Facing Climate Change in Forests and Fields

U.S. FOREST SERVICE TAPS INTO SCIENCE-MANAGEMENT PARTNERSHIPS

By Amy Daniels, Nancy Shaw, Dave Peterson, Keith Nislow, Monica Tomosy, and Mary Rowland

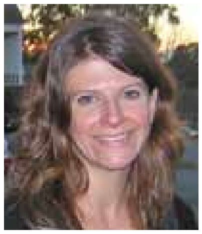
As a growing body of science shows, climate change impacts on wildlife are already profound—from shifting species' ranges and altering the synchronicity of food sources to changing the availability of water. Such impacts are only expected to increase in the coming decades. As climate change shapes complex, interwoven ecological processes, novel conditions and ecosystems will continue to emerge. This reality poses unprecedented challenges, but also opportunities for natural resource managers as they plan for the decades to come.

Addressing the impacts of climate change on wildlife and habitats involves assessing how the various components of and interactions within an ecosystem may change together and then, considering dynamic conservation targets informed by society's values. Achieving such a complex goal can be daunting for any one organization or single branch of science and, as a result, the U.S. Forest Service (USFS) is building on long-established research-management partnerships to develop real-world applications suitable to specific landscapes. The following partnerships illustrate these efforts.

North Cascadia Forests

The North Cascadia Adaptation Partnership (NCAP)—led by the USFS and University of Washington in collaboration with the National Park Service and more than 30 stakeholders—is the largest science-management climate change adaptation partnership of its kind. Established in 2011, this project focuses on two national forests (Mount Baker–Snoqualmie and Okanogan–Wenatchee) and two national parks (North Cascades and Mount Rainier), encompassing about five percent of the area of Washington State and 2.4 million acres of public lands. "Science management partnerships are integral to assessing vulnerability and successfully developing adaptation actions with land managers," says Becky Gravenmier, USFS Pacific Northwest Region Climate Change Coordinator.

In an effort to develop such climate change adaptation strategies, in 2011 and 2012, the NCAP organized a series of two-day workshops for resource managers, scientists, and stakeholders. The workshops—held at the University of Washington—focused on climate change in relation to key themes like hydrology, human access, vegetation management, fish and fish habitat, and wildlife and wildlife habitat. The NCAP team focused on the following activities:



Courtesy of Amy Daniels

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Thousands of hectares of the Okanogan-Wenatchee National Forest in Washington lie charred from the Tripod Fire of 2006. Wildlife biologists work with fire managers to reduce fuels that contribute to wildfires even before fires break out and, in the process, influence the condition and distribution of post-fire habitat.

Credit: Richy Harrod

Credit: Sam Beebe/Ecotrust

Biologists reestablish historic channels, replace large in-stream wood, and plant native riparian trees and shrubs in an effort to restore riparian systems in lower elevation sites in the Cascade Range. Management measures such as these help enhance habitat and counter the effects of a warming climate on stream temperatures.

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Vulnerability Assessments. Researchers conducted vulnerability assessments, which involved characterizing what about climate is changing or expected to change and how species and habitats are expected to respond to those changes. As part of the assessments, partners reviewed downscaled projections of climate change for the region and identified climate-related sensitivities of various habitats including low-elevation maritime forests on the western slopes, riparian forests, and wetlands, as well as wildlife species such as the American pika (*Ochotona princeps*) and the northern red-legged frog (*Rana aurora*). Researchers explored the respective roles of animal physiology, phenology, distributional shifts, inter-specific interactions, and non-climatic stressors like land use change. They also considered components of species' adaptive capacity such as dispersal abilities and reproductive strategies.

Adaptation Strategies. NCAP members combined extensive information about vulnerability with local expert knowledge and ecosystem experience to develop science-based adaptation options for existing management plans. For example, changes in hydrologic regimes impact amphibian habitat. As North Cascades watersheds receive less snow and become increasingly rain dominated, resulting lower spring and summer flows diminish reproductive habitat for amphibians. Similarly, the increased frequency of extreme precipitation events will produce higher peak flows that scour riparian habitat, removing more eggs and individuals than in the past. As a solution, managers work to increase upland water storage to moderate runoff downstream. One tactic is to manage upstream beaver populations to increase dam building, which creates functional wetlands. Another is to maintain diminished snowpack with reflective tarps or fences so the resulting slower snow melt feeds streams longer into the summer. Also, managers can increase microhabitat structures like woody debris as microclimate refugia for amphibian nesting and egg deposition.

Monitoring. The partnership has helped managers devise a meaningful approach to prioritize monitoring. Increased monitoring of wildlife population trends and habitat conditions—such as for early detection of insect infestations—allows managers to focus on critical regions, locations, and species as climate change ensues. For example, the team designed monitoring measures to detect critical changes to alpine habitat like the encroachment of trees into meadows, changes in the upper treeline, and the establishment of herbaceous species in areas previously occupied by perennial snow or glaciers. Strategic monitoring of habitat for species, such as elk that rely on alpine and subalpine habitat for summer forage or mountain goats and hoary marmots that live exclusively in the alpine, allows managers to implement adaptation measures before populations become imperiled.

Outcomes from this pioneering partnership are important not only to the lands encompassed in the partnership, but more broadly to resource management across the Pacific Northwest. In fact, the Washington Department of Fish and Wildlife is updating its State Wildlife Action Plan with a more detailed climate change component that also complies with the requirement to collaborate with federal agencies. NCAP is both a resource and a tangible work-in-progress as a climate change adaptation partnership that might be a useful model. According to Gravenmier, "The efforts of scientists working with planners and managers to assess vulnerabilities and implement adaptation actions enables us to manage the North Cascade forests for the long-term sustainability of all resources in the context of climate change."

Great Basin Grasslands

The Great Basin is a 135-million-acre desert that sprawls across five arid western states. Sagebrush steppe is an important vegetation community of the Great Basin, providing habitat to more than than 200 species of conservation concern including the greater sage-grouse (*Centrocercus urophasianus*) and pronghorn antelope (*Antilocapra americana*) (Suring et al. 2005). Land use conversion has led to the loss of more than half of all sagebrush habitat in recent decades (The Nature Conservancy). In addition, factors such as increasing temperatures and changes in wildfire regimes accelerate the spread of exotic plant species like the pernicious cheatgrass, deplete native seed banks, simplify sagebrush community structure, and reduce desirable landscape patchiness. Native conifers encroach on sagebrush grasses in part due to fire control, while Mojave vegetation has begun to migrate northward in response to warming temperatures.

Simulations of climate change impacts on sagebrush showed a potential reduction to a mere 20 percent of present sagebrush area within the next century (Nielson et al. 2005). In short, the future of the entire sagebrush community and its component species are at risk due to climate change, altered wildfire regimes, invasive species, habitat fragmentation, and resulting bottlenecks to plant migration. Major losses of populations and species can be expected if current trends continue, making innovative, science-based management solutions more critical than ever.

In response, scientists with the USFS have developed mechanisms to protect and restore native grasses in the sagebrush ecosystem. SageSTEP, for example, is a multi-agency regional effort to examine the effectiveness of vegetation treatments such as mowing and burning on disturbed and degraded sagebrush. Further, USFS scientists are collaborating with universities to evaluate biological controls for cheatgrass to mitigate the invasive plant's ability to out-compete native grasses in restoration sites.

Still, conserving remaining sagebrush communities alone will likely be inefficient in sustaining sagebrush-dependent species like the greater sage-grouse and, as a result, managers must implement forward-looking conservation practices that create suitable habitat resilient to future climate conditions. A major bottleneck to creating resilient sagebrush habitat with native plant species, however, is the limited availability of native seed, largely due to the difficulty and nuanced practices of collecting, growing, and distributing native seed sources.

USFS scientists are working to address this bottleneck. With funding from the Bureau of Land Management's (BLM) National Plant Conservation Program, scientists conducted genetic studies to match adaptive traits within native grass species to the appropriate environmental conditions. Then scientists developed seed transfer zones—areas within which plant materials can be transferred with little risk of being maladapted—to guide the establishment of future sagebrush plant communities tolerant of tomorrow's climate conditions. Further, to conserve native plant diversity that may provide vital seed sources for resilient native vegetation in future landscapes, scientists contributed hundreds of samples of plant genetic material to the USDA Agricultural Research Service's National Plant Germplasm System through the interagency Seeds of Success Program, started by the BLM.

Seemingly endless rows of forbs grow at the U.S. Forest Service's Lucky Peak Nursery in Boise, Idaho. Forbs are a critical component of the diet of sage-grouse (inset). As climate change and other factors threaten sagebrush habitat, researchers are tapping into unique solutions such as developing methods to produce seeds of grass species used in sage-grouse habitat restoration.

Credit: Nancy Shaw/USFS

Credit: Bill Mullins

Within the broader sagebrush native plant community, research specifically on plant species important to wildlife can provide a conservation boost. For example, forbs are an extremely important component of the sage-grouse diet, but have been little used in restoration. Seed zone maps are lacking for forb species, so USFS scientists developed a provisional seed zone map based on climate variables. The map is hosted at the agency's Western Wildland Threat Assessment Center. By combining soil data and ecological site descriptions, this tool has informed the selection of

Credit: Ben Letcher/USGS CAFRC

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Biologists insert transponder tags (left) in wild eastern brook trout (*Salvelinus fontinalis*) to track their movements into a tributary in western Massachusetts where an improperly designed road-stream crossing has kept the fish from getting across. Meanwhile, an undersized road-stream culvert crossing (right) perched above the streambed is also likely to keep fish and aquatic wildlife from passing through. Properly designed crossings allow fish and wildlife to move freely and, in the process, better respond to more frequent and intense precipitation events that are characteristic of climate change.

seed sources originating from conditions similar to those at the planting site. The National Forest System and the BLM have used the seed zone map tool extensively in the Pacific Northwest, Great Basin, and elsewhere to establish ecological communities with traits that can withstand temperature and precipitation variability and are resilient to environmental disturbance.

Also to facilitate the use of forbs in sagebrush restoration, USFS scientists have led extensive collaboration to complete the production cycle of native forb species—from research, to production, to use—to increase the list of options available for restoration after disturbance. Agricultural fields now produce native forb materials for specific provisional seed zones while the BLM purchases the seed to improve diversity and habitat value of native seedlings. Private sector seed growers are overcoming the bottlenecks in the propagation of newly available species—and all of this is a positive advancement for sage-grouse and other wildlife that eat forbs. “This research is directly applicable to all public land management throughout the Great Basin,” says Peggy Olwell, Plant Conservation Program Lead for the BLM. “There is a vital need for genetically appropriate native seed in restoring resilient sagebrush plant communities after disturbances such as wildfire and cheatgrass invasion.”

Increasing the use of genetically appropriate plant materials and the production of high quality seed, along with the development of improved restoration practices, are all essential adaptation tactics necessary to establish native sagebrush communities resilient to future climate conditions. Through these science-management partnerships, federal and state land managers in the Great Basin aim to sustain and enhance the sagebrush ecosystem and species like sage-grouse that depend on it.

Northeastern Rivers

Numerous wildlife species such as aquatic salamanders, water thrushes, and mink rely on riparian corridors to access thermally resilient habitats critical to their survival. However, infrastructure such as roads and dams fragments stream habitat, which in turn threatens wildlife populations. This is perhaps of greatest concern in streams and rivers of the densely populated Northeastern corridor, and climate change only exacerbates these challenges. Wetter winters and overall warmer temperatures projected for the Northeast will drive increased winter runoff and decreased spring runoff, and push peak runoff to much earlier in the year (Hayhoe et al. 2007). Rising stream temperatures and increasing frequency and intensity of flood events combine with infrastructure-related fragmentation to significantly diminish the connectivity of aquatic wildlife populations and the availability of aquatic habitat.

In response, USFS researchers developed tools to prioritize barrier removal sites, monitor their effectiveness for reconnecting populations, and evaluate the cost-benefit balance of implementing riparian habitat enhancements that promote thermal resilience. Since 2008, Forest Service scientists, along with USGS, The Nature Conservancy, and universities, have provided managers in the Northeast and Midwest with tools to deal with these challenges.

In 2013, for example, managers in Vermont's Green Mountain National Forest developed a protocol to prioritize road-stream crossings that incorporates both habitat area and thermal resilience—a critical aspect of habitat quality—into its ranking criteria. The protocol was implemented to enhance resilience of vulnerable coldwater stream systems and the unique set of fish and wildlife species they support. According to Nick Schmal, Fish and Aquatic Ecology Program Manager for the USFS Northeastern Region, "The ability to monitor the effectiveness of barrier removal in restoring aquatic organism passage, reestablishing population connectivity, and increasing effective population size are all critical for continued support of these efforts."

USFS scientists have also developed a landscape-genetics approach to monitoring the effectiveness of barrier removal efforts. As part of the approach, they assign individuals of eastern brook trout to sibling groups based on genotypes. Presence of siblings on either side of a removed barrier is evidence of movement and population connectivity. Since individuals "mark themselves" by family affiliation, this technique helps in saving the expense, time, and uncertainty of traditional marking techniques. Last year, the Huron-Manistee National Forest in Michigan used this barrier removal monitoring protocol to demonstrate successful re-establishment of population connectivity after a dam removal project. Following their success, a number of other national forests have since adopted this monitoring technique.

Further, Forest Service scientists developed a GIS tool that allows managers to predictively compare the costs and benefits of implementing riparian vegetation restoration to shade streams and thus lower stream temperatures. With many competing demands on land management budgets, tools that assist managers in evaluating the cost-benefit ratio for riparian habitat enhancement, along with measures to help prioritize and monitor barrier removal projects, will help managers facilitate resilience in riparian habitats and the species that depend on them.

On-the-Ground Adaptation

Spanning some 18 degrees of latitude—from the tundra to the great plains and the north woods to the tropics—identifying specific conservation challenges and applying appropriate science and research-derived tools offers USFS and its partners unique opportunities to adapt to climate change. Such opportunities will only increase over the coming decade as our understanding of climate change at finer scales, along with habitat and species responses, is refined and systems for evaluating opportunities and tradeoffs evolve. The built-in research capacity within USFS has already proved critical to developing and working with federal, state, and private land managers to test adaptation options and replicate successful approaches.

Engaging in collaborative partnerships affords USFS the ability to stitch together the broad swaths of jurisdictions and ownerships that match the scale of wildlife species' adaptation trajectories. With climate change adaptation, these partnerships not only lend themselves to greater long-term efficiency toward achieving meaningful outcomes, but will likely prove the only way forward. "At the end of the day, there is much better buy-in and ownership on the ground for adopting climate change adaptation tactics when managers are directly involved in their development," Gravenmier says.

Careful consideration of habitat resilience, landscape connectivity, and species movement over time and space are the building blocks of focused climate change adaptation actions. The last decade of experiences in designing and implementing adaptation strategies has built a solid foundation for methodically chipping away at the uncertainty surrounding complex ecosystem responses to climate change and what managers might do about it. Over time, the refined understanding resulting from purposeful, deliberate science-management partnerships is key to the successful, dynamic management to conserve habitat, wildlife species, and the many goods and services resilient ecosystems provide to society. ■

For a complete bibliography and more information about the USFS's Research and Development branch, go to news.wildlife.org/twp.