USDA United States Department of Agriculture
Forest Service

PNW Pacific Northwest Research Station

Science FINDINGS

issue one hundred ninety seven / june 2017

INSIDE

"Science affects the way we think together."

Lewis Thomas

Mapping the Future: U.S. Exposure to Multiple Landscape Stressors

Chris Sinnett/Flickr

The 2014 Two Bulls Fire near Bend, Oregon, led to evacuations and threatened the city's water supply. Maps developed by scientists with the Pacific Northwest Research Station highlight where stressors such as wildfire potential, forest insects and disease risk, housing development, and climate departure are likely to overlap.

"The trouble with the future is that it usually arrives before we're ready for it."

—Arnold H. Glasow

In June 2014, central Oregon was in the middle of a drought, and had just experienced its worst fire season in 60 years. Two separate human-caused fires were allegedly set on private land near the City of Bend. The two fires quickly merged and, spurred by high winds, moved into the adjacent Deschutes National Forest. About 250 homes were evacuated and 2,000 more were on high alert.

"The fire was very close to town," says Craig Letz, who at that time was the fire staff officer for the Deschutes and Ochoco National Forests and the Bureau of Land Management in Prineville.

The Two Bulls Fire eventually burned an 11-square-mile area, took 8 days to contain,

IN SUMMARY

Landscape exposure to multiple stressors can pose risks to human health, biodiversity, and ecosystem services. Attempts to study, control, or mitigate these stressors can strain public and private budgets. An interdisciplinary team of Pacific Northwest Research Station and Oregon State University scientists created maps of the conterminous United States that indicate landscape exposure to concentrated wildfire potential, insects and disease risk, urban and exurban development, and climate change. The maps, which show where these stressors might occur and overlap, provide a valuable resource for regional and national land use, land management, and policymaking efforts by helping to guide resource prioritization.

The researchers identified locations where each stressor is more prevalent on the landscape relative to other locations, and then combined future climate projections from 30 separate global circulation models to establish a climate change metric. The climate change metric represents when the average annual temperature is projected to permanently depart from the prevailing climate of the past century under a "business as usual" scenario. The goal was to identify large contiguous areas of stress exposure—locations that may be vulnerable to ecological and social disruption.

This information has been used in Oregon, for example, to inform discussions about urban expansion and fire risk around the City of Bend.

and cost local governments an estimated $6 million to fight. It put the city's water supply at risk, and smoke from the fires reached as far south as northern California and as far east as central Utah. It occurred about 6 weeks before central Oregon's usual wildfire season begins.

"June is very early for us to have fires, and especially fires that move that fast," says Letz, adding that drought was just one factor that set the stage for the devastating fire.

As distinct phenomena, wildfire, insect infestations, tree diseases, urban and exurban development, and a warming climate can negatively affect landscapes. When two or more of these stressors are combined, the problems can multiply and tax the ability of land managers, land-use planners, and policymakers to effectively assess, manage, and mitigate damage to natural and human-made resources. It can also put undue strain on agency budgets and personnel.

KEY FINDINGS

- By 2060, 91 percent of the conterminous (lower 48) United States is projected to depart from the prevailing climate of the past century under a "business as usual" scenario, which assumes no coordinated climate policy has been established. In the Pacific Northwest, temperatures are projected to be outside historical ranges of variability by mid-century.
- Thirty-seven percent of the conterminous states could be affected by concentrated exposure to at least one landscape stressor (wildfire, insects/disease, development, or climate departure), and multiple coinciding stressors are likely to affect about 9 percent of the landscape.
- The most prevalent coinciding stressors are wildfire potential combined with insects/disease (about 2 percent), and climate departure combined with urban and exurban development (about 2 percent).
- Combined exposure to three or more stressors was rare, but when development is one of the stressors, it flags potential risks for the people living in that area.

Introducing Threat Maps

About 10 years ago, Becky Kerns was assistant director of the Pacific Northwest (PNW) Research Station's newly formed Western Wildland Environmental Threat Assessment Center, which was charged with developing integrated approaches to management and resource allocation decisions for public forests and rangelands. She became one of two scientists tasked with figuring out how to create a "threat map" that would act as an early warning system for stressors to individual landscapes in several Western states.

"We had maps showing us how these threats occur individually, but we wondered how often they coincide," says Kerns.

She pulled together a research team that included Jeff Kline, a PNW Research Station research forester and economist with a background in land-use issues. Their goal was to create maps of Idaho, Montana, Oregon, Washington, and Wyoming that assessed the multiple threats of wildfire, insects/disease, and housing development. Although invasive species also can threaten landscapes, no comprehensive database was available for mapping purposes. The team's biggest challenge was to figure out how to combine, evaluate, and display disparate stressor datasets at appropriate spatial scales.

"You often can't just put two maps together and get anything meaningful out of them because they're produced at different scales, and they have different assumptions about the data," says Kerns, who is now a research

Jeff Kline

A small portion of the more than 90,000 acres burned by the 2003 B&B Complex fire in central Oregon. Climate projections suggest that large or intense wildfires, such as the B&B Complex, could become more prevalent in some locations in coming years. Understanding where such changes are most likely to occur enables forest managers, policymakers, and local officials to anticipate and plan for these future changes.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208

Send new subscriptions and change of address information to:

pnw_pnwpubs@fs.fed.us

Rhonda Mazza, editor; rmazza@fs.fed.us

Cheryl Jennings, layout; cjennings@fs.fed.us

Science Findings is online at: http://www.fs.fed.us/pnw/publications/scifi.shtml

To receive this publication electronically, change your delivery preference here:

http://www.fs.fed.us/pnw/publications/subscription.shtml

USDA United States Department of Agriculture

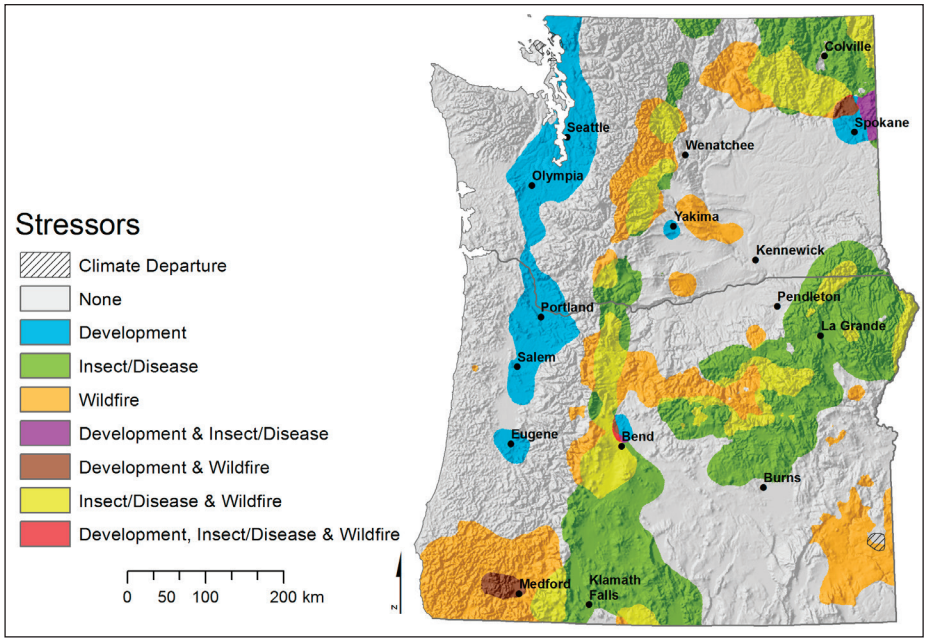
Forest Service

ecologist with the station. "We went through a spatial smoothing process and developed thresholds to map concentrated areas. The process allowed us to compare data layers."

The innovative process the team developed, which they refer to as a multi-step neighborhood analysis, reveals overlapping threats at the spatial scale of an average-size county. Letz learned about the maps when Kerns introduced them at a professional conference, and he later used them to make a case for funding fire protection and mitigation measures in the area for which he was responsible.

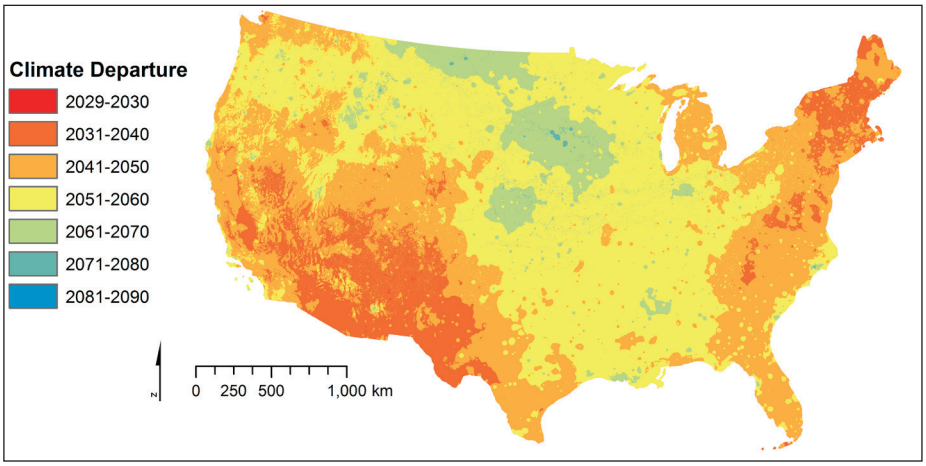
"The thing that really got my attention was that the maps really lit up Bend as being at risk, based on the factors they looked at," says Letz, who has since retired from the Bureau of Land Management and is now a private fire consultant.

The maps were so well-received that many scientists wanted to see similar maps for the entire United States. Meanwhile, concerns about the dangers associated with rapid climate change were coming to the fore, and Kerns was keenly interested in including a climate change metric in their studies. She invited John Kim, an ecological modeler with the station, to join her and Kline in a new study. Their latest maps reveal the combined threats of wildfire, insects/disease, development, and climate departure throughout the conterminous United States.



Adapted from Kerns et al. 2016

Concentrated exposure to landscape stressors and their overlap in Oregon and Washington. Climate departure is mapped where average annual temperatures are projected to permanently exceed the historical range of variability by 2040. Bend, Oregon, is the one area where development, forest insect and disease risk, and wildfire overlap.



Kerns et al. 2016

The anticipated arrival of record-setting temperatures, or when average annual temperatures will rise above historical ranges, and never return, within the conterminous United States if greenhouse gas emissions continue to rise throughout the 21st century (representative concentration pathway 8.5).

Climate Departure

A warming climate threatens landscapes in numerous ways. Early snowmelt and extreme weather patterns can cause flooding, unseasonable cold snaps, and drought. Drier, hotter weather can increase fire risk, damage trees, and alter water temperatures, flows, and levels in rivers, streams, ponds, and lakes. These and other changes can endanger all living things on the landscape and lead to extinctions if species have difficulty adapting to new temperature norms.

To frame climate change as a stressor on a national scale, the team recognized the need to identify one metric to encompass the many facets of climate change. Kim recommended a "climate departure" metric to represent these issues. The metric is calculated from climate projections based on the representative concentration pathway (RCP) 8.5, which is one of four possible climate change scenarios published by the Intergovernmental Panel on Climate Change in its 2014 report. Kim refers to it as the business-as-usual scenario, because it assumes the absence of a coordinated climate policy and continued high population growth, resulting in no change to the current upward trajectories of greenhouse gas concentrations.

The metric was calculated from 30 separate global circulation models simulating RCP 8.5, and it identifies when the average annual temperatures will begin to permanently exceed the historical range of variability.

"That means you're never going to go back to historical norms," says Kerns.

Data show that the Southwest could depart from the historical range of temperature variability within the next 12 years, and parts of the Northwest and the East Coast are expected to depart within the next 24 years. Predictions show that, by mid-century, 91 percent of the conterminous United States will depart from the prevailing climate of the past 100 years.

Kim supplies an example: "According to the most recent projections under the business-as-usual scenario, by the end of the century, Seattle is going to have the mean annual temperature of Sacramento. Meanwhile, precipitation is likely to stay about the same," he says. "I think anyone who watches the weather and is observant of the trees and plants and wildlife around them would appreciate what a dramatic change like that would mean for the trees around them."

Precipitation is not included on the maps because current models produce differing projections for changes to average annual precipitation. "There is less consensus emerging out of various models that simulate future precipitation," says Kim. "What consensus there is among the models is that climate change will amplify the seasonal patterns we have now."

Overlapping Threats

It doesn't take too much imagination to understand that interrelated landscape changes can cause a cascade of issues to arise, including social and economic disruptions. Kerns' team wanted to provide a visual representation of where major stressors overlap so the information could help drive resource prioritization at regional and national levels of planning.

"As far as we know, there's absolutely nothing out there like this—maps that show the potential for the coincidence of these threats, where the issue of spatial scale and the combination of the data have been rigorously vetted," says Kerns. "We're hoping to help folks that are trying to make regional and national management and budget decisions prioritize their projects based on a time period. For example, we see that climate is going to become unprecedented in the Southwest and the Northeast earlier than it is in other areas; that's a prioritization issue—an early warning system."

Management decisions are particularly challenging in the wildland-urban interface—areas, like central Oregon, where development occurs in or next to forests or rangelands. This development increases the risk of wildfires, complicates land management, and makes emergency response decisions trickier when wildfire does occur. Add some insect and disease outbreaks to the wildland-urban interface and the management challenges increase.

"You have a big incentive for forest management agencies to spend a lot of their fire management budget in doing treatments on the landscapes to try to protect houses from potential wildfires. In the larger scheme of things, there might be other resources we'd like to protect as well, such as endangered species habitat or watersheds," says Kline. "When wildfires happen, there's not only the concern about what should fire managers do about managing the forest fire, but the houses actually limit their options."

The researchers reported that 37 percent of the conterminous United States will potentially be affected by concentrated exposure to one of the mapped stressors, and two or more stressors overlap in 9 percent of the nation. Also, two percent of the landmass shows the potential for wildfire combined with insects/disease, and 2 percent is at risk owing to the overlapping of development with climate change. The overlapping of three or more stressors is rare.

Although the coincidence of multiple concentrated stressors is not that prevalent on the landscape in terms of spatial measurements, the researchers are quick to point out that the importance of these risks should not be diminished. "Because it happens to be the part of the landscape where people live," says Kline.

Kline was surprised by a couple of things when he saw the final maps. First, as a Northwesterner, he is concerned about the extent of threats from insects/disease and wildfire in Oregon and Washington. "That's kind of scary when you see big swaths of forest with beetle damage and other issues," he says.

He also was surprised at what he learned by comparing the eastern part of the United States with the West. "In some ways, the maps shatter preconceived notions we have," he says. "For example, when you compare western development at the wildland-urban interface to how much development occurs in the East, it could lead people into thinking that development is only something to worry about in the East. But in the Northeast, especially, you don't have a lot of wildfire risk. So even though a smaller proportion of the landscape is affected by development in the West, it's very important when juxtaposed with wildfire risk."

Jeff Kline

A home outside Corvallis, Oregon. Continued development in the wildland-urban interface puts homes closer to forests. The current challenges these homes pose for wildfire protection strategies, and the wildfire risk faced by the homeowners, will likely increase as the climate becomes warmer and drier in the future.

Jeff Kline

Forest management can help to mitigate increased wildfire risk through various fuel reduction activities, such as this prescribed burn near Sisters, Oregon.

Planning Ahead

Central Oregon's Two Bulls Fire highlights what can happen when drought, fire, and urban development overlap, and it points to the need for careful planning. The researchers suggest that their maps can be used in conducting vulnerability assessments, and can be combined with strategic decision theory methods to discover the most cost-effective regional conservation methods.

"We can't manage ecosystem services as if things are going to stay the same for decades," says Kim. "We have to plan for the climate being different so that the plan doesn't become obsolete in the next 20 years, but instead anticipates the range of changes that are possible to the various ecosystem services we expect from the landscape."

Letz continues to use the original maps as a consulting tool for Oregon cities, such as Bend, that are considering expanding their urban growth boundaries.

"You often only have a few minutes to get people's attention to an issue," he says. "So I put the map in front of them and showed them that Bend is at high risk. Fire is going to continue to be a problem for us. So we needed to consider whether to expand and what conditions under which to expand."

The City of Bend recently decided to extend its boundaries, pushing the city into an additional 2,380 acres of forest and rangeland. About half of the space is designated residential and can accommodate an additional 17,000 homes. The rest is zoned for commercial/industrial development. Letz says that without the maps, wildfire risk and the need for mitigation matters may not have been as easy to communicate to city planners.

"The map worked as an attention getter," he says, "and I was able to go on and have a more detailed conversation."

"Big thinking proceeds big achievement."

–Wilferd Peterson

LAND MANAGEMENT IMPLICATIONS

- Maps are now available that provide the first spatially explicit projections of the likely concentrated coincidence of multiple stressors for the conterminous United States: potential wildfire, insects and disease risk, urban and exurban development, and climate change.
- The maps can be used by policymakers, land-use planners, and land managers to assess, manage, and mitigate concentrated landscape stressors.
- The maps will be useful in discovering where and why biodiversity and ecosystem services may be at risk, where additional resources could be applied, and where research could be focused to study actual interactions among stressors.
- The maps can be used in vulnerability assessments and combined with strategic decision theory methods to discover the most cost-effective regional conservation methods.

For Further Reading

Kerns, B.; Kim, J.; Kline, J.; Day, M. 2016. U.S. exposure to multiple landscape stressors and climate change. Regional Environmental Change. 16(7): 2129–2140. doi:10.1007/s10113-016-0934-2. https://www.treesearch.fs.fed.us/pubs/53986.

Kerns, B.K.; Powell, D.C.; Mellmann-Brown, S., et al. 2017. Effects of climatic variability and change on upland vegetation in the Blue Mountains. In: Halofsky, J.E.; Peterson, D.L., eds. Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-939. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 149–250. Chapter 6. https://www.fs.fed.us/pnw/pubs/pnw_gtr939.pdf.

Kline, J.D.; Kerns, B.K.; Day, M.; Hammer, R.B. 2013. Mapping multiple forest threats in the northwestern United States. Journal of Forestry. 111(3): 206–213. https://www.treesearch.fs.fed.us/pubs/43646.

Tulloch, V.J.; Tulloch, A.I.; Visconti, P. et al. 2015. Why do we map threats? Linking threat mapping with actions to make better conservation decisions. Frontiers of Ecology and the Environment. 13(2): 91–99. doi:10.1890/140022.

Writer's Profile

Marie Oliver specializes in science writing and developmental editing. She can be reached through her website at http://claritywriting.com.

Science
FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW Third Avenue
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, $300

PRSRT STD
US POSTAGE
PAID
PORTLAND OR
PERMIT N0 G-40

Scientist Profiles

BECKY KERNS is a research ecologist with the Pacific Northwest Research Station in Corvallis, Oregon. She earned a M.S. in quaternary science and a Ph.D. in forest ecosystem science from Northern Arizona University. Her research, which she conducts at multiple biological, spatial, and temporal scales using empirical, experimental, and landscape modeling approaches, increases understanding of how natural and human-caused disturbances and their interactions affect vegetative and plant communities.

JOHN KIM is a biological scientist and ecological modeler with the Western Wildland Environmental Threat Assessment Center and the Pacific Northwest Research Station. He studies climate change impacts on vegetation using dynamic global vegetation models. He has an M.S. in computer science and a Ph.D. in fisheries and wildlife management from the University of Massachusetts, Amherst.

JEFF KLINE is a research forester and economist with the Pacific Northwest Research Station. His research examines the effects of population growth and land use change on forests and their management. Recent work includes working with interdisciplinary science teams to examine how biophysical and socioeconomic data and methods can be combined to address the wildfire issue.

They can be reached at:

USDA Forest Service
Pacific Northwest Research Station
3200 SW Jefferson Way
Corvallis, OR 97331

Kerns: phone: (541) 750-7497
E-mail: bkerns@fs.fed.us

Kim: phone: (541) 750-7287
E-mail: jbkim@fs.fed.us

Kline: phone: (541) 758-7776
E-mail: jkline@fs.fed.us

Collaborator

Michelle Day, Oregon State University