USDA
United States Department of Agriculture

Rocky Mountain Research Station
Science You Can Use Bulletin

DECEMBER 2020 | Issue 46

Through the Smoke: Spotted Owls, Wildfire, and Forest Restoration

SUMMARY

Wildfires in the western United States are expected to increase both in size and severity in coming decades. These trends are likely to accelerate large-scale habitat loss and fragmentation for the spotted owl in the Pacific Northwest, California, and the Southwest. All three subspecies that occupy these regions have declined over the last century, and the Mexican and northern subspecies are listed as threatened under the Endangered Species Act in the United States. Predicted changes in the extent and severity of wildfire are driven by a combination of climate change and cumulative effects on forest composition and structure that stem from a history of land uses including fire suppression and timber harvest. High fuel loads and connected canopies make the matrix among patches of old-growth forest. Owls prefer these old-growth forests for nesting, which are prone to stand replacing megafires.

Scientists at the Rocky Mountain Research Station are helping managers better understand how climate change, wildfire, and forest management interact to drive forest changes. It is important to define what those changes mean for the ecology and conservation of the Mexican spotted owl. In the Southwest, scientists and managers are working together to find ways to reduce the risk of future megafires while also maintaining critical nesting habitat.

Tucked away, high in the canopy of an old-growth Douglas-fir, a Mexican spotted owl sits on a nest inside a cavity in a tree, unable to see out. She waits patiently, protecting and incubating two newly laid eggs, alert to sounds of any threat that could launch her into a fierce defense. Her mate perches nearby and calls out. He knows better than to appear unannounced after returning with the mouse or vole he has captured. Only after she calls back, signaling it's safe, does he enter to deliver the meal.

Spotted owls generally prefer to nest in closed-canopy forests with large trees. Year after year, a pair is inclined to use the same area to nest and roost. This inclination, which scientists call *site fidelity*, means nesting habitat is critical for this long-lived species that inhabits forests in the Pacific Northwest, California, and the Southwest. Nesting habitat has become

A pair of Mexican spotted owls, Sacramento Mountains, New Mexico (photo: USDA Forest Service) increasingly rare due to habitat loss and fragmentation from past timber harvest and other land uses. Today, changes in how wildfire behaves threaten further loss now and into the future.

In the last two decades, wildfires in the southwestern United States have covered larger areas and burned more severely. This trend in so-called "megafires," which is expected to increase in coming decades, is driven by a combination of climate change and a history of fire suppression. Warmer temperatures lead to drought stress, making forests drier and more flammable, while fire suppression has had the unintended consequence of increasing the amount of fuels that can burn. In other words, drier conditions plus more fuel that is more flammable results in more area burned and more high-severity fires.

"We're talking about fires that kill all of the trees--canopy replacing fires," says Sam Cushman, a research landscape ecologist at the Rocky Mountain Research Station based in Flagstaff, Arizona. Sam studies habitat connectivity of spotted owls. "And large areas of canopy replacing fire are bad for Mexican spotted owls."

The interlaced canopies of old-growth forests, combined with an accumulation of fuels, mean that critical nesting areas are now more prone to high-severity canopy fire. This is true for the Mexican spotted owl, which occurs in the mountains and canyons of Utah, Colorado, Arizona, New Mexico, and parts of Mexico, as well as the Northern and California spotted owls. All three subspecies have declined over the last century and the Mexican and northern subspecies are listed as threatened under the Endangered Species Act in the United States.

Cushman and Joe Ganey, research wildlife biologist at the Rocky Mountain Research Station in Flagstaff, share a long history of studying how climate change, wildfire, and forest management interact to drive forest changes and what those changes mean for the ecology of the Mexican spotted owl. Recently, together with Ho Yi Wan, a USFS collaborator, the scientists projected how climate change is expected to influence wildfire, including how much area is likely to burn and how likely severe megafires are in the regions occupied by all three owl subspecies.

"There's a high potential for rapid loss of the highest quality owl habitat due to increasing wildfire extent and severity," Ganey says. "That's kind of the crux of the issue. Everything that we know from 40 years of research on spotted owls across their entire range suggest that this could be the case."

Fourteen years after the Rodeo-Chediski fire, which burned more than 450,000 acres in 2002, the number of Mexican spotted owl nesting pairs in 20 Protected Activity Centers decreased by more than 50 percent (photos: J. Ganey, USDA Forest Service).

Wildfire Now and in the Future

Since the beginning of the 21st century, 3 large fires burned more than 1.3 million acres in Arizona and New Mexico. In Arizona, the Rodeo-Chediski fire burned more than 450,000 acres in 2002 and the Wallow fire burned more than half a million acres in 2011. In 2012, the Whitewater Baldy burned 306,925 acres in New Mexico.

“The big fires we’ve seen recently in the Southwest are not even two or three times what we’ve seen historically,” says RMRS landscape ecologist Sam Cushman. “We’re talking seven or eight times. And it’s going to be a lot more in the future.”

Large fires have left their mark in the range of the Northern and California spotted owls as well. In the Pacific Northwest, it’s estimated that more than 470,000 acres of nesting habitat on federal lands were lost to wildfire within 20 years of designating protections for Northern spotted owl habitat under the Northwest Forest Plan in 1994. That habitat loss is four times the amount considered lost from timber harvest during the same time frame.

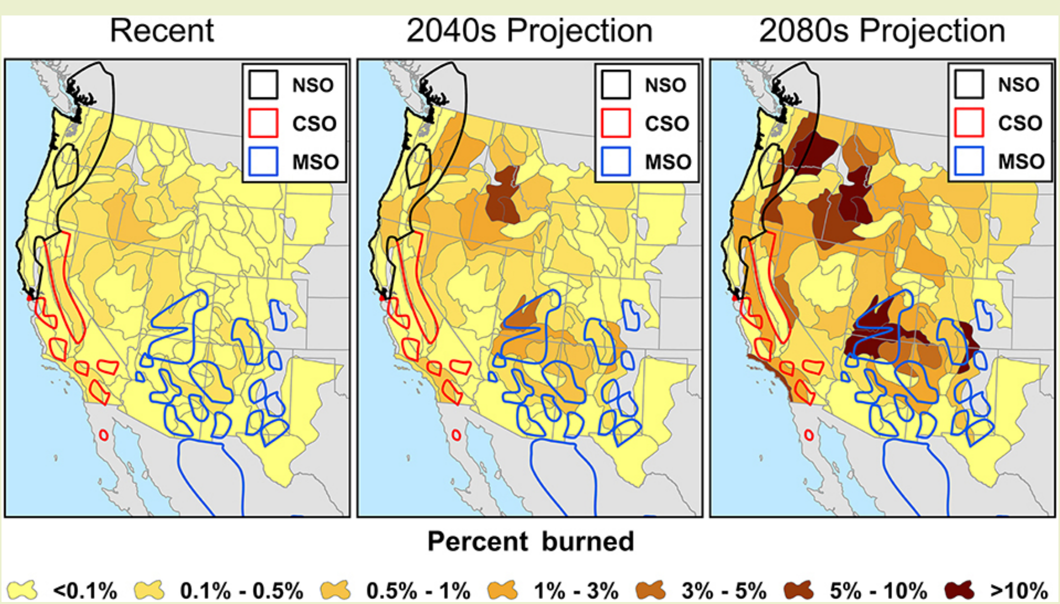
Cushman, RMRS wildlife biologist Joe Ganey, and Ho Yi Wan, a USFS collaborator, have extensively modelled the effects of climate change on wildfire and forests. Among their most significant findings is that the likelihood of fires of greater size, severity, or both is expected to increase dramatically over the next several decades. At stake for the spotted owl is greater habitat loss and fragmentation across the range of all three subspecies.

The extent of wildfires, or area burned, is expected to increase the most in the range of the Mexican spotted owl. Using some of the most sophisticated climate and wildfire models available, the scientists projected a 13-fold increase in area burned in this region by the 2080s. For regions occupied by the Northern and California spotted owls, 10-fold and 13-fold increases are expected.

The picture becomes bleaker when fire severity is considered. Whether a fire crawls along the forest floor, climbs up “ladder fuels” into the canopy, or engulfs everything from forest floor to tree crown depends on a multitude of factors.

Using models based on temperature, wind, topography, and fuel moisture, the scientists predicted that severe fires will likely comprise a large portion of the expected increase in total fire area, especially for the Northern spotted owl.

The findings show that the probability of severe fire was highest in the range of the Northern spotted owl—particularly on the western slope of the Cascade Mountains. There is a combination of factors that make the subspecies highly vulnerable to changes in fire regimes that are driven by climate change. A projected 10-fold increase in area burned and high probability of high-severity fire in the Pacific Northwest, along with the Northern spotted owl’s relatively more dire population trajectory and greater dependence on large areas of late seral forest, create this vulnerability. By comparison, the probability of high-severity fire per unit area was lowest across the range of the Mexican spotted owl, reflecting shorter fire return intervals and generally lower fuel loads. Nonetheless, in forests with high canopy cover and fuel loads, like those found in Colorado, northern New Mexico, and pockets of Utah and Arizona, severe fire is likely. More than timber harvest, severe fires are now considered a primary threat to nesting habitat of the Mexican spotted owl. This is true despite the owl’s ability to also nest in rocky canyons that are less prone to wildfires.



Maps showing trends in percent area burned across the western United States (based on climate-fire models) with ranges of the Northern spotted owl (NSO), California spotted owl (CSO), and Mexican spotted owl (MSO) indicated by black, red, and blue polygons respectively (image source: Wan et al. 2019).

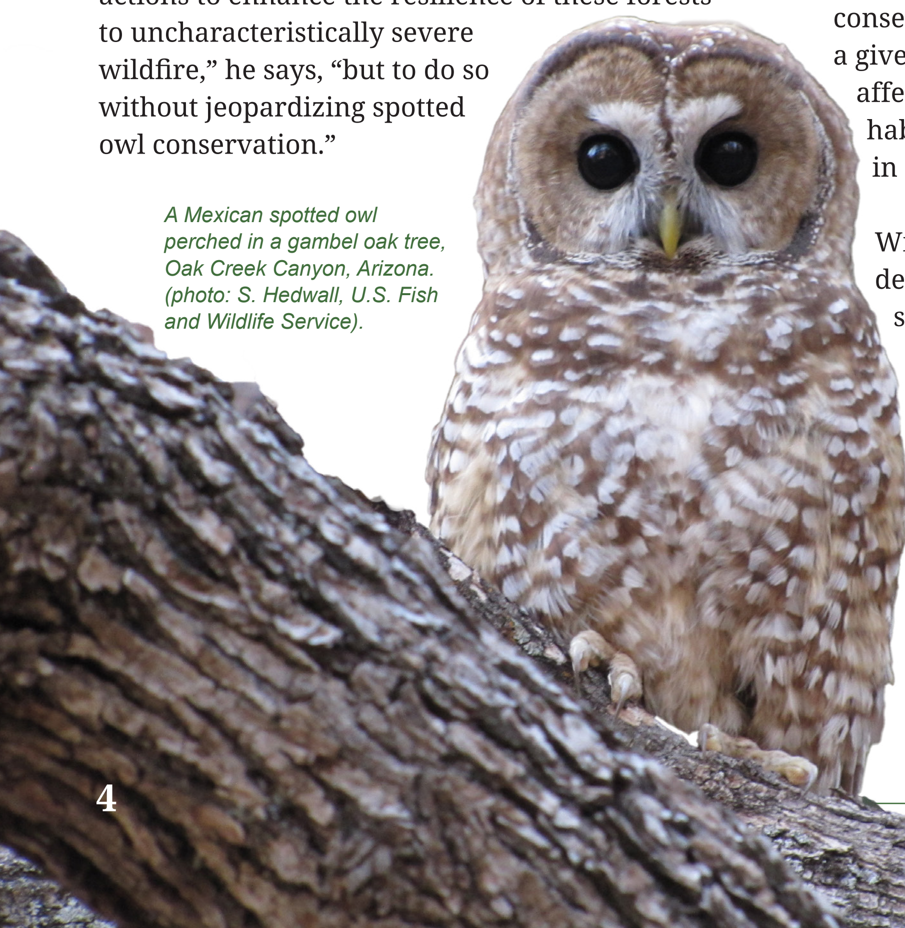
A Growing Sense of Urgency

Karl Malcolm is deeply troubled by what's on the horizon in the coming decades. He was, until a recent move to the Eastern Region of the Forest Service, the regional wildlife ecologist for the Southwestern Region of the Forest Service, which includes the largest area of forested habitat in Arizona and New Mexico that contains Mexican spotted owls.

He and other managers are challenged to design and implement plans that integrate spotted owl habitat conservation with efforts to reduce the risk of uncharacteristically severe fire. All as conditions continue to change.

"There are some things that we can do to manage the vegetation and try to make the forests more resilient to wildfire," says Malcolm. "But with climate change likely to exacerbate wildfire severity and extent, retaining the kind of habitat characteristics on the landscape that Mexican spotted owls need will likely become harder and harder."

"I feel a sense of urgency to take management actions to enhance the resilience of these forests to uncharacteristically severe wildfire," he says, "but to do so without jeopardizing spotted owl conservation."



A Mexican spotted owl perched in a gambel oak tree, Oak Creek Canyon, Arizona. (photo: S. Hedwall, U.S. Fish and Wildlife Service).

> *"I feel a sense of urgency to take management actions to enhance the resilience of these forests to uncharacteristically severe wildfire, but to do so without jeopardizing spotted owl conservation."*
>
> —Karl Malcolm, former Regional Wildlife Ecologist, USDA Forest Service

Malcolm understands that remnant patches of old-growth, mixed-conifer forests provide critical nesting habitat. At the same time, he and Ganey both know it's not possible to protect these areas in their current state forever, because forests are dynamic and ever-changing.

"We need to develop replacement habitat for owl habitat that we lose," Ganey says. "The bottom line is there are many areas where we can't develop the kind of habitat owls are looking for so we need to focus on the areas where we can."

Locating Owl Habitat

Given the urgency, it is important for managers and conservation planners to locate suitable owl habitat on a given landscape and to understand how fire might affect it. But what owls in one area consider suitable habitat for nesting and roosting may differ for owls in another region.

With this in mind, Cushman, Ganey, and Wan developed models to help managers identify suitable habitat for the Mexican spotted owl. However, because habitat variables such as vegetation and topography vary by location, a model designed for one region may not work well for another. The scientists compared predictions from three different models to evaluate habitat suitability (the likelihood of a spotted owl selecting an area for nesting based on habitat) in different parts of the Mogollon Plateau in Arizona. One model was developed based on local habitat variables, one on habitat conditions in the Sacramento Mountains in New

Mexico, and a third as a hybrid of the first two. Although all three models identified the White Mountains region of the Mogollon Rim as a core area of important habitat for the owl, and the local model generally performed best in the portion of the study area where it was developed, the hybrid model performed best across the entire study area.

From his perspective as a manager, Malcolm values these contributions to understanding habitat suitability "because not all spotted owl habitat is created equally. What you're looking for in central Arizona might be different than what you're looking for in southern New Mexico."

In addition to accounting for differences in habitat that vary by location, the scientists are developing a model that takes into account variation across multiple scales.

"Owl recovery requires looking at the bigger picture," says Shaula Hedwall, senior fish and wildlife biologist with the U.S. Fish and Wildlife Service. "We need to be looking at what habitat individual owls are using as well as what the population is using across an area."

Hedwall works closely with the Forest Service to design Mexican spotted owl monitoring plans and is encouraged by the multiscale habitat models that RMRS scientists have developed.

KEY FINDINGS

- Wildfires are likely to increase in extent or severity, or both, throughout most of the range of the spotted owl, indicating a potential for large-scale habitat loss in the future.
- Within the range of the Mexican spotted owl, a 13-fold increase in area burned is expected by the 2080s.
- High-severity fire can decrease habitat suitability considerably for nesting Mexican spotted owls. For example, mean habitat suitability decreased by 21.9 percent 3 years after the Wallow Fire in Arizona.
- Mexican spotted owl occupancy decreased by more than 50 percent 14 years after the Rodeo-Chediski fire in Arizona in 2002.
- Areas with suitable nesting habitat may be more prone to high-severity fire.
- Some types of fire can result in improved habitat for prey and food resources for the Mexican spotted owl, but that improvement may not compensate for the loss and degradation of nesting habitat.

Considering habitat variables at scales that range from several acres (e.g., individual nesting and roosting sites) to more than 50,000 square miles (e.g., the Gila Mountains Ecological Management Unit) provides managers a more complete picture to work with. A multiscale model will help to create a regional map of recovery habitat for the Mexican spotted owl. And that, says Hedwall, will help managers like Malcolm to see where areas can be managed now to provide future nesting and roosting habitat or where it makes sense to break up the continuity of fuels on a landscape to mitigate fire risk.

Modeling has become an essential tool for designing restoration treatments that helps managers evaluate tradeoffs.

Forest Restoration Tradeoffs

Forest restoration efforts to reduce fire risk are designed to drive forest structure and composition back to how it was before past land uses collectively changed it. The complexity of forest dynamics requires managers to carefully weigh the tradeoffs of various treatments. For example, landscape level restoration treatments (such as reducing canopy cover by selectively removing large overstory trees) may harm nesting sites in the *short term*, but they can promote forest health and reduce the risk of megafires and thereby reduce habitat loss in the long term. The effects of thinning—to reduce canopy density and ladder fuels—on nesting habitat is less severe than removing large overstory trees. However, if not done properly, it can also be detrimental to nesting habitat. Forest canopies can regenerate over a few decades—that's short term on forest time—so the consequence may be temporary. By comparison, severe fire that eliminates large, old-growth trees can degrade spotted owl habitat for centuries.

Mechanical treatments like thinning are labor intensive and costly and, at large scales, often impractical. A potentially more efficient approach is to allow naturally ignited or prescribed fires to burn in a deliberate, controlled way.

"The biggest opportunity that we have in terms of having an effect on forest resilience on an ecologically significant scale is how we manage fire," Malcolm says. "It's the most obvious large-scale option that we have in the [forest management] toolbox."

Lower-severity fire can create habitat that supports an abundance of prey that Mexican spotted owls prefer. A mix of low and moderate fire severity may help create the forest structure that owls need while also reducing the potential for more severe fire. But controlled burning requires a window of opportunity when the weather and fuel moisture (among other conditions) are just right.

Whether mechanical or fire based, restoration treatments that both minimize short-term negative effects and yet provide the long-term benefits for the Mexican spotted owl are ideal.

"The goal is to identify activities that both reduce fire risk—move us closer towards what we think is a more natural structure, composition, fire regime—and yet still maintain those elements important to spotted owls," Ganey says.

The Camillo Fire 20 miles south of Flagstaff, Arizona was started by lightning in 2015. The low-severity fire was allowed to burn and managed in order to restore wildlife habitat, promote healthy vegetation, and reduce fuels and the risk of severe fire (photo: S. Hedwall, US Fish and Wildlife Service).

*The **presence** of owls is not necessarily an indicator of **persistence**.*

Integrating the beneficial roles of fire and restoration thinning into spotted owl conservation offers hope for maintaining nesting habitat. Doing so requires knowing more about how owls respond to treatments over time.

Owl Response to Fire and Restoration

Because Mexican spotted owls are devoted to the sites they inhabit, they may continue to occupy burned area many years later. They may even eat well because fire can create habitat that supports the prey owls prefer. But Cushman cautions that the *presence* of owls is not necessarily an indicator of *persistence*.

"We need to know not just where the owls are nesting, but whether they are producing offspring and whether the population is able to persist over time," he says.

How fire (or mechanical restoration, for that matter) affects owl occupancy, reproduction, and other aspects of their demography is difficult to study experimentally, especially long term. That is, unless you're lucky enough to access

Adult and juvenile Mexican spotted owls perched above a nesting cavity in a large gambel oak tree, Coconino National Forest, Arizona (photo: J. Ganey, USDA Forest Service).

monitoring data collected from protected nesting habitat before the second largest fire in Arizona's history swept through it in 2002. Mike Lommler, a doctoral candidate at Northern Arizona University working under the guidance of Cushman, Ganey, and Professor Paul Beier, documented how the Mexican spotted owl responded to the Rodeo-Chediski Fire 14 years after the fact. He compared field data he collected from 2014 to 2016 to data that had been collected from 20 Protected Activity Centers (PACs) prior to the fire. More than a decade after the fire, the number of nesting owl pairs was reduced by more than 50 percent.

Wan, Cushman, and their colleagues used habitat suitability models to compare predicted nesting habitat before and after the 2011 Wallow Fire—the largest fire in Arizona's history. Their findings show a significant decline in habitat suitability (a mean decrease of 21.9 percent) across the landscape 3 years after the fire, with the greatest loss in areas of high-severity fire. The model also shows that areas with high habitat suitability before the fire were more likely to experience severe fire.

Reducing fire risk while retaining nesting habitat for the Mexican spotted owl also requires evaluating how owls respond to different management treatments.

"There's a million ways you can go about implementing restoration treatments," Ganey says. "We need to identify the things that work and really the only way to do that is through experimental work coupled with monitoring."

Shaula Hedwall, with the Southwestern Region with the U.S. Fish and Wildlife Ecological Services office in Flagstaff, Arizona, is doing just that.

"We know we have the ability to minimize the effects of high-severity fire on the Mexican spotted owl," she says. "Now we have this opportunity to look at how different treatments affect owls and their habitat."

As part of a project to reduce the risk of high severity wildfire and subsequent flooding in two watersheds near Flagstaff, Arizona, Hedwall designed a monitoring plan to evaluate how mechanical thinning and prescribed burning affect owl occupancy, reproduction, and habitat. The experiments include using prescribed fire only, mechanical thinning combined with prescribed fire, and no treatments as a control.

The project has been more challenging than Hedwall anticipated—it took 8 years to get the necessary approvals. And because the Southwest lacks the infrastructure associated with a robust commercial timber industry, it is difficult and costly to hire operators with the equipment and skills to do mechanical thinning.

It's too early to come to any conclusions based on the results of the experiments—treatments were

MANAGEMENT IMPLICATIONS

- Protecting remnant patches of mixed conifer and pine-oak forest with large trees and high canopy cover is important to conserve Mexican spotted owl nesting sites.
- Long-term monitoring is essential to understanding spotted owl population trends and response to fire.
- Integrating the beneficial roles of fire and restoration thinning into spotted owl conservation in the West may be critical for maintaining habitat, especially with a changing climate.

applied in 2017—but based on the experience so far, Hedwall, like Malcolm, sees the value of prescribed burning. It may not be a precise tool and it is not without risks to manage, but it is less expensive than thinning. Using mechanical thinning strategically in smaller areas and relying on prescribed burning to treat larger swaths of forests make sense to Hedwall.

"We can put fire on the ground in a more time-efficient manner," she says. "And let's face it, we're running up against the clock. Climate change continues to tick and we're getting warmer and drier. If we wait too long for the ability to treat hundreds of thousands of acres, we may miss an opportunity to have done more good for these forests than not. I hope we can restore some function to these systems before it's too late."

Cushman and Ganey have contributed significantly to the body of research on climate change, wildfire, and spotted owls in recent decades. A new research ecologist recently joined the Rocky Mountain Research Station team: Gavin Jones. He brings with him experience studying the California spotted owl. Jones is now based in Albuquerque as part of the RMRS Wildlife Program's 3E strategy to "embed" researchers within the management branch to co- "educate" each other on relevant issues and "enhance" the coproduction of science between NFS and RMRS. He will co-produce information with Forest Service managers like Malcolm to further explore strategies to promote conservation under climate change. Given the growing sense of urgency among scientists and managers, working together to determine the best approaches to reduce the risks of megafires while also retaining critical nesting habitat in forests of the Southwest is imperative. Doing so may well determine whether pairs of Mexican spotted owls can continue to go about the business of hunting prey, building nests in tree cavities, and rearing future generations.

FURTHER READING

Ganey, J.L.; Wan, H.Y.; Cushman, S.A.; Vojta, C.D. 2017. Conflicting perspectives on spotted owls, wildfire, and forest restoration. Fire Ecology. 13(3). doi: 10.4996/fireecology.130318020. https://www.fs.usda.gov/rmrs/publications/conflicting-perspectives-spotted-owls-wildfire-and-forest-restoration.

Littell, J.S.; McKenzie, D.; Wan, H.Y.; Cushman, S.A. 2018. Climate change and future wildfire in the western United States: an ecological approach to nonstationarity. Earth's Future. 6: 1097–1111. doi: 10.1029/2018EF000878 https://www.fs.usda.gov/rmrs/publications/climate-change-and-future-wildfire-western-united-states-ecological-approach.

Lommler, M. 2019. Mexican spotted owl breeding population, site occupancy, and habitat selection 13–15 years after the Rodeo-Chediski fire in east-central Arizona. Northern Arizona University. Dissertation.

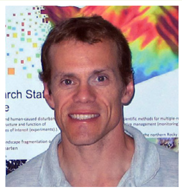
Wan, H.Y.; Cushman, S.A.; Ganey, J.L. 2019. Recent and projected wildfire trends across the ranges of three spotted owl subspecies under climate change. Frontiers in Ecology and the Environment. 7:37. doi: 10.3389/fevo.2019.00037. https://www.fs.usda.gov/rmrs/publications/recent-and-projected-future-wildfire-trends-across-ranges-three-spotted-owl-subspecies.

Wan, H.Y.; Cushman, S.A.; Ganey, J.L. 2019. Improving habitat and connectivity model predictions with multi-scale resource selection functions from two geographic areas. Landscape Ecology. 34: 503–519. doi: 10.1007/s10980-019-00788-w. https://www.fs.usda.gov/rmrs/publications/improving-habitat-and-connectivity-model-predictions-multi-scale-resource-selection.

Wan, H.Y.; Cushman, S.A.; Ganey, J.L. 2020. The effect of scale in quantifying fire impacts on species habitats. Fire Ecology. 16:9. doi: 10.1186/s42408-020-0068-2. https://www.fs.usda.gov/rmrs/publications/effect-scale-quantifying-fire-impacts-species-habitats.

SCIENTIST AND MANAGER PROFILES

The following individuals were instrumental in the creation of this Bulletin:



SAM CUSHMAN is a research landscape ecologist at the Rocky Mountain Research Station in Flagstaff, Arizona. His current research involves developing statistics and software for landscape pattern analysis, vegetation distribution, growth and regeneration along biophysical gradients, and effects of management, fire, and climate regimes on vegetation pattern and process at landscape levels. Additional projects include effective multiresource monitoring, multiscale wildlife habitat relationships modeling, and new approaches to model habitat connectivity. Connect with Sam at https://www.fs.usda.gov/rmrs/people/scushman.

JOE GANEY is a research wildlife biologist at the Rocky Mountain Research Station in Flagstaff, Arizona. His current research on spotted owls includes studies of occupancy and reproduction after the Rodeo-Chediski fire, effects of high-severity wildfire, and multiscale habitat relationships. Additional research involves monitoring dynamics of snag and log populations in southwestern mixed-conifer and ponderosa pine forests, evaluating fire effects on bird and small mammal communities, developing sampling designs and optimizing resources for monitoring programs, and assessing large-scale effects of wildfire and climate change on bird and vegetation communities in the Sky Islands, Arizona. Connect with Joe at https://www.fs.usda.gov/rmrs/people/jganey.

GAVIN JONES is a quantitative research ecologist with the Rocky Mountain Research Station located in Albuquerque, New Mexico. He earned his Ph.D. from University of Wisconsin-Madison, where he studied the effects of fire, forest restoration, and climate change on the conservation of California spotted owls in the Sierra Nevada. Gavin's research primarily focuses on understanding how sensitive wildlife species respond to forest management and how management strategies can be used to promote species conservation under climate change. Prior to arriving at RMRS, Gavin was a postdoctoral researcher at the University of Florida. Connect with Gavin at https://www.fs.usda.gov/rmrs/people/Gavin.Jones.

HO YI WAN is a faculty member at Humboldt State and an RMRS research affiliate. His research integrates multiple disciplines, including landscape ecology, remote-sensing, conservation biology, and landscape genetics, to understand interactions between humans and nature. He uses advanced spatial and statistical analyses to evaluate biodiversity and ecosystem responses to drivers such as climate change, fire, and human activities. Contact Ho Yi at hw83@humboldt.edu.

KARL MALCOLM recently transitioned from his role as the Forest Service's Regional Wildlife Ecologist for the Southwestern Region to a position serving as Assistant Director for Renewable Resources in the Forest Service's Eastern Region, now based in Milwaukee, Wisconsin. He is an enthusiastic supporter of collaborations among scientists and managers to enhance the degree to which emerging and relevant science helps guide improved land management and species conservation. Contact Karl at karl.malcolm@usda.gov.

SHAULA HEDWALL is a senior fish and wildlife biologist with the Southwestern Region of the U.S. Fish and Wildlife Ecological Services office in Flagstaff, Arizona. She is the USFWS's Mexican spotted owl species lead and has extensive experience with both Northern and Mexican spotted owls. Shaula is passionate about using the best available science and working with forest and fire managers to conduct forest and watershed restoration to benefit fish, wildlife, plants, and the ecosystems upon which they depend. Contact Shaula Hedwall at shaula_hedwall@fws.gov.

WRITER'S PROFILE

SYLVIA KANTOR is a science writer for the Rocky Mountain Research Station in Fort Collins, Colorado, as well as the Pacific Northwest Research Station in Portland, Oregon. She has a master's degree in forestry from the University of Washington and lives in Seattle, Washington. Her portfolio is available at www.sylviakantor.com.

About the

Science You Can Use Bulletin

The purpose of SYCU is to provide scientific information to people who make and influence decisions about managing land.

Nehalem Clark: Bulletin Editor / Science Delivery Specialist
nehalem.clark@usda.gov

Jessica Brewen: Bulletin Editor / Science Delivery Specialist
jessica.brewen@usda.gov

To subscribe online to future Bulletins via email,
use this link: tinyurl.com/RMRSsciencebulletin. Previously published Bulletins are posted on our website at: https://www.fs.usda.gov/rmrs/science-you-can-use.

You may also be interested in regular science delivery bulletins similar to Science You Can Use, produced by the Pacific Northwest and Southern Research Stations: PNW Science Findings and SRS CompassLive.

Rocky Mountain Research Station is one of 7 Forest Service Research & Development Stations located throughout the U.S. Within the 12 state RMRS footprint, we maintain 12 research locations, conduct long-term ecological research on 14 experimental forests, ranges and watersheds and work in hundreds of research natural areas.

www.fs.usda.gov/rmrs
twitter: @usfs_rmrs
facebook: @fsresearch