipitation change, pinyon-juniper expansion may slow, and certain areas where cheatgrass currently is dominant may no longer support that species. However, climate conditions may render these same areas unsuitable for native species that were out-competed by cheatgrass. Work by Bethany Bradley identified many such locations. Understanding relationships among the current distribution of species, topography, and climate can help identify candidate species—including some non-native but not highly invasive species—for reconstructing areas formerly dominated by cheatgrass.

Management Implications

- One management prescription may not meet the needs of multiple species, even if those species are associated with similar land-cover types.
- Few reliable data on weather, including annual precipitation, are available in remote areas of the Great Basin. Obtaining ground data on weather patterns from more locations and over long periods of time is a high priority.
- To maintain diverse riparian species of birds, treatment plans should include maintaining or restoring native understory vegetation in addition to the overstory.

Decisions on when and where to burn or otherwise manipulate the landscape are often made to meet mandates issued at higher levels, such as limiting the expansion of pinyon-juniper or cheatgrass or treating a certain number of acres. The term *encroachment* is often used to describe expansion of woodlands into sagebrush systems, but there is some disagreement in the ecological community about the use of that term. Fleishman says, "Encroachment implies that something is coming in where it doesn't belong. We know the system is changing, but that is not necessarily good or bad."

Further Information: Publications and Web Resources

Bradley, B.A., D.S. Wilcove, and M. Oppenheimer. 2009. Climate change and plant invasion: restoration opportunities ahead? *Global Change Biology* 15:1511–1521.

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Scientist Profile

Erica Fleishman is a Researcher at the Bren School of Environmental Science & Management, University of California, Santa Barbara. Her research focuses on the effects of land use and climate change on the distributions of species in the western United States.

Erica Fleishman can be reached at:
6832 Ellison Hall
University of California, Santa Barbara
Santa Barbara, CA 93106-3060
Phone: 805-893-7352
Email: FLEISHMAN@bren.ucsb.edu

David Dobkin is the Founder and Executive Director of the nonprofit High Desert Ecological Research Institute in Bend, Oregon. The institute is a regional center for ecological research and policy analysis focusing on natural resource issues related to the Intermountain West and Pacific Northwest.

David Dobkin can be reached at:
High Desert Ecological Research Institute
15 S.W. Colorado Avenue, Suite 300
Bend, OR 97702
Phone: 541-382-1117
Email: dobkin@hderi.org

Cooperators

Jeanne Chambers, USDA Forest Service, Rocky Mountain Research Station
Brett Dickson, Northern Arizona University
Bethany Bradley, University of Massachusetts

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John Cissel
Program Manager
208-387-5349
National Interagency Fire Center
3833 S. Development Ave.
Boise, ID 83705-5354

Tim Swedberg
Communication Director
Timothy_Swedberg@nifc.blm.gov
208-387-5865

Writer
Elise LeQuire
cygnete@mindspring.com

Design and Layout
RED, Inc. Communications
red@redinc.com
208-528-0051