NW CLIMATE magazine

October 2016

DROUGHT! A Look into our Future and a Chance to Plan Ahead

Protecting Biodiversity in Our Streams

Conservation in the Great Basin

Nooksack Tribe Works to Save Salmon

Stories about climate change research in the Northwest

NW CLIMATE magazine

October 2016

Letter from the Editorial Board

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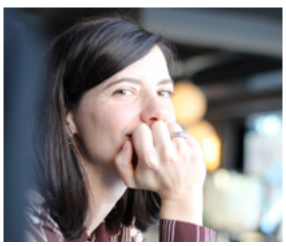
Contributing Writers

Diana Gergel is a University of Washington Graduate Fellow with the Northwest Climate Science Center working to model the impacts of climate change on snowpack and fire risk in the Western United States. She lives in Seattle.

Nathan Gilles is the Communications Specialist for the Pacific Northwest Climate Impacts Research Consortium and a freelance writer. He lives in Vancouver, Washington.



Lisa Hayward Watts is the Manager of Communications for the Department of the Interior's Northwest Climate Science Center. She lives in Seattle, Washington where she works for the University of Washington.

Dan Isaak is a researcher for the US Forest Service, Rocky Mountain Research Station based out of Boise, Idaho. He receives funding for Climate Shield from the Great Northern Landscape Conservation Cooperative.

Meghan Kearney is the Communication Specialist for the North Pacific Landscape Conservation Cooperative. She lives in Portland, Oregon.

Levi Old is the Project Coordinator for the Northwest Basin and Range Synthesis and for the Great Basin Landscape Conservation Cooperative. He lives in Lakeview, Oregon.

Editors

Lisa Hayward, University of Washington, The Northwest Climate Science Center
Nathan Gilles, Oregon State University, The Pacific Northwest Climate Impacts Research Consortium
Meghan Kearney, The North Pacific Landscape Conservation Cooperative
Emily Zelig, University of Washington, The Northwest Climate Science Center

Design

Audra Mote

On the cover: *Rylee Murray, a PhD student with Wendy Palen at Simon Fraser University, studies the effects of climate change on high mountain amphibians in the Seven Lakes Basin of Olympic National Park in Washington. (Photo by Robin Munshaw.)*

Please direct correspondence to:

Northwest Climate Science Center C/O Lisa Hayward
University of Washington
Box 355674
Seattle, Washington 98195
lhayward@uw.edu

Member: *University Research Magazine Association*

CIRC Climate Impacts Research Consortium A NOAA RISA Team

North Pacific Landscape Conservation Cooperative

NW CSC Northwest Climate Science Center U.S. Department of the Interior

From the Editorial Board

Gustavo Bisbal
U.S. Geological Survey,
NW Climate Science Center

John Mankowski
U.S. Fish and Wildlife Service,
North Pacific Landscape
Conservation Cooperative

Phil Mote
Oregon State University, Climate
Impacts Research Consortium,
NW Climate Science Center

Eric Salathé Jr.
University of Washington, Bothell
NW Climate Science Center

Dear Reader,

With its massive El Niño, 2015 was the warmest year on record globally, substantially exceeding the previous record, set only a year earlier. The Northwest felt particularly strong impacts, experiencing record temperatures across the region. Despite ample precipitation, a relief from 2014's drought, we saw the snowpack disappear with remarkable speed in spring. El Niño has ended, but the past year gave us a look at the climate challenges we expect in the not-so-distant future.

We are pleased to bring you this latest issue of *Northwest Climate Magazine*, full of stories about the collaborative research, information development, and capacity-building we deliver to help our region prepare for climate change. This online publication is jointly produced by three regional, climate-focused enterprises in the Northwest. We had an overwhelming positive response to our first issue, and our second issue includes stories from additional sources, the Great Basin and Great Northern Landscape Conservation Cooperatives. While our first issue revealed who we are, where we work, and what we do, this issue demonstrates the practical utility of the research we produce, information we generate, and collaborative efforts we support. It is gratifying to see our work help natural and cultural resource managers throughout the region understand and prepare for a changing environment.

Many of the stories in this issue deal with water availability, a pressing issue for the Northwest, particularly after the low snowpack and associated drought of 2015. Our feature story describes how people across our region are preparing for future drought—from researchers studying how to manage forests to better conserve snowpack, to scientists developing better early warning systems for drought, to ski resort operators building zip lines and concert venues on their slopes to provide revenue that doesn't depend on snow. A second story explores how applications of the *Beaver Restoration Guidebook* and construction of artificial beaver dams can help restore drying watersheds. We also tell stories about the science and support we offer to address threats from wildfire and from increasing stream temperatures; about adaptation efforts of the Nooksack Tribe; an effort to train our next generation of climate professionals; and new, cross-boundary, landscape-level conservation planning.

These stories bring to life some of the important collaborations that are helping our region prepare for the future, and we hope they will encourage you to participate in our joint research-for-management enterprise. Your input and participation are needed to guide our future work and to make our science actionable as we work to meet the challenges and opportunities of climate change.

Sincerely,
The Editors

The North American Beaver (Photo courtesy of hehaden, Flickr Creative Commons.)

Leave it to Beavers

By Meghan Kearney, Nicole DeCrappeo, and Lisa Hayward Watts

How researchers from the Pacific Northwest and Great Basin are working with the toothy, hardworking beaver to restore river watersheds under threat from climate change

Our changing climate is altering Northwest watersheds at an increasing rate. Many watersheds are suffering from drying streams, changes in vegetation, and loss of habitat connectivity for fish, wildlife, and plants. These changes threaten our natural and cultural resources, inspiring researchers from the Rocky Mountains to the Pacific coast to better understand, conserve, and restore natural systems using science, traditional knowledge, and good old trial-and-error. Now they're turning to an unexpected and hardworking ally—the North American beaver, a remarkable water engineer.

Climate in the Northwest is changing, as it is elsewhere in the world. Much of the Northwest has long been characterized by wet winters and dry summers, but a changing climate is expected to increase temperatures and exaggerate seasonal patterns of precipitation so that winters get wetter and summers drier. At the same time, reduced snowpacks and increased evapotranspiration will limit surface and ground water even further. The Southwest is facing similar, more progressed challenges, where long-term drought is already changing stream flow regimes.

Given these projected changes, residents, resource managers, and scientists in these two regions face critical questions like: How will streams and ecosystems, already altered by human activities, respond to a warming future? Are there actions we can take now to increase the capacity of the land to keep providing key resources, livelihoods, and ecosystem services in the future? What strategies for restoring and improving watersheds are most effective, given future climate change? Can we simultaneously maintain human resource use while retaining critical ecosystem functions?

To begin, last year the North Pacific Landscape Conservation Cooperative (NPLCC) took an important step toward answering some of these questions by funding the production of the *Beaver Restoration Guidebook*, a comprehensive guide showcasing multiple ways that beaver can be used in restoration and management projects to benefit rivers, streams, and adjacent lands.

Drawing on research from around the nation the *Guidebook* explains the benefits of beaver reintroduction to areas where streams are changing. There was a time in the not-too-distant past when beavers swam the rivers, lakes, and streams of the Northwest by the millions. During the early 19th century, Hudson Bay trappers caught over 200,000 beavers in Oregon's Silvies River basin alone. Evidence of former beaver populations still exists in the form of remnant meadows, abandoned and decomposed beaver dams, and geologic rock layer evidence of former beaver lakes now filled with sediment. Loss of beaver populations combined with widespread grazing has contributed to the deepening of stream channels and lowering of floodplains, the loss of wet meadows and riparian habitats, and the invasion of valley bottoms by upland tree species in some parts of the Northwest.

Beavers initiate ecological changes that can recreate wet meadows and riparian woodlands in valley bottoms.

As pilot projects have demonstrated, much of what was lost by removing beaver can potentially be restored by reintroducing them. Beavers initiate ecological changes that can recreate wet meadows and riparian woodlands in valley bottoms. Beaver reintroduction is a restoration strategy that has many benefits for fish, animals, plants, and people—such as allowing ranchers to grow grass in previously inhospitable, dry valley bottoms and allowing for livestock grazing or the harvest of hay to improve ranch economics. Reestablishing wet meadows also introduces natural fire breaks on the landscape that stop or slow down wildfires.

While the "whys" of beaver reintroduction may be clear, the "hows" are often not. The *Guidebook* was developed in response to numerous requests from resource managers on where, when, and how to use beaver reintroduction for restoration. It has been called the most comprehensive effort to date explaining how best to undertake beaver reintroductions.

The *Guidebook* was developed in response to numerous requests from resource managers on where, when, and how to use beaver reintroduction for restoration.

The *Guidebook* is the result of exhaustive literature review augmented by multiple workshops and a year's worth of input from experts from across the Pacific Northwest. Now in the hands of natural resource managers, best practices from the *Guidebook* are being implemented in restoration projects around the globe.

Beaver in Colorado Restoration

The *Guidebook* is being used by practitioners across North America. One user is Mark Beardsley of EcoMetrics, a Colorado-based ecological consulting company specializing in the scientific assessment and monitoring of stream, riparian, and wetland systems. Beardsley and his team work closely with conservation practitioners from federal, state, and local governments. He says beavers are a perfect fit for the type of restoration work he does, and he's on a mission to get people to recognize beaver-mediated systems.

"These beaver-mediated systems seemed to exhibit so many of the things everyone says they like in a good functioning stream: diverse and plentiful terrestrial and aquatic habitats, wetland support, floodplain connectivity, water storage, flood reduction, base flow maintenance. I could go on," says Beardsley.

Beardsley was first introduced to the *Guidebook* by Kent Woodruff, a biologist with the USDA Forest Service and a member of the core Beaver Workgroup that pioneered the document. Beardsley says the *Guidebook* has been extremely helpful in his work, adding that one of the biggest benefits of the book is how it has made him aware of the different techniques and approaches others are using around beavers.

"I refer to [the *Guidebook*] for treatment designs and as a reference for my clients and other audiences who want to learn more about the role of beaver and their potential use in restoration," he says. Beardsley says using beavers in restoration has the dual benefit of reintroducing the animals to their previous habitat and restoring that habitat in the process.

A temporary beaver 'lodge' at Winthrop National Fish Hatchery. (Photo courtesy of Pacific Biodiversity Institute.)

Beavers in Idaho

A few states northwest of Beardsley sits Susan Frior, a partner in the environmental engineering firm TerraGraphics. The firm, based out of Moscow, Idaho, provides river restoration services, from engineering to water resource services, for clients around Idaho, Montana, and Washington. Frior says her firm is no stranger to dealing with beaver.

"The most common conservation goals that we address are rehydrating meadow ecosystems and restoring habitat for Endangered Species Act-listed fish, especially steelhead, coho and Chinook salmon, and bull trout," explains Frior.

Frior says dams built by beavers are excellent for rehydrating ecosystems. Beaver dams create surface pools and ponds that help expand riparian and wetland habitats. Frior says she has seen this in practice and is now a firm believer that beavers should be a strong ally in restoration efforts.

Nowhere is this more evident, says Frior, than in her firm's efforts to restore sections of watershed along the Potlatch River in northern Idaho. To restore the flow and bring rivers back to their historic channels, her firm constructed Beaver Dam Analogs, man-made structures that mimic beaver dams. She says she got the idea for the analog dams and instructions on how to build them from the *Guidebook*.

"The *Guidebook* contains the best literature review on beavers that I know of, and I refer to it often when specific questions arise," says Frior.

Frior also attributes to the *Guidebook* an even larger benefit: creating partnerships that have helped her connect with a new community.

"The *Guidebook* has added to the body of knowledge that we rely upon, but it's the community and learning how to do this work together that is of the greatest value to me," says Frior.

With interest in implementing techniques outlined in the *Guidebook* continuing to grow, the guide has established itself as a quintessential tool for beaver restoration. Meant to be a fluid document, the *Guidebook* is also being continually improved as practitioners like Frior and Beardsley utilize it in individual efforts and have additional info to offer the topic.

In addition to informing on-the-ground efforts, the *Guidebook* is a coffee-table conversation starter that has brought together an entire community of restoration groups and entities that work with beaver. It has led to further efficiency, cost leveraging, and has facilitated one of the most important benefits in conservation: collaboration.

What Do You Do When You Can't Reintroduce Beaver?

As beneficial as they are when they work, beaver reintroductions still face many challenges. Often, beavers' required foods—mostly aspen, cottonwood, and willow—may be unavailable or in short supply in certain areas because of changes in water ways and ecology, further effects of beaver removal. To reintroduce and retain beaver, there must first exist beaver habitat. This requires raising water tables, an effort now being conducted by researchers using artificial beaver dams (ABDs). ABDs are engineered structures of rock, wood, or other materials that partially dam channels, creating many of the same ecological effects as beaver reintroductions.

Artificial beaver dams (ABDs) are engineered structures of rock, wood, or other materials that partially dam channels.

Beaver reintroduction, facilitation of beaver dam construction, and construction of structures that mimic beaver dams are techniques that are being explored in the Great Basin for restoring incised streams, recreating wet meadows, and building resilience against future droughts. Implementation of these options depends on perceived costs and benefits, which differ among land managers.

The Northwest Climate Science Center (NW CSC), U.S. Department of Agriculture NW Regional Climate Hub, and Great Basin LCC have jointly funded a multidisciplinary project focused on how these low-rise ABDs can help reconnect incised streams to their floodplains and increase wet meadow habitat in rangelands. The project team includes hydrologists, ecologists, GIS specialists, social scientists and, importantly, private land owners and ranchers. Together, they're working to better understand the multiple dimensions associated with restoring beaver or mimicking their transformative influence as ways to modify landscape features to provide climate resilience. Notably, the project also examines ranchers' attitudes toward both artificial dams and beaver reintroductions as well as the economic costs and benefits of these restoration strategies.

Scott Campbell, president and owner of Silvies Valley Ranch in eastern Oregon, is a project collaborator and rancher whose family has pioneer roots in the area. Starting in the late 1950s, Silvies Valley Ranch passed through the hands of various owners who harvested the land's timber, crops, livestock, and wildlife but did little to build or maintain a working cattle ranch with valuable natural environmental assets. When the Campbell family acquired Silvies in 2007, they set out to create a new model for ranches throughout the United States—one that valued and prioritized natural ecosystem processes, hydrologic connectivity, and fish and wildlife habitat as highly as livestock grazing and hay cultivation. They installed ABDs on a few of the ranch's creeks in the mid-2000s and saw astonishing results. As Campbell puts it, "These structures started the process for restoring our sensitive watersheds by conserving our most important natural resource: water. We have seen the ABDs bring back wet meadows and riparian areas within one year; dry area plants like pine and sagebrush drown and retreat to their natural areas, making a long green riparian area that stops wildfires naturally; a multitude of long-lost species from insects to birds re-inhabit the new habitat; and new late-season water (from water slowed behind ABDs) appear in the lower part of the watershed, which helps fish and other species thrive. After 10 years, we're still seeing ever-improving habitat and increased forage production and land values—all without infringing on water rights."

The project team also works with ranchers who are not necessarily friendly to beaver reintroduction, but may be interested in low-rise rock dams to help increase water availability during summer months and "green" their rangelands. The team has been conducting interviews with ranchers in eastern Oregon and northern Nevada, where beaver-oriented restoration is currently underway on private land and public grazing areas. The team is particularly interested in ranchers whose operations have been affected by the presence of beavers, along with a variety of federal and state land managers, wildlife biologists and watershed council members.

Practitioners are learning to better use beaver introduction and ABDs to restore and protect watersheds for generations to come.

The project team has already contacted over 100 land managers from government and private organizations to determine their current and past use of beaver and ABDs in restoration of rangeland streams across the Great Basin and the degree of success land managers have had using these techniques.

There has been a sharp increase in the number of projects using beaver and ABDs since 2000. Most projects involve moving nuisance beaver out of urban areas or areas where they would otherwise be killed and re-locating them to streams in need of restoration. Successful projects report increased wildlife and plant diversity and higher water storage at streams where beaver were introduced. However, many projects were not monitored after their completion, leaving much for the researchers to learn about the biological, hydrological, and social responses to beaver reintroduction and ABDs.

This summer, the team will sample streams with and without beaver or ABDs to assess how biological diversity responds to these management techniques. The researchers will do this by collecting "environmental DNA" from streams—put simply, they'll be able to detect the presence of various stream organisms by filtering water samples and then analyzing the samples for the species' DNA. The team may also be able to detect terrestrial animals like bats, birds, and mammals living near streams in riparian areas or visiting streams as water sources. The researchers expect to find higher levels of biodiversity in streams with beavers or ABDs, as the wet meadows and riparian habitat that result can harbor a greater number of unique plants and animals.

Done right, beaver reintroduction and the use of ABDs may help address some of the impacts brought about by our changing climate. Healthy watersheds produce and sustain healthy cultural and natural resources. Through collaborative projects like those discussed above, practitioners are learning to better use beaver introduction and ABDs to restore and protect watersheds for generations to come.

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Native bull trout prefer cold glacier-fed streams. (Photo by Joel Sartore.)

Turning Conservation on its Head

By Dan Isaak

Building a Climate Shield: Protecting Our Coldest Streams to Preserve Biodiversity

The realization struck me as I drove the winding mountain highways along rivers and streams through Montana and Idaho to my home in Boise. Those of us in the conservation community working with cold-water species had been thinking about the problem in the wrong way. We had the world upside down!

As a fisheries scientist with Forest Service research, I have spent much of the last 15 years contemplating why some populations of native cutthroat trout and bull trout, two endangered native species that anglers love to catch, were being lost while others persisted. And I wasn't alone—this basic conundrum had perplexed much of the fisheries community for a much longer time. Then I realized that most of the places where species losses occurred were in warmer, low elevation streams and rivers where they had been systematically displaced (or eaten) by a long list of popular nonnative sport-fishes like bass, pike, brown trout, rainbow trout and lake trout. But what if instead of that bottom up view, we viewed the world from the top down, starting high in the mountains? That view—from a much colder vantage point—would reveal robust and widespread populations of bull trout and cutthroat trout, even some amphibian species like tailed frogs—everywhere we looked! How could those two views be of the same world, especially one where decades of rapid climate change have occurred and nonnative species seem ubiquitous?

Temperature is Destiny

The answer to that riddle is, quite simply, that temperature is destiny for ectothermic animals, be they fish or frogs. Each species has a narrow range of temperatures where its physiological processes have evolved to work best. As a result, the spatial arrangement of stream temperatures across landscapes dictates where organisms live and breed, how fast they grow, and which ones win competitive battles when different species come into contact. In my research, I'd seen these basic patterns, manifested through species distributions, play out time and time again on streams across the Northwest during summer field sampling campaigns. That fundamental bit of aquatic ecology now held the key to something far more profound. The huge temperature gradients across mountain landscapes, combined with the preference that native species like bull trout and cutthroat trout have for particularly chilly streams, explained the dichotomy between bottom-up and top-down views. It also raised an intriguing conservation possibility: we could use climate as an ally to help exclude non-native species and to identify specific streams that would serve as long-term climate refugia for native species. Quite the grand plan, I thought to myself, but implementing it would require stream climate maps of unprecedented accuracy across a huge area, including some 150,000 miles of rivers and streams in the Northwest.

Each species has a narrow range of temperatures where its physiological processes have evolved to work best.

Data, Data Everywhere

The problem, as I knew all too well, wasn't a lack of data. It was too much data. Or rather, too much data that wasn't organized to be useful. A few years before my world-flipping epiphany my research group had done a project to develop a stream temperature model for a small river network in central Idaho. The project's budget was limited. So, rather than collect new temperature data, we solicited existing data from biologists that worked within the basin. They sent lots of data. And they kept sending it. Soon we were buried in data that would take us months to organize. But once we organized the data into a large database, we were able to build a stream temperature model so accurate we could predict where different species occurred in the network.

The biologists that sent us the data validated the accuracy of our predictions and started using the stream temperature maps themselves. They loved having an organized database that gave everyone access to everyone else's data. Once they had a picture of the overall efforts, they began organizing their future temperature monitoring to minimize redundancy and fill in gaps on streams with little data.

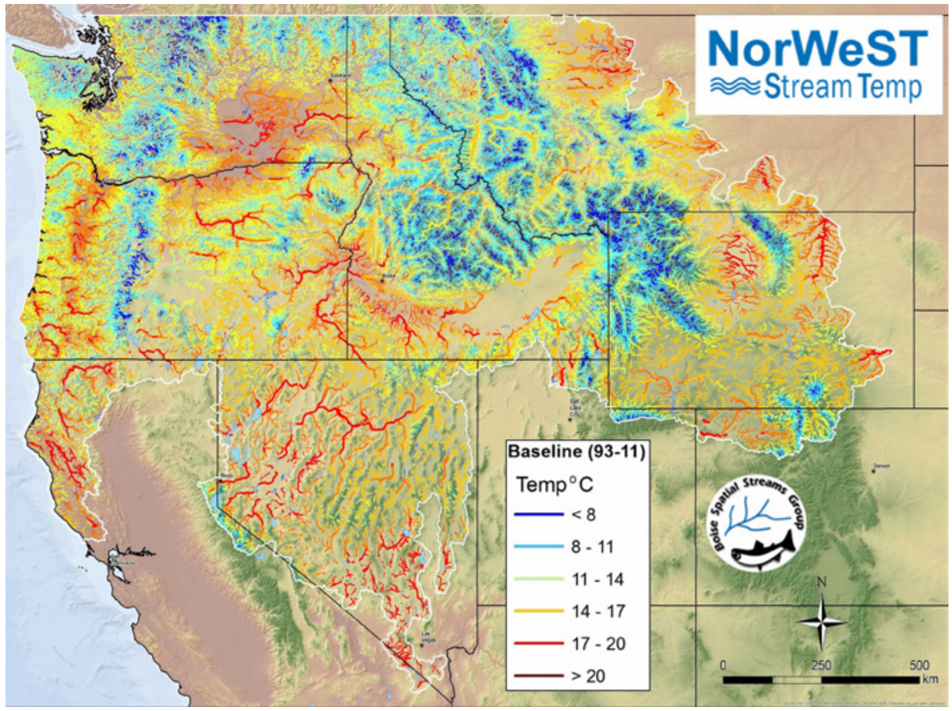
Timing is Everything

In early 2011, shortly after our research group had mastered the technical aspects of temperature data mining, the Great Northern and North Pacific Landscape Conservation Cooperatives came into being, and funded a regional expansion of the approach through the NorWeST project. More than 150,000 miles of streams now have climate maps, and the project has proven so successful that it continues to grow, which means we're organizing messy temperature datasets to this day.

We could use climate as an ally to identify specific streams that would serve as long-term climate refugia for native species.

The NorWeST data team recently completed a comprehensive interagency temperature database and climate scenarios for the state of California and the project is set to expand throughout the remainder of the American West later this year.

Along the way, our small team will have organized a mind-boggling 200 million hourly temperature records from more than 20,000 stream sites and developed scenarios for almost 500,000 miles



A NorWeST stream temperature climate map used in the Climate Shield project to highlight refuge streams for cold-water species. This project started in the Northwest and has grown to encompass all rivers and streams in the American West. (Map courtesy of Daniel Isaak.)

of stream. This massive database includes the contributions of hundreds of individuals working for more than 100 state, tribal, federal, private, and municipal resource organizations.

Turning the World Right-side Up

The NorWeST stream climate maps, combined with large datasets describing fish species distributions, confirmed my original insight. Once the data was organized, it was easy to see that cutthroat and bull trout populations were abundant in climate spaces that were too cold for invasion by most of their competitors. Those basic insights were encapsulated in the Cold-Water Climate Shield research project, which now provides user-friendly digital maps and GIS databases showing which streams throughout the Northwest are most likely to serve as climate refugia this century.

The maps and databases have been broadly adopted by many agencies for conservation planning and the work has inspired other groups to develop similar applications for other species. Most recently, the Environmental Protection Agency (EPA), in coordination with the Oregon Department of Environmental Quality, began using the NorWeST database to map cold-water refugia for salmon in larger rivers throughout the Northwest.

As the conservation and social networks among organizations strengthen, my hope is that they will build another type of climate shield to reinforce protection for the Northwest's iconic cold-water species. Then, who knows, maybe later this century we will turn the world right-side up again with regards to our greenhouse gas emissions and will get this climate thing under control. At that point, we'll have brought with us a bunch of cold-water critters that future generations can enjoy and marvel at in the post climate-change world.

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Author Dan Isaak is a researcher for the US Forest Service, Rocky Mountain Research Station. He studies how native stream fish communities throughout the American West are affected by natural landscape gradients and human alteration of those gradients. (Photo by Dan Isaak.)

A dirt road in Oregon's Warner Valley. (Photo by Levi Old.)

Conservation Priorities in the Big Empty

By Levi Old

An eco-regional approach to landscape conservation in the NW Great Basin

Late April in the Tallest Town in Oregon: On the heels of several days above 80 degrees Fahrenheit, giant wet snowflakes whipped sideways as I stepped inside the real estate office to drop off my rent. I started to converse with my landlady, an elderly rancher with a sharp ability to tell a story about people in landscapes. (We're withholding her name for privacy reasons).

She recounted intrepid tales in which she traversed steep mountain deer trails by horseback. She described the transitions in ranching life from all-day rides into the mountains on horseback, to a time when ranchers loaded horses in the back of pick-up trucks and drove to the edge of the mountains before saddling-up, to more recently, riding ATVs. Ranch life has evolved quickly during her lifetime. Listening to her, I get the impression that the only constant in her life is change. The same can be said for the landscape she inhabits: the Northwest Great Basin.

The Northwest Great Basin is arid. Where rivers exist, they rarely make it to the ocean; instead converging in wetlands and lakes that equilibrate through evaporation and groundwater infiltration. It's been called The Big Empty—a vast sea of sagebrush that, upon a closer look, is far from empty. Pronghorn antelope and pygmy rabbits, Lahontan cutthroat trout, sage-steppe and aspen stands, mollisol soils (known for their fertile surface horizon), and basalt cliffs, vast migrations of Sandhill cranes and snow geese, and ranches and cattle all shape the region's identity—an identity that is currently threatened.

Ranching is not the only thing that has changed in the last century; the region's ecology has

A herd of pronghorn antelope running across the sagebrush steppe. (Photo by U.S. Fish and Wildlife Service.)

also undergone unprecedented change: altered fire regimes, invasive species, development, water scarcity, and climate change compromise the integrity of habitats across the landscape. Conservationists in this part of the region have no time for myopic visions. Coordinated preparation for the future is crucial for ranchers and other natural resource managers. One recent effort by my team aims to tackle this need at the landscape level.

Coordinated preparation for the future is crucial for ranchers and other natural resource managers.

As part of my job as Project Coordinator for the Great Basin Landscape Conservation Cooperative (GBLCC), I've spent the last four months traveling The Big Empty, engaging with over 60 people from a diverse set of organizations and walks of life in order to assess long-term landscape conservation needs. Engaging people is easier said than done. The human populations are dispersed widely, and building trust takes time. Many local residents are currently suffering a sense of planning fatigue from such incredible efforts as the Sage Grouse Initiative. However, based on our initial outreach, it's clear that there's a need for continued collaboration and a synthesis of the existing efforts and planning on the landscape.

Assessing conservation needs and convening a diverse group are the first two steps of a new effort called the Northwest Basin and Range (NWBR) Synthesis. The project area covers part of south central/eastern Oregon, northwest Nevada, and part of northeastern California (map 1). Led by the GBLCC staff, and colleagues, the NWBR Synthesis is creating a collaborative effort that will facilitate organizations and communities toward a conservation blueprint for the region's people and the landscape they are so intimately connected to.

On May 27, 2016, the NWBR team held our first Steering Committee Meeting in Lake County, Oregon, which included the Bureau of Land Management, Nevada Department of Wildlife, US Fish and Wildlife Service, Oregon Department of State Lands, Oregon Natural Desert Association, and the Oregon Department of Transportation. We're also in conversation with The Nature Conservancy, Oregon Cattleman's Association, Oregon Department of Fish and Wildlife, Trout Unlimited, county planners, the Natural Resource

The Great Basin spans Oregon, Nevada and a small portion of Northeastern California. (Figure by Max Taylor.)

The South Calico Mountains of High Rock Canyon Wilderness, in Nevada. (Photo by Stephen Chandler.)

Conservation Service, and others to gather input for the project. This meeting and our broader outreach highlighted the need for increased cross-jurisdictional planning, common strategies for project implementation, and science communication.

Before our outreach efforts commenced, our initial NWBR project team began by doing our homework. We synthesized shared priorities for species and habitat management gathered from more than 60 natural resource plans around the landscape. This included a threats and viability assessment for habitats using the Open Standards for the Practice of Conservation tool. This summer, we're hitting the road to vet our synthesis work with experts. However, through this process of outreach and plan synthesis, we must not forget one of the most important parts: our human communities and their values.

People, from my landlady and her family to members of local tribes, have been an integral part of the Great Basin landscape for thousands of years. The roots of the NWBR Synthesis project lie not only in the cutting-edge conservation science that informs best practices, but also in working with the people that inhabit this landscape and their rich cultural history. Although we're only in the initial stages of exploring the human dimension side of the NWBR effort, there's a lively discussion around ways to best incorporate the values and socioeconomic factors that affect people's everyday lives.

What are the steps towards success for this project?

Partnering with landowners for collaborative stewardship in the Great Basin is crucial for the conservation of regional resources. (Photo by Britney Glitch.)

First, we must build human relationships. The slog of hitting the pavement and trying to reach people and listening to their needs and values is the only path to meet the region's collective conservation needs.

Imagine a conservation blueprint that is defined by bioregional boundaries rather than political ones.

Second, the project's science and technical team will create a series of spatially-explicit tools for conservation decision makers, including maps to address needs such as where to place fire breaks or implement prescribed burns, where to restore habitat and increase connectivity for wildlife, and strategies for climate adaption.

Imagine a conservation blueprint that houses synthesized data and tools for natural resource information that is defined by bioregional boundaries rather than political ones, and includes a social, economic, and ecological approach. We're creating this place through a shared landscape visioning process with a group of diverse stakeholders. Landscape-level conservation blueprint projects are alive and running throughout the country. The Northwest Great Basin is only one of the landscapes involved in this model of pro-active, long-term conservation planning (see sidebar).

Levi Old is the Project Coordinator for the Northwest Basin and Range Synthesis. The Great Basin Landscape Conservation Cooperative received support for this project from the Wildland Fire Resilient Landscapes Program. Please visit our website to sign-up for our email list and learn more. (Photo courtesy of Levi Old.)

Third, this is an iterative process. The products will be interactive and ongoing, adapted based on feedback from users.

As Secretary of the Interior Sally Jewel stated in reference to the conservation efforts for greater sage grouse, "What we need is smart planning on a landscape-level, irrespective of manmade lines on a map. We need to take a holistic look at an ecosystem—on land or in the ocean—to determine where it makes sense to develop, where it makes sense to protect the natural resources, and where we can accomplish both."

The NWBR Synthesis is a collaborative group working toward this end.

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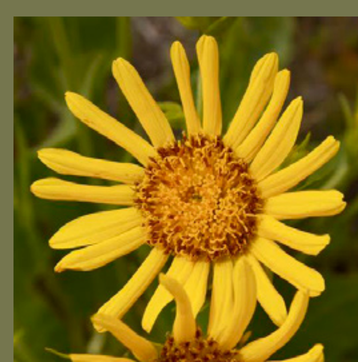
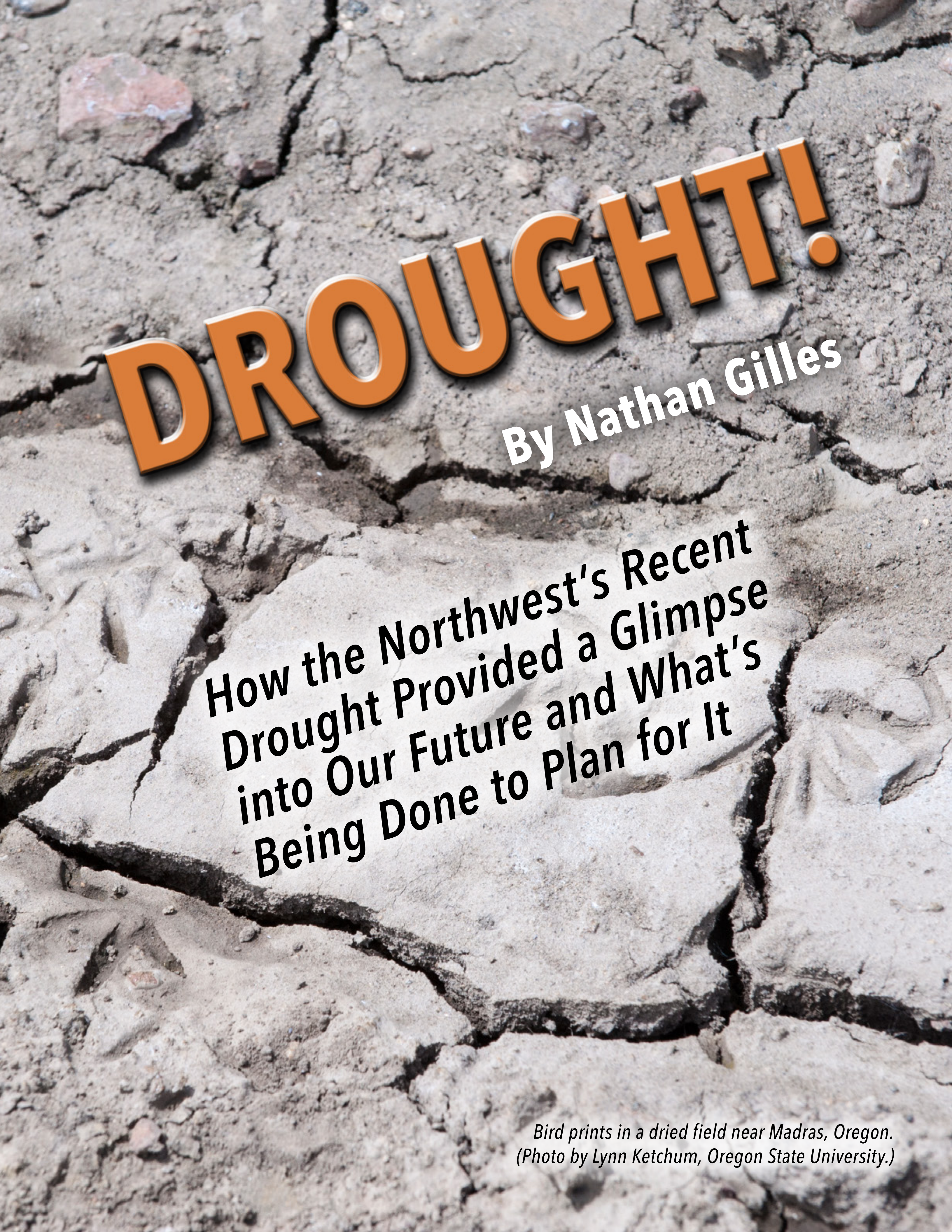
Similar Efforts Elsewhere

If you're interested in learning more, similar efforts around the country include the Arid Lands Initiative of eastern Washington and the Southeast Atlantic's Conservation Blueprint. Practitioners from these regions use project outcomes to strengthen funding proposals, place individual projects in a landscape context, and use shared strategies across political boundaries. By bringing together a diverse group of stakeholders and developing priorities at a landscape scale, stakeholders can identify research and data gaps, and fill them through cooperative research efforts. The NWBR project teams envision a process with similar benefits for our region.



(Photo by Levi Old.)



DROUGHT!

By Nathan Gilles

How the Northwest's Recent Drought Provided a Glimpse into Our Future and What's Being Done to Plan for It

Bird prints in a dried field near Madras, Oregon. (Photo by Lynn Ketchum, Oregon State University.)

From the fall of 2012 until the spring of 2016, much of the Northwest was mired in severe drought. Ski areas closed. Agriculture was hit hard. And wildfires ripped across the landscape. But during this past winter sections of the Northwest got especially soggy, with both Seattle and Portland registering their wettest winters on record. The extra precipitation—during one of the largest and most unpredictable El Niños on record—led to flooding and helped dampen the drought in some parts of our region. Still, much of the Northwest continues to face considerable water deficits, the result of four years of accumulated losses. What's more, it's now clear that the recent drought could be a harbinger of climate to come.

As the Northwest warms under climate change, research strongly suggests our region will experience major shifts in its hydrology, potentially leading to more drought years like 2012 through 2016. This fact has not gone unnoticed. From the region's two largest municipal water suppliers to small, nonprofit ski resorts, from farmers to fish conservationists, many in our region are planning now for the changes ahead.

Kathie Dello, Associate Director of the Oregon Climate Change Research Institute. (Photo by Vanessa Cholewczynski.)

Drought and Snowpack: Part One

While most of us think of a drought as being really dry, Associate Director of the Oregon Climate Change Research Institute (OCCRI) Kathie Dello says that's not always true.

A trained meteorologist and climatologist who runs the Oregon Climate Service, Dello explains, "The drought in the Northwest has primarily been not about the *amount* of precipitation we received, but the *type* of precipitation we received. Warm temperatures meant we got rain when we wanted snow."

Mountain snowpack, says Dello, acts as a kind of water savings account. Melting slowly through the dry summer months, snow provides water for hydropower, fish, farms, and soil moisture when it's needed most. But for much of the drought, snow was scarce, even while precipitation sat just below average. The recent drought, in other words, was driven primarily by warmer temperatures. This was especially true in 2015 when both Oregon and Washington experienced their warmest years on record. And they weren't alone. Globally, ten of the warmest years on record have occurred since 1998, according to the National Oceanic and Atmospheric Administration (NOAA). This warming reflects what scientific evidence suggests we will see in the near future.

"The 2015 drought has been called a lot of things. A dress rehearsal for our future, a shot

Owyhee Reservoir in Malheur County, Oregon. (Photo by Vanessa Cholewczynski.)

across the bow from climate change, or a snow drought," says Dello.

This shot across the bow is being taken seriously both regionally and federally. Besides very public drought declarations in Oregon, Washington, and Idaho, a lot of work has gone on behind the scenes. Consider Dello's efforts.

Since the drought began in 2012, Dello has worked closely with stakeholders and the state of Oregon's drought coordination project. She is active in the National Integrated Drought Information System (NIDIS), an interagency effort created by US lawmakers in 2006 and led by NOAA. The goal of NIDIS is to help coordinate drought research across the US. Among other projects, NIDIS helps fund the US Drought Monitor, which provides weekly updates on drought conditions. Recently, NIDIS also launched the Drought Early Warning System (DEWS), an extended network designed to help federal, state, and local officials prepare for and manage future droughts. Dello, who receives funding from NIDIS for her efforts, says the level of coordination has been encouraging.

"It's great to see this much interest and dedication directed at tackling the drought problem. It makes me hopeful," she says.

In Oregon and Washington, state and regional planners used the 2015 "dress rehearsal" as an opportunity to confront drought risks. Publically recognizing the effect climate change is expected to have on her state's water resources, Oregon Governor Kate Brown has required all state agencies to reduce their water use by fifteen percent by 2020.

Drought and Snowpack: Part Two

Snowpack is essential to water supply and ecosystems in the Northwest. The recent drought's devastating consequences for snowpack has sent climate researchers to the mountaintops. One group tackling the problem is the University of Washington's Mountain Hydrology Research group, formed in 2006 by UW Professor Jessica Lundquist.

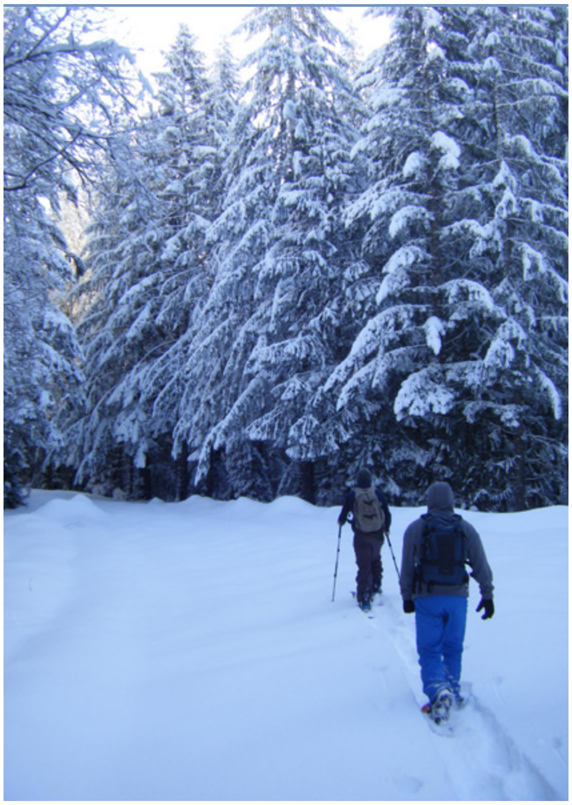
"The 2015 drought hit us terribly: we didn't have the snow in the bank," says Lundquist.

"Snow can be tricky," says Lundquist. Her group has taken a multi-faceted approach to studying snowpack, utilizing remote sensing, various computer models, and in-the-field measurements that take advantage of citizen science. It's this

last method that occupies one major effort of her group.

Funded by the Northwest Climate Science Center and including researchers from Oregon State University, the University of Idaho (UI), and Utah State University, Lundquist's project, Forests and Snow Storage in the PNW, is collecting snow data from fourteen sites high in the mountains.

"We are interested in how forests affect snow storage. The challenge is there aren't many observations of snow in forests. The measurements tend to be from open spaces," says Susan Dickerson-Lange, who heads up the citizen science side of the project.



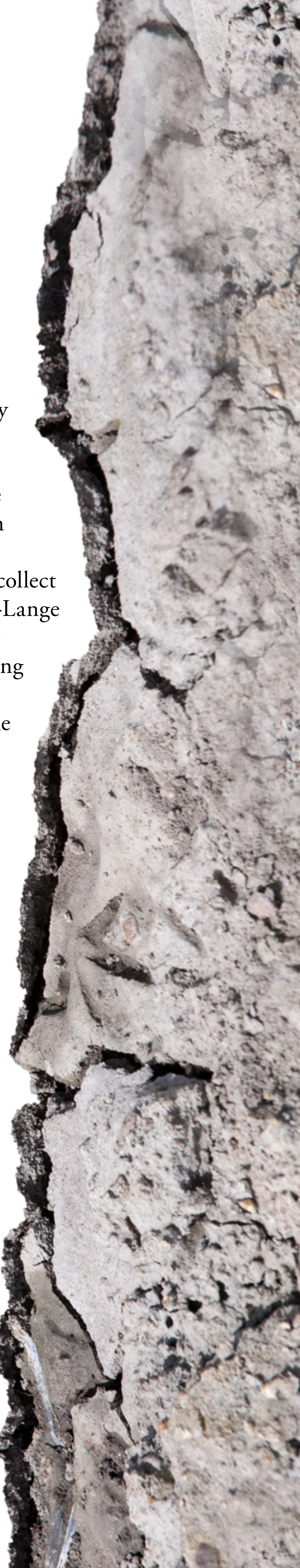
Members of the Mountain Hydrology Research Group snowshoe to a remote site in the Cedar River watershed. Note the large amount of snow stored in the branches of the trees. When stored on branches, snow is much more likely to melt, or sublimate. (Photo by Susan Dickerson-Lange.)

"As any skier or snowshoer will tell you, snow accumulates differently in forests than in meadows. On a very basic level," says Dickerson-Lange, "forests tend to hold snow longer than open meadows, but that's not always the case. Climate, elevation, sun exposure, and tree size all play a role, making it tough to predict where snow will accumulate." According to Dickerson-Lange, that unpredictability also makes it difficult to project changes to local hydrology. This is one reason her group has turned to citizen-based science to fill the data gap. Joining students from UI, recreationists—cross-country skiers, snowshoers, and snowmobilers—helped collect the team's observational data. Dickerson-Lange and her colleagues are now analyzing the four years of data they've collected, turning it into a kind of guidebook for resource managers that will help them navigate the complexity of forest/snow interactions.

Adapting to the Drought: Part One

The Mountain Hydrology Research members aren't the only ones looking beyond the science community to help understand the drought. Last summer, the drought was the subject of a joint project by two NOAA-based research organizations, Oregon Sea Grant (OSG), a NOAA group that funds marine resource efforts, and the Pacific Northwest Climate Impacts Research Consortium (CIRC), a member of NOAA's climate adaptation effort the Regional Integrated Sciences and Assessments (RISA) program.

Starting in July 2015, John Stevenson, an extension specialist funded jointly by CIRC and OSG,



and a small team interviewed Oregonians dealing with the drought.

"Our goal was to document those areas of Oregon most severely impacted by the drought. But we also saw the 2015 drought really as an opportunity to sneak a peek at our future and the kinds of climate changes people will have to adapt to," says Stevenson.

In southern Oregon, snow scarcity devastated ski resorts. During the winter of 2013/2014, the Mt. Ashland Ski Area, a nonprofit ski resort in southern Oregon, never opened due to lack of snow. Seeking help, the resort hired Hiram Towle, previously a ski manager in Maine, where ski resorts rely on smaller amounts of snow than in the West.

"We got creative in how we used the snow that we got," Towle told Stevenson.

At Mt. Ashland, Towle employed a series of innovative strategies, including snow-harvesting (e.g., scooping snow from unused areas) and thinning vegetation. For the 2014/2015 season, Mt. Ashland stayed open. Looking to the future, Towle says his organization plans to diversify to include zip lines, concerts, and other activities not dependent on snow.

"We also saw the 2015 drought as an opportunity to sneak a peek at our future and the kinds of climate changes people will have to adapt to."

Elsewhere in Oregon, Stevenson and his team spoke with farmers using water more efficiently by fallowing their lands, switching to higher value crops, and converting from open irrigation ditches—a method prone to losing water through evaporation—to buried pipe and drip irrigation systems.

Hiram Towle, General Manager Mt. Ashland Ski Area. (Photo by Vanessa Cholewczynski.)

Stevenson and his crew also sought out adaptation efforts directed at a key Northwest industry: fishing. Salmon and many other fish have limited *thermal niches*—ranges of temperatures—they can tolerate. In drought years, water in the summer and spring months is often too low and too warm for them. Frank Burris, an OSG watershed educator, showed the team how lowering the water temperature by a mere six to seven degrees Fahrenheit and extending stream flow improved the health of juvenile salmon.

"We found that people were working really hard to make their farms and other businesses more efficient. People are out there doing good work. And we often don't appreciate the progress people are making," says Stevenson.

Stevenson and team's efforts can be found in *Documenting the Drought*, a series of short films produced by OSG. Stevenson, a trained social scientist, is currently putting his interviews through a formal analysis.

Adapting to the Drought: Part Two

Outside the region's rural areas, the Northwest has millions of thirsty urbanites, and the drought, especially in 2015, had many concerned. Good thing the region's two largest public water utilities have been planning for drought.

Both the Portland Water Bureau (PWB) and Seattle Public Utilities (SPU) are part of the Piloting Utility Modeling Applications (PUMA) project, an effort by large water providers to adapt to climate change. PUMA, whose other participants include water utilities for New York City and Tampa Bay, is a sub-project of the larger coalition Water Utility Climate Alliance (WUCA), an effort comprised of ten of the nation's largest water providers.

"This project was really about bringing together researchers and utilities collaboratively in what we're calling the co-production of knowledge, to develop what we're calling actionable science."

To help PUMA members become more resilient to climate change, the utilities reached out to various climate research organizations. In the Northwest, the PWB and SPU found CIRC.

"This project was really about bringing together researchers and utilities collaboratively in what we're calling the co-production of knowledge, to develop what we're calling actionable science," says Kavita Heyn, Climate Science and Sustainability Coordinator at the Portland Water Bureau.

Heyn's employer supplies water for some 950,000 Portland-area residents, and that number is growing. Concerned about the future of its water supply, PWB joined WUCA and PUMA. As part of her duties, Heyn, a native Portlander, oversaw the implementation of PUMA at PWB.

PWB's first step was to computer model their watershed. While the utility had in-house modeling capabilities, according to Heyn, their internal models needed to include climate projections in order to plan far into this century. CIRC researchers John Abatzoglou and Katherine Hegewisch, both at UI, as well as Bart Nijssen at UW, aided this effort, with Abatzoglou and Hegewisch providing climate data and Nijssen running hydrologic computer models to help simulate changes to the utility's watershed.

Together, the engineers at PWB and researchers at CIRC worked to integrate the results of their climate and hydrologic models with PWB's in-house engineering model. (A similar process was employed by CIRC researchers and SPU engineers to model SPU's watershed.)

"Our goal was to help both providers build their own internal capacities," says CIRC researcher Meghan Dalton, who led the climate analysis effort for SPU.

Both PWB and SPU are currently working to integrate the PUMA work into their long-term water management initiatives. Edward Campbell, Resource Protection and Planning Director for PWB, says his bureau is in the process of hiring additional staff to use the tools CIRC helped set up.

For a full description of PUMA, see the WUCA publication *Actionable Science in Practice*.

Drought in Real Time

PUMA and the other efforts outlined here illustrate how information projecting long-term trends can greatly improve planning and adaption. But for adaption to be truly effective, short term information and planning are also needed. We've seen this in projects such as the US Drought Monitor, which compiles hydrology data from across the nation into weekly updates. (For instance, data from Bart Nijssen's UW Northwest Drought Monitor feeds into the US Drought Monitor.) As part of its second round of funding, CIRC is creating a series of user-friendly computer tools it calls the Northwest Climate Toolbox. One tool in CIRC's toolbox is the Climate Engine.

"What you see with these types of tools is a real step forward in responding to drought. We expect to see more droughts under future climate change. We need to plan ahead. We need to adapt."

Susan Dickerson-Lange downloading meteorological observations at the Cedar River watershed in September 2013. (Photo by Michelle Ma, University of Washington.)

Led by Abatzoglou and his team at UI, Climate Engine is a far-reaching effort that includes involvement from the Desert Research Institute and Google, and comes in response to the White House Climate Data Initiative. Climate Engine works by feeding global climate data into Google Earth, allowing anyone with a browser to track changes across the globe in weather, drought, and vegetation in near real time.

"There is so much information and data on drought out there. One goal of Climate Engine is to increase the accessibility of this information to assist with drought monitoring and decision making," says Abatzoglou.

Currently, Climate Engine works as a monitoring tool, but Abatzoglou says he hopes to hone it into a forecasting tool that can be used to help farmers and others plan ahead. This work is currently being developed with the Regional Approaches to Climate Change–Pacific Northwest Agriculture project (REACCH) and includes REACCH's Climate/Weather Tools project.

"What you see with these types of tools is a real step forward in responding to drought," says OCCRI's Kathie Dello. "We expect to see more droughts under future climate change. We need to plan ahead. We need to adapt."

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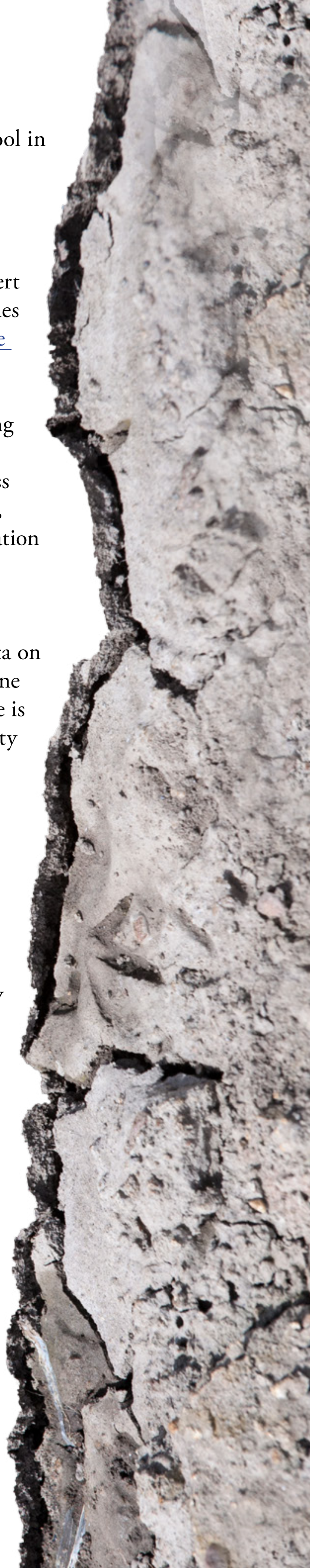


Black bears were one of eleven case study species to have their potential future range shifts mapped by Meade Krosby in a project aimed at helping managers build climate resilience by enhancing landscape connectivity. (Photo by Diane Renkin.)

Science Without Borders

By Lisa Hayward Watts

A look at how scientists and resource managers are hammering out useful tools and approaches to build habitat connectivity across political boundaries

Connectivity and Climate

On a grey Monday in the middle of March, Dr. Meade Krosby and I drive north from Seattle. Outside our windows, suburbia gradually gives way to farmland, and we begin to glimpse forest in the distance.

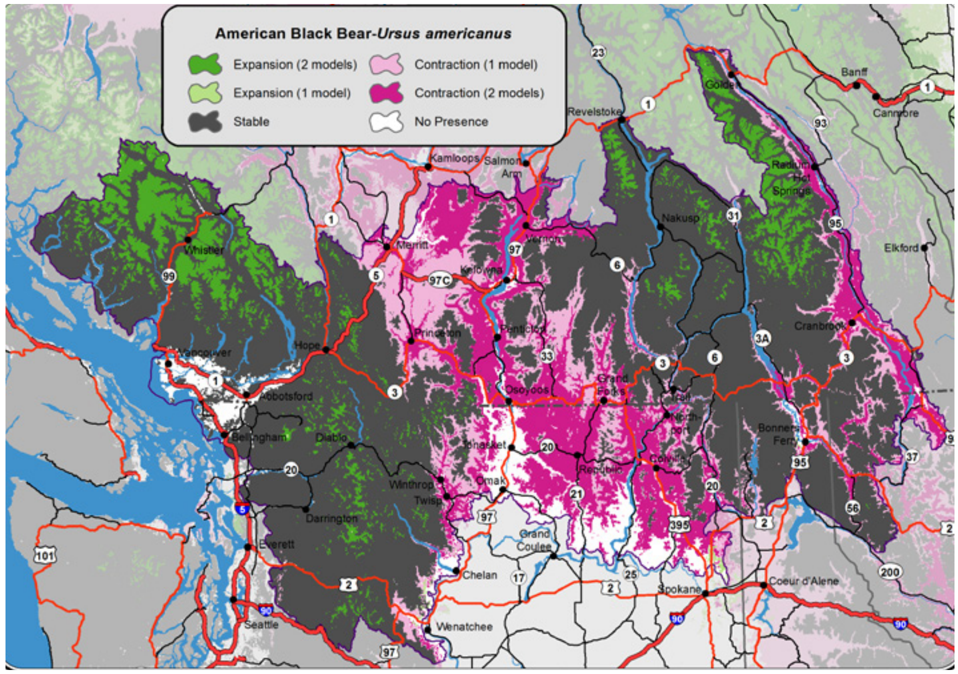
We're headed to a workshop at the North Cascades Institute, where Krosby will present her latest research to a group of National Park Service managers. She's also planning on unveiling a brand new computer tool to help these same resource managers and others like them respond to climate change.

As a researcher with the University of Washington's Climate Impacts Group, Krosby has been busy compiling a series of maps that span northern Washington, northern Idaho, and southern British Columbia. These maps feature complicated shapes that look as if someone spilled colorful ink into the valleys of the North Cascades. In fact, the shapes represent output from models that combine information about habitat suitability for each of 12 different case study species with projected climate change and land use data to outline where future range shifts are likely to occur for species like black bear, bull trout, and lynx.

Under climate change, plant and animal communities are expected to shift in distribution. In the Northwest, species are expected to move further north and higher in elevation as they seek cooler habitats. Maintaining habitat connectivity to allow these range shifts to occur is a top conservation priority, but protecting critical corridors can be complicated.

Many corridors span a patchwork of land use types including agricultural, residential, and public, much like the patchwork of land use types we see on our drive north. Even in protected areas rules and policies for management depend on whether land is private, National Forest, National Park, or tribal, and whether it lies within the United States or Canada. These divisions make it hard to plan at the landscape level.

Krosby's colorful maps are the result of an impressive effort working with multiple agencies on both sides of the international border and with several tribes and First Nations to pull the best information into her maps. This effort required her to get all sorts of data sets to "talk to each other" and to get officials from multiple groups to do the same. The work has been challenging. At one point, Krosby had to hold a key meeting at the Peace Arch Park on the international border because getting clearance for American and Canadian officials to meet in either



This map shows projected changes in the black bear climatic niche (area of climatic suitability) for the 2080s created with results from two different global climate models under a high emissions scenario. Areas with types of land use or vegetation that are not compatible with Black bear have been removed. Maps like this help managers identify which areas are most important to long-term species conservation. (Image courtesy of Meade Krosby.)

country was too complicated. Ecological connectivity requires a high degree of political connectivity, she says. But despite what she's already accomplished, Krosby is nervous that her biggest challenge may still be ahead of her.

"I'm a little worried to be honest," says Krosby. "I'm worried that managers may be getting jaded about yet another climate tool that won't actually help them do their job." Meade's end goal is to turning all the data that she has compiled and organized into a tool that will be helpful for land managers.

Dr. Meade Krosby compiled a series of maps spanning northern Washington and Idaho and southern British Columbia to outline where future range shifts are likely to occur for species like black bear, bull trout, and lynx. She has also developed online tools to help make her maps easy to use for resource managers in different agencies and governments. (Photo courtesy of Meade Krosby.)

As we arrive at the North Cascades Institute we meet Regina Rochefort, a science advisor for North Cascades National Park Complex and the group's lead on climate adaptation. Soon more managers file in, including Jason Ransom, park wildlife biologist, and Ashley Rawhouser, park aquatic ecologist. Once everyone has introduced themselves, Krosby takes the stage.

"Enhancing ecological connectivity—the degree to which landscapes facilitate the movement of the organisms within them—is the most frequently recommended strategy for increasing biological resilience to climate change," Krosby begins. "This is because a primary way species respond to climate change is by adjusting their geographic ranges to track shifting areas of climatic suitability."

Maintaining habitat connectivity to allow these range shifts to occur is a top conservation priority, but protecting critical corridors can be complicated...Ecological connectivity requires a high degree of political connectivity.

After her introduction, Krosby shows the workshop participants how to access her data files in the North Pacific Landscape Conservation Cooperative's Conservation Planning Atlas (powered by Databasin), an online tool for mapping and analysis. Once the participants log in, they find a series of folders with the data files and final reports for each case species. Krosby walks everyone through simple functions from combining map layers to adjusting transparency—tasks that can be done in DataBasin without any expertise in Geographical Information Systems.

By the session's end, everyone seems impressed. "We need to have more workshops like this," says Rochefort. Krosby is more than ready to return for a follow up. She and Rochefort agree to schedule a future workshop for the end of summer.

"The main lesson learned from this project is that we need to be working across the border if we really want to help species respond to climate change," said Krosby in her wrap up. "But to do that effectively requires intention and commitment. Seeing the barriers we've faced just with this project—like getting people in the same room, getting data to talk and people to talk—this stuff doesn't happen unless you do something to make it happen. We've learned the importance of flexibility, creativity, and persistence in finding ways to bring people to work together, because people have really different jobs and really different mandates, and it can be hard."

As we exit into the drizzle, I'm reminded of a meeting of the Northwest Climate Science Center (NW CSC) Executive Stakeholder Advisory Committee that was held in Portland more than a year earlier. After Krosby presented a summary of her work there, one of the agency managers summed up the research needs of her agency by saying, "We just need thirty more Meades [Krosby]."

Scaling Up/ Scaling Down

Further to the east of us in Idaho and Montana, Linh Hoang faces similar challenges trying to manage resources across changing

Meade Krosby works with partners at the National Park Service to provide data synthesis for climate-smart conservation planning. (Photo courtesy of Meade Krosby.)

Linh Hoang is the Regional Climate Change Coordinator for U.S. Department of Agriculture's Forest Service Region One. Currently, she works with Forest Service planning teams to develop strategies for building climate resilience into forests and landscapes in northeastern Washington, northern Idaho, and Montana. (Photo by Linh Hoang.)

landscapes that span multiple borders. Hoang is the Regional Climate Change Coordinator for the US Department of Agriculture's Forest Service's Region One. Her work with the Forest Service is guided by the USDA Climate Change Action Plan, developed in 2014 and by a series of executive orders requiring the Forest Service to evaluate the impacts of climate change to their public lands.

Forest Service Region One, like all forest service regions, received a Climate Change Performance Score Card in 2011 that requires, among other things, a climate vulnerability assessment for all managed resources.

"Every region is taking a different angle at meeting this particular requirement," explains Hoang. "I felt it was best to go all in and do it all at once, large scale—assessing all the resources that we manage across the whole region."

"Enhancing ecological connectivity—the degree to which landscapes facilitate the movement of the organisms within them—is the most frequently recommended strategy for increasing biological resilience to climate change."

Going "all in" resulted in the Northern Rockies Adaptation Partnership (NRAP), a region-wide climate change vulnerability assessment for natural resources and ecosystem services with a set of recommended adaptation strategies. It's a several-hundred-page-long written synthesis of the very best climate science with multiple tables of recommended adaptation tactics. Hoang created NRAP with David Peterson and Jessica Halofsky of the University of Washington and Jessi Kershner of EcoAdapt.

Now Hoang has the dual challenge of connecting NRAP to larger, transboundary adaptation efforts while helping to turn it into something useful for managers in their day-to-day decision making. Essentially, she has to both scale it up and scale it down.

As for scaling it up, Hoang sits on the steering committee of the Crown Managers Partnership (CMP), a transboundary partnership among the agencies of Alberta, British Columbia, and Montana and several First Nations and tribes. To date, the CMP has worked with partners in the Crown Adaptation Partnership (CAP—Crown Managers Partnership, Crown Conservation Initiative, the US Forest Service's Northern Rockies Adaptation Partnership, and The Wilderness Society) to hold a series of workshops on cold water fisheries, terrestrial invasive plants, and whitebark and limber pine. The next topic to be addressed will be mesocarnivores, mid-sized predators like coyote, lynx, fox and wolverine.

Hoang's current challenge is related to scaling down. Specifically, she's working with Forest Service planning teams to develop approaches to filter through NRAP's recommended strategies and tactics to determine which are most relevant—not just for their subregions—but for their forests, landscapes, and projects. The goal, as Hoang describes it, is to use the hundreds of pages of synthesis to decide "what to do first and what to do second, and what to spend money on in the short term and what to spend money on in the long term." Essentially, how to weigh climate vulnerabilities with the feasibility of specific actions.

It can be hard to get managers to commit the time to be deliberate about climate adaptation planning, according to Hoang. There's a temptation to jump to one of two strategies: trying to protect all refugia or putting money toward the most vulnerable resources. In some cases, it may be better to identify areas that are projected to stay refugia and leave those places alone. Similarly, it may be best to stop investing in the most vulnerable resources with the recognition that money is better spent elsewhere.

"Thinking big is scary," explains Hoang, "because it creates accountability. Managers have to explain, Why this action? Why here? Why now? What they need is a framework for justifying those decisions."

This is where Jessi Kershner of EcoAdapt and Alicia Torregrosa and Andrea Woodward of the US Geological Survey come in. With funding from the NW CSC, Kershner, Torregrosa, and Woodward are working with Hoang to create exactly that type of framework—one that will help managers use NRAP to rationalize difficult decisions about how to manage their resources. Their aim is to develop flexible, informative tools that support decisions without being too prescriptive or complicated. As Torregrosa explains, "As a scientist I can get really deeply into the scientific climate change data and why this projection is better for this area, but a lot of that 'how the car works' stuff is unimportant to someone who only wants to drive the car."

According to Hoang, success for the project will mean being able to say that specific pieces of NRAP were used to incorporate specific elements of climate adaptation planning into specific forest plan components. "In the next two years or so, I think we'll be able to actually show how we're using this information," says Hoang. "But for now, that process is still under development." The Forest Service is currently developing a revised set of climate scorecards due to come out in 2017. Hoang hopes the emphasis in the 2.0 generation will shift from synthesizing the science to developing and sharing the processes of using that science.

"We will evolve as we do this, and we'll have to go back and evaluate what part worked and what part didn't." As Hoang puts it, "We're in the trenches right now, and rather than planning the trenches, we have to stay down in there digging them."

Krosby is funded by the NW CSC, Wilburforce Foundation and the North Pacific and Great Northern Landscape Conservation Cooperatives. Additional funding from the Charlotte Martin Foundation, allowed Krosby to pay for one month of her own time and one month's time for two additional specialists to put the project's data files into Databasin.

Kershner, Torregrosa, and Woodward have funding for their project from the NW CSC.

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Planning for large-scale habitat connectivity to support climate-driven range shifts means pulling together data and people from multiple agencies and governments–a task that is rarely easy. Pictured: the Columbia River in Washington. (Photo by the Army Corps of Engineers.)

A firefighter uses a drip torch to apply fire during a prescribed burn. (Photo by Swanson Scott, U.S. Fish and Wildlife Service.)

Lessons in the Ashes

By Lisa Hayward Watts

How two geographers in Idaho are studying wildfire destruction in an effort to make our forests more resilient to climate change

Before Crystal Kolden became an assistant professor of Geography at the University of Idaho she fought wildfires. Originally a history major, Kolden says she had no interest in the career paths of lawyer or history teacher that lay before her. So after graduation, she headed off to the El Dorado National Forest near Lake Tahoe. There, she worked in timber and recreation until someone handed her a giant metal can with a curled prong at the end. The can, called a drip torch, is used to light fires during prescribed burns. “And that was it,” says Kolden. “I fell in love with fire.”

In more than a decade that Kolden spent on the ground in fire management, she witnessed first-hand the impacts of fire on a range of different landscapes. She also heard many different perspectives on fire’s role in ecosystems. One thing she observed across the board, was that fire will rarely burn through an area completely. Instead, fires usually leave behind unburned islands of vegetation within the perimeter of the burned area. To an ecologist, these unburned islands are valuable assets. They serve as refugia for wildlife and as landscape features that can accelerate forest regeneration after fire. But to a firefighter, unburned islands pose a threat.

“An island of unburned trees could torch out and launch an ember across the fire line that could create a spot fire that might perpetuate the wildfire,” explains Kolden. For this reason, she says, firefighters often intentionally burn to ashes any unburned vegetation near a fire’s perimeter.

Kolden’s curiosity about the relative merits of practices like this and like suppressing fires in wilderness areas eventually led her to enroll in a master's program in geography at the University of Nevada in Reno, and later, in a geography Ph.D. program at Clark University in Worcester, Massachusetts. In graduate school, Kolden increased her understanding of fire's impacts by honing her skills using geographic information systems (GIS) and information from satellites, including USGS's Landsat satellites, and planes to analyze landscape-level patterns of wildfire over time. Using data like this is known as "remote sensing."

"Ever seen the movie Twister?" asks Kolden. "We'd do something similar to that, but with more safety measures."

While still a graduate student, Kolden joined a US Forest Service Enterprise Team devoted to fire ecology and fire behavior research. Enterprise teams are units within the Forest Service that act somewhat like private contractors to help find ways for government agencies to do better work. Kolden's team primarily focused on collecting real time fire behavior data on wildfires.

"Ever seen the movie Twister?" asks Kolden. "We'd do something similar to that, but with more safety measures." She and her team would work with the incident team to predict where fire was likely to go the next day or two and try to get ahead of it to place data collection equipment in its path.

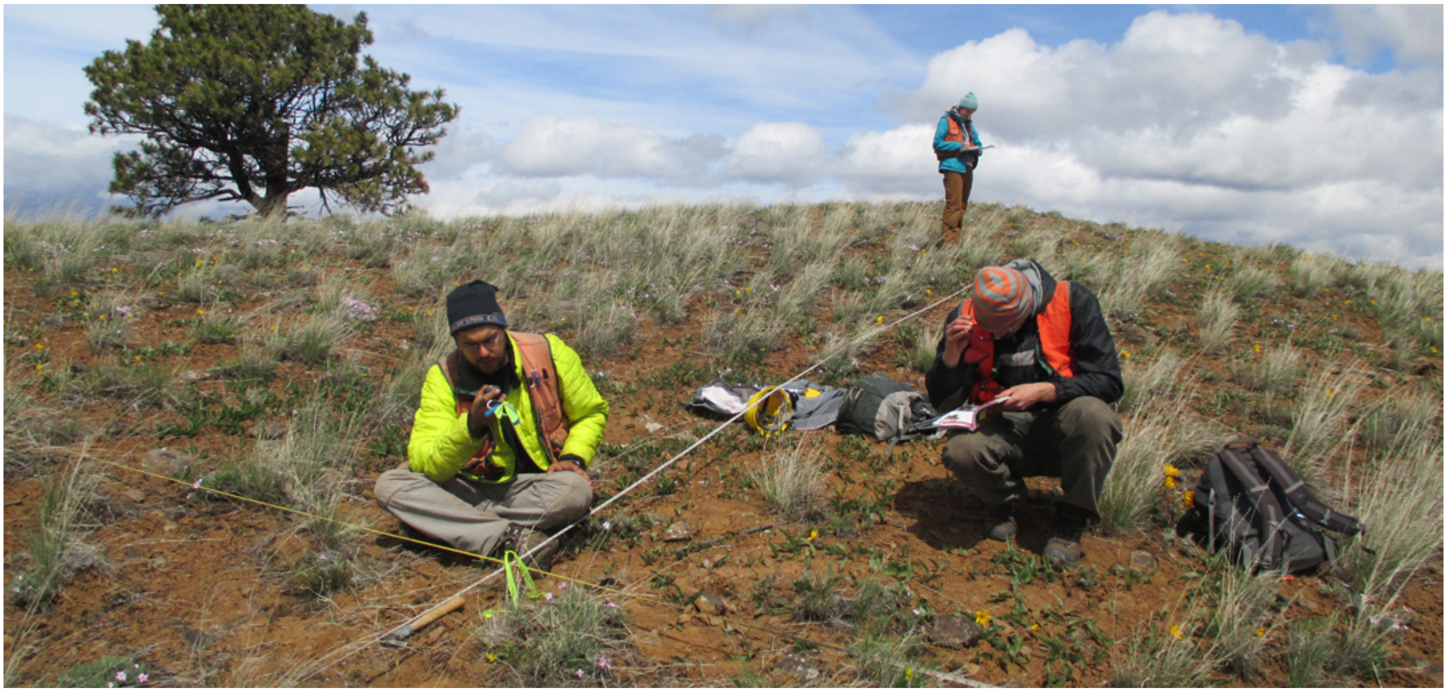
Today, Kolden manages teams that collect information after fires all across the Northwest. She combines the on-the-ground data they collect with information from Landsat data to answer several key questions relating to wildfire and unburned islands. One of these questions is whether fires have been or will become more intense due to climate change. To date, there is no consensus on the answer to this because fire intensity can be a hard thing to measure, or even define.

Kolden had the idea of using Landsat data to locate unburned islands in order to see whether they have been getting smaller or fewer in number over time. She reasoned that if this were the case it would suggest that wildfires are getting more intense. If they are getting more intense, as many suspect, then future fire management strategies will need to be adjusted accordingly.

With Kolden's teams traveling all over the Northwest to get fire behavior data, Kolden is able to test and improve mapping capabilities. Once she has validated her results from remote sensing by comparing them with the data collected on the ground, Kolden will be able to apply her improved model to 32 years of remotely sensed data to map all unburned islands for the entire Northwest.

Another goal of Kolden's research is to better understand the variables that contribute to the creation of unburned

Unburned islands left behind in the wake of wildfire play an important role as refugia for wildlife and can help speed forest regeneration. (Photo by Crystal Kolden.)



Members of Crystal Kolden's field crew collect data on an area that was burned in the previous year. (Photo by Crystal Kolden.)

islands—things like invasive versus native grasses, tree density, forest structure, and natural barriers, such as streams and rock. As she puts it, "Once we understand the factors that determine where unburned islands form, we can use that information to manage and manipulate vegetation across the landscape to cause the intentional formation of unburned islands to protect places we don't want to burn: cultural resources, homes, critical habitat, and endangered species."

Jason Kreitler. (Photo by Susan McIlroy.)

Building fire resilience into these features of the landscape in advance may save Forest Service and other groups the huge expense of emergency measures down the road.

About 300 miles away from Kolden's office at the University of Idaho in Moscow, is the Boise office of the US Geological Survey (USGS)'s Western Geographic Science Center and the base of Jason Kreitler, a USGS research geographer. Like Kolden, Kreitler has spent considerable time thinking about the policies that shape wildland fire management. However, Kreitler is examining the problem with a different lens, using economics and social science.

Kreitler explains his research focus like this: "We have fixed budgets for most, if not all, of our public land management, so the question is, how do we optimize the use of those funds to best meet our conservation goals, like protecting biodiversity or ecosystem services? I hate to use buzzwords, but it's really how can we manage our public lands in a more 'holistic' way?"

As Kreitler's research is showing, one key tactic is to incorporate costs into fuel treatment planning. Although it's not common practice, incorporating costs can substantially increase returns on fuel treatment expenditures.

"By incorporating cost effectiveness you can treat more acres for the same cost than if you just consider benefits," says Kreitler. "When you can reduce fire risk for more acres of forest, that translates at the landscape scale to a reduction in expected fire intensity and probability, or fewer of what are considered negative fires from a hazards perspective."

"Once we understand the factors that determine where unburned islands form, we can use that information to manage and manipulate vegetation across the landscape to cause the intentional formation of unburned islands."

Rather than adding yet another independent tool, Kreitler has been careful to incorporate a cost analysis tool into existing Forest Service software that managers use already. This helps estimate expected revenue or cost to treat any given tree stand by allowing users to input factors, ranging from the price of timber at the local mill and how much biomass is being harvested to how steep and remote a harvest site might be.

"The overall goal of using all these inputs," says Kreitler, "is to use resources as effectively as possible to bring forests into a more fire resilient state." However, he is quick to point out that quantifying resilience can be tricky, pointing out that different people may define resilience differently. Semantics aside, there's an excellent case to be made for building fire resilience into our Northwest landscapes. As Kreitler's research indicates, resilience is important to protect both our forests and our watersheds.

To better understand the impact of fire on water quality, Kreitler is currently working as part of an interdisciplinary team funded by the Northwest Climate Science Center to model expected changes in sedimentation caused by future wildfire in watersheds of the Western US. His collaborators on the project are Joel Sankey, a USGS research geologist based in Arizona; Todd Hawbaker, a Colorado-based USGS research ecologist; Nicole Vaillant, an Oregon-based Forest Service fire ecologist; and Scott Lowe, a professor of economics at Boise State University in Idaho.

"So far the biggest surprise for us has been the projected increases in sedimentation that our ensemble of climate, fire, and erosion models show for future scenarios of potential fire across the west," says Kreitler.

The research team found that a full three-quarters of the watersheds modeled show an increase in sedimentation of ten percent, while one quarter show a whopping 100 percent increase in sedimentation. As Kreitler put it, "A quarter of these watersheds across a large portion of the west could see pretty drastic increases if the future turns out to be anything like our scenarios."

Kreitler says he's optimistic that this is a problem we can get ahead of, pointing out that the city of Denver recently saw the development of an ecosystem service-based market when the city's water utility began levying an additional voter-approved fee on their users. This fee covers forest treatments for hazardous fuels and forest restoration to restore watersheds damaged by severe wildfires during the late 1990s and early 2000s.

"By incorporating cost effectiveness you can treat more acres for the same cost than if you just consider benefits."

"That's one great example of wildland fire interacting with the provision of ecosystem services," says Kreitler. "We're interested in the circumstances that set that up. Where else could that occur? Seeing residents recognizing the problem and being willing to pay moves us in a much more positive direction."

NWC

What Makes a Megafire?

by Lisa Hayward Watts

There is no strict scientific definition of a megafire, but better understanding how they develop is critical to future planning. The term "megafire" is generally applied to fires with unusually large impacts to ecological and/or human communities. Due to a range of factors including climate change, human development in the urban-wildland interface, and a legacy of fire suppression, megafires are becoming more common across the American West. How common we can expect them to become in the future is an important question for forest managers, insurance companies, budget planners and community developers, among others.

Harry Podschwit, a Northwest Climate Science Center graduate fellow in the Quantitative Ecology and Resource Management Department at the University of Washington (UW) is developing a new way to predict how regional fires regimes will change in the future. Podschwit uses statistical methods and machine learning to describe how environmental factors contribute to wildfire development. He then combines his models of fire growth with downscaled climate projections to map how the probability of megafire is likely to change with future climate change. "We're pretty excited about the results we're getting," says Podschwit. "It's hard to find other people that are doing something similar."

Some of the relationships that Podschwit is finding are surprising–high wind, a factor often expected to intensify wildfires, tends to associate instead with smaller wildfires. "Probably because high wind is often associated with precipitation," say Harry, "and precipitation helps dampen fire." Results also vary regionally and seasonally–in some parts of the country precipitation may reduce the probability of wildfire, while in other parts precipitation may lead to a surge of vegetative growth that later contributes to increases fire risk.

Podschwit has been working closely with Ashley Steele of Forest Service's Pacific Northwest Research Station to help ensure that his results are useful for forest managers. So far, the complete picture that he's helping to develop of how wildfires develop from ignition to extinction promises to be a useful planning tool for people in fire suppression.

"It's still very simplistic," says Podschwit, "but it can give us a general sense of how fire regimes will change in the future." Podschwit plans to defend his master's thesis this summer and will stay at UW to pursue his Ph.D., while further developing his statistical tools into useful aids for regional planning.

Harry Podschwit is a Northwest Climate Science Center Graduate Fellow in the University of Washington's Quantitative Ecology and Resource Management program. He uses statistical methods and machine learning to improve our understanding of wildfire development. (Photo courtesy of Harry Podschwit.)

Mt. Baker in the North Cascades of Washington is home to a number of glaciers that feed into the Nooksack River. (Photo by Oliver Grah, Nooksack Indian Tribe.)

Can We Keep Salmon in the Nooksack?

By Meghan Kearney

The Nooksack Indian Tribe acts to understand a changing watershed

Deming, Washington is a town nestled among ferns and evergreens at the base of Mt. Baker in the North Cascades. Its tiny size belies its cultural significance as the ancestral home and current government headquarters of the Nooksack Indian Tribe. For thousands of years the Nooksack have lived here, relying on resources of the Nooksack River watershed like salmon, bracken fern, wild carrots, berries, and clams. The upper reaches of the river are cold waters, fed by mountain glaciers. But glaciers in the North Cascades are disappearing. They're smaller than they have been in nearly 4,000 years and continue to shrink steadily. Since the late 1800's, river temperatures have also increased, challenging the ability of salmon to survive in the river.

As the climate warms, decreases in snow accumulation and glacier melt will lead to lower flows throughout the watershed from late spring through early fall. Lowered flows and increasing air temperatures will also lead to higher stream temperatures. Higher peak flows will likely occur during the winter, scouring important salmon habitat. These climate change impacts will continue to threaten the Nooksack Tribe's natural and cultural resources. For the last 25 years, the Tribe has been heavily involved in understanding current, legacy, and potential impacts caused by continued climate change, seeking ways to maintain resiliency in the watershed.

Working with partners, including federal, state, and local entities, and combining funds from the North Pacific Landscape Conservation Cooperative (NPLCC) and several other grant programs, the Nooksack Indian Tribe is leading a project that examines the effects of climate change on glaciers in the Nooksack River watershed to evaluate impacts on salmonids the Tribe depends on.

Oliver Grah, Nooksack Water Resources Program Manager, knows the potential severity of these impacts. "Members of the Nooksack Indian Tribe rely on salmon for subsistence, cultural, and commercial uses. The Tribe's reliance on Pacific salmon goes back time immemorial," he explains. The Nooksack River watershed is home to Chinook, Coho, cutthroat, steelhead, and bull trout, three of which are listed as threatened under the federal endangered species act. Today, these populations are critically low. "Only about ten percent of the total salmon returns that occurred in the late 1800's occur today," adds Grah. And these returns continue to decline.

The Nooksack Indian Tribe is leading a project that examines the effects of climate change on glaciers in the Nooksack River watershed to evaluate impacts on salmonids the Tribe depends on.

Dramatic increases in Pacific Ocean temperatures, poor habitat conditions and fewer food sources take a toll on migrating salmon. For example, according to current predictions, nearly every Puget Sound coho salmon stock is expected to return in numbers lower than the "escapement threshold," meaning returning fish will not be numerous enough to support tribal, commercial or recreational fisheries. Fraser River sockeye, which usually migrate through Puget Sound, will likely migrate north and bypass Nooksack land in Northern Puget Sound.

Exploring Mt. Baker. (Photo by Oliver Grah, Nooksack Indian Tribe.)

For the Nooksack Tribe, this is not a good sign, explains Grah, stating "this decline in salmon populations impacts Tribal members benefiting from treaty rights."

These discouraging scenarios attracted the attention of a notable number of local and national entities interested in partnering with the Nooksack Tribe. Though the Tribe has been participating in salmon recovery for over 25 years, newer climactic predictions have spurred them to incorporate climate change adaptation into their planning of future habitat restoration.

The project first looked at behavior of glaciers high in the watershed. Mt. Baker and surrounding peaks are covered by approximately 148 glaciers and glacierets (miniature alpine glaciers). Late summer stream flows and cooler stream temperatures, critical to salmon, are provided by snowmelt from these glaciers.

In 2012, the Tribe began monitoring the Sholes, Heliotrope, and Hadley glaciers on Mt. Baker. They measured snow depth, melt rate of accumulated snow and glacial ice, stream flow, sediment loads, and stream temperature. These measurements characterized a baseline of current conditions against which to measure climate change impacts. A weather station was also installed and operated at

A research team from the Nooksack Indian Tribe explores the glaciers lining Mt. Baker. (Photo by Oliver Grah, Nooksack Indian Tribe.)

the Sholes Glacier to collect data on air temperature, precipitation, humidity, and solar radiation.

"We will be into our fifth year of glacier flow, temperature, and sediment field studies directed at evaluating effects of climate change," shares Grah. Early results of glacier monitoring showed higher turbidity (suspended sediments) for glacial melt than snow melt and higher turbidity recorded with high air temperature events, confirming the Tribe's need for action.

The condition of the glaciers directly affects salmon residing in glacier-fed rivers. With better understanding of glacier behavior, the Tribe is able to evaluate effects of recent and future climate-driven changes on salmonids.

With support from the NPLCC, the Tribe has developed a climate change impact vulnerability assessment and adaptation plan for salmon in the South Fork Nooksack River watershed. "NPLCC's funding was fundamental to the success of that project," Grah describes. It allowed the Tribe to work closely with the Environmental Protection Agency (EPA), Washington Department of Ecology, Western Washington University, Nichols College, and University of Washington and other key partners, including the Lummi Nation and Stillaguamish Tribe. "All of these agencies, individuals, and other groups substantially contributed to our project," Grah notes.

Working with these partners, the Tribe is developing targeted restoration actions to address climate change. These include reconnecting fragmented floodplains, restoring historic stream flow regimes, managing erosion and sediment delivery, improving riparian functions, and rehabilitating degraded streams.

"Our overall project has several components in various stages of completion," explains Grah. "We will continue to pursue completion of the overall project through adaptive management, and supplement our overall work plan as funding and new information supports additional work."

For now, the future for salmon in the Nooksack is uncertain. Challenges remain, but by looking ahead, uniting collaborators, and showing leadership, the Nooksack Tribe is increasing the odds that culturally-significant natural resources will be there to support future generations.

In the future, the Tribe plans to take a similar approach to address non-freshwater ecosystems like forests and marine systems, and is already in the early stages of collaboration with the Stillaguamish Tribe and the University of Washington to move in these new directions.

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Oliver Grah measures stream velocity as part of the Nooksack Tribe's glacier monitoring efforts. (Photo courtesy of Oliver Grah, Nooksack Indian Tribe.)

Mapping Columbia River Basin Tribal Adaptation Capacity

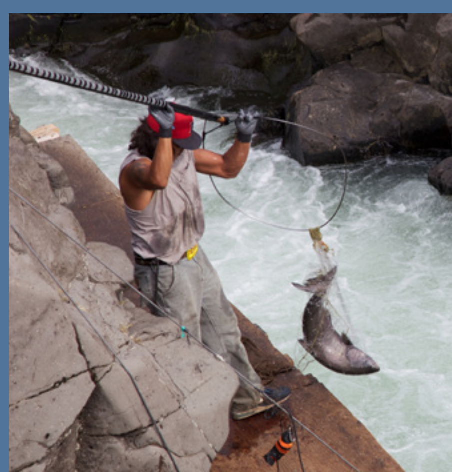
by Lisa Hayward Watts

The mighty Columbia River drains 166,400,000 acres as it flows from the Rocky Mountains of British Columbia to the Pacific coast of Oregon and Washington. For generations it has provided critical habitat for many species of fish, wildlife, and plants that Tribes refer to as "first foods." First foods are central to the indigenous way of life, vital not only for subsistence, but also for spiritual and ceremonial practices. Now, as temperatures warm and precipitation patterns shift, even the powerful Columbia is subject to the impacts of climate change, threatening the sustainability of first foods. Because the resources that sustain Tribes are vulnerable to climate change, native communities are among the most climate-sensitive communities in the Northwest.

This reality requires that we ask a serious question: Are Tribes in the Columbia River Basin ready to address the challenges of climate change? As a step toward answering this, the Northwest Climate Science Center (NW CSC) funded Don Sampson and the Tribal Leadership Forum to undertake an assessment of the climate change capacity of 15 Tribes and 3 intertribal organizations in the Columbia River Basin. Sampson is the Executive Director of the Institute for Tribal Government at Portland State University's Hatfield School of Government. In the past, he also served as Executive Director of the Confederated Tribes of the Umatilla Indian Reservation and Executive Director of the Columbia River Inter-Tribal Fish Commission (CRITFC). His findings were published last fall in a report titled "Columbia River Basin Tribes Climate Change Capacity Assessment."

Sampson found that tribal management and policy leaders have relatively moderate levels of awareness of climate impacts and planning methods while tribal citizens have slightly lower awareness. Perhaps not surprisingly, policy priorities reflect these levels of awareness: fewer than half of the tribes assessed are currently engaged in federal, state, tribal or local government agency climate change planning efforts.

Sampson's report identified an increase in dedicated staff as one key way for Tribes to build climate capacity. Many Tribes have staff with scientific expertise, but for various reasons, these staff do not currently focus their efforts on issues related to climate change. Sampson's study also identified a need for downscaled climate and hydrology data specific to particular tribal needs, such as low stream flows and their potential impacts on first foods.



A member of the Yakama Tribe uses a dip net to fish for Fall Chinook salmon in the Klickitat River, a tributary of the Columbia. (Photo by U.S. Fish and Wildlife Service- Pacific Region.)

For the NW CSC, a key goal in supporting Sampson's assessment was to help provide a roadmap toward adaptation for Tribes. According to Gustavo Bisbal, Director of the NW CSC, "The key here is not just to ask what services and tools we can provide to Tribes to build climate resilience, but to try to stimulate how tribes can learn from one another as to how to best address the realities associated with a changing climate." The goal is to develop a close working relationship between Tribes and climate research groups so that there is co-production of knowledge, leading to ownership by both the user and the producer.

Based on recommendations from Sampson's report, the NW CSC, in partnership with the Great Basin Landscape Conservation Cooperative, commissioned work by climate experts at the University of Washington to make the climate vulnerability assessment process more accessible to tribal staff by providing online guidance materials. They will also staff a Climate Technical Support Help Desk to provide rapid response to questions and consult a Tribal Advisory Committee to ensure that their work is useful for Tribes throughout the Northwest.

Climate Boot Camp Fellows gather to hear National Park Service geomorphologist, Paul Kennard, and geologist, Scott Beason, discuss the impacts of climate change on Mt. Rainier glaciers. (Photo by Lisa Hayward Watts.)

Experiencing Climate Boot Camp

By Diana Gergel

How a week in the woods helped me "problematize" and why that's a good thing

Standing near the Nisqually glacier while listening to National Park Service geomorphologist Paul Kennard and geologist Scott Beason discuss the impacts of climate change on Mt. Rainier glaciers, I felt the effects of climate change in a deeply profound and different way. I had known glaciers were retreating but hadn't realized that this process had been underway since before the 1970s. Nor did I know just how much glaciers had suffered in the Pacific Northwest just this past year alone from the unusually warm temperatures.

This deeply profound feeling occurred throughout my time at the Climate Boot Camp, an annual weeklong event sponsored and organized by the Northwest Climate Science Center. Each summer, Climate Boot Camp brings together graduate students and early career professionals working in federal and state agencies, tribes, and non-profits for a week of interdisciplinary learning about climate change.

Last year, sessions ranged from producing videos to learning about salt marshes at the Nisqually National Wildlife Refuge. In essence, as Climate Boot Camp coordinator Arwen Bird put it, we were "following the water" from source to sink—from observing glacier retreat to seeing low water levels at the salt marshes to understanding drought impacts on Oregonians. Kathie Dello, Deputy Director of the Oregon Climate Change Research Institute (OCCRI), discussed how dire the recent drought has been in Oregon. But what really hit home for me were my conversations with other Climate Boot Camp fellows who were thinking about management and experiencing climate impacts in an immediate sense.

In my research, I work on modeling the impacts of climate change on snowpack and fire risk in the western US. It is rare that I think about the management implications of my work in anything beyond a superficial way. As a modeler, my research

Participants of the Northwest Climate Science Center's fifth annual 2015 Climate Boot Camp assembled at University's Pack Forest in Eatonville, Washington. (Photo by Ryan McClymont, U.S. Geological Survey.)

is largely removed from the management side of things. Just before boot camp, I had performed a new analysis showing how much moisture loss soil is projected to experience in Northwest forests and had been thinking about fire risk changes in the coming years. On the first day of Boot Camp, several fellows from across the Pacific Northwest talked about how fires were approaching their families' land. I felt my work—and my understanding of it—shift from looking at plots on a screen to thinking about people unable to pursue the livelihoods that their predecessors had practiced for generations.

A session led by Julie Vano, a postdoc at OCCRI, and Meade Krosby, a research scientist at University of Washington's Climate Impacts Group, focused on scientist/stakeholder interactions. Boot camp fellows were assigned either "scientist" or "stakeholder" roles and asked to prepare for a research grant call. Role playing exercises can seem cheesy, but this one was meaningful. It made me realize the extent to which research grants are framed in terms of science questions driven by scientists,

Diana Gergel, author and Northwest Climate Science Center Graduate Fellow at the University of Washington. She attended the Climate Boot Camp for the first time last year. (Photo courtesy of Diana Gergel.)

rather than in consultation with stakeholders and driven by the immediate and/or long-term science needs of resource managers attempting to adapt to climate change.

Social scientists often use the word "problematize" to describe the process of calling into question one's own assumptions and others' conceptions, about an issue or ostensible fact. I came away from boot camp having problematized my work within a broader framework of climate change impacts and adaptation, with a far more holistic understanding of intersections between my work and other aspects of climate research. More importantly, perhaps, I came away with an injunction of sorts to communicate my science more effectively and make sure that my work reaches more than just a purely scientific audience. **NWC**

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NW CLIMATE
magazine
October 2016

Northwest Climate Science Center
C/O Lisa Hayward Watts
University of Washington
Box 355674
Seattle, Washington 98195
lhayward@uw.edu

Northwest Climate Science Center Oregon State University Graduate Fellow, Lindsey Thurman, helps conduct amphibian surveys at Mount Rainier National Park for the Centennial Anniversary of the National Park Service. (Photo by Danielle Nelson, Oregon State University.)