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Smoke in a New Era of Fire

On Sunday, September 21, 2014, Sheila McCann woke up at 4 a.m. and ate 2,000 calories. In a few hours, she planned to start the Ironman Lake Tahoe triathlon in which she would quickly burn up all those calories and more as she swam 2.4 miles, cycled 112 miles, and then ran a marathon. “You start training at least 6 months in advance and then you really get disciplined for the last 3 months with your diet, training, everything,” she said. “I was really dialed in.”

“My reaction was to get the hell out of there.”

Within half an hour of the starting gun going off, her plans, hopes, and expectations for the day changed radically. Race directors announced the cancellation of the triathlon due to smoke from the King Fire, which had started the week before and eventually burned across 97,000 acres in northern California. “We were all in our wetsuits standing there at the lake, ready to start. It was such a shock. Especially because where we were, there was hardly any smoke.



Pioneer Fire, Idaho. This was the largest fire on Forest Service land in 2016.

- Smoke from wildfires is a public health concern. Smoke affected the entire Pacific Northwest region in 2015, and again in 2017. Scientists developed the BlueSky Modeling Framework that forecasts where smoke will travel, allowing public health agencies and communities to prepare for smoke impacts.
- Wildfires are here to stay. Scientists predict that with climate change, the annual area burned will continue to increase. Learning to coexist with wildfire means we will have to learn to coexist with some amount of smoke.
- Large areas of the Intermountain West are in need of some sort of landscape restoration to change fuel patterns, forest age, and forest-density conditions. Restoration often includes fuel treatments, including prescribed fire.
- A benefit of prescribed fire over wildfire is that you can plan for it, control the conditions of the burn, and minimize the smoke impacts.
- The more people understand about the ecological benefits of prescribed burning, the fewer concerns they have about its use, and that includes concerns about smoke.



People were crying and hugging each other, trying to figure out what to do next. I had to pack up all my stuff in two big backpacks and bike 20 miles back to Squaw Valley where we were supposed to finish. As I rode I came into the smoke and understood why they canceled it,” McCann said. “My reaction was to get the hell out of there. But it was a big disappointment not to be able to compete.”

Triathletes had gathered from long distances, including a busload of people from Mexico, for the chance to compete. Officials from state and county health departments had been closely monitoring air quality in the area. The day before the race, it looked like smoke from the King Fire would not overlap with the course. However, fire behavior and wind patterns shifted that afternoon and air quality quickly deteriorated in the area. Health officials advised that the high levels of particulate matter in the air were unsafe for athletes, event volunteers, and spectators, and shortly before the planned 6:30 a.m. race time, triathlon directors called off the race.

NASA image courtesy Jeff Schmaltz,
LANCE MODIS Rapid Response Team, NASA GSFC.



The King Fire burning near Lake Tahoe on September 14, 2015.

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Cynthia L. Miner, Communications and Applications Director
Frank Vanni, Publishing Director, fvanni@fs.fed.us
Rachel White, Writer and Managing Editor, rachelwhite@fs.fed.us
Jason Blake, Layout, jpbake@fs.fed.us
Send change of address information to pnw_pnwpubs@fs.fed.us

◀ *Firefighters endure smoke on the job.*

Big fires, unhealthy air

Smoke is an unwanted but unavoidable byproduct of fire—and fire is here to stay. “Fire is not only inevitable, but a lot more fire and smoke are coming our way,” Paul Hessburg said. He is a research landscape ecologist for the U.S. Forest Service’s Pacific Northwest (PNW) Research Station. For nearly 40 years, he has been studying the way disturbances such as wildfire shape forest landscapes, as well as the reverse: the way topography, climate, and vegetation mosaics historically have influenced the size and behavior of past fires.

“Historical fires created these amazing patchworks of burned and recovering vegetation. Some fires thinned out the trees and burned up the surface fuels. Some killed most of the trees. Most fires were small to medium size, far fewer were large. This burned patchwork helped to regulate future fire sizes and their severities,” he said. “But over the past century, our management practices have created an epidemic of young trees in dense and layered conditions. In these conditions, fires easily spread long distances. When large, they are often severe, burning under more extreme fire weather.”

In addition to being a research priority, this issue hits close to home. Hessburg lives and works in Wenatchee in the heart of Washington state, which has experienced several historically destructive wildfire seasons in the past few years. In 2015, the total number of acres burned by wildfire in the state was more than six times greater than the 10-year average. More than a million acres burned in Washington that year, while about two-thirds of a million acres burned in Oregon. Across the Pacific Northwest, the frequency of large fires has increased 1,000 percent.

“We’ve entered a new era of megafires—fires that oversimplify the landscape. Climate change scientists tell us that the area burned since 2000 will double or triple over the next three decades,” Hessburg explained. “Right now, with our practice of putting out 95 to 98 percent of all wildfire starts, big fire is the only story the landscape is able to tell.”

Hessburg and other fire scientists hold that the “command and control” approach to fire is not the answer. He and a group of colleagues published an article in *Nature* outlining the scientific reasons why we need to learn to better coexist with wildfires, rather than shun them. Fire, they say, is a disturbance factor on the landscape that we cannot remove. The more we try to eliminate it, the more insistently it welcomes itself back. Moreover, many plants, animals, and ecosystems benefit from fire; fire exclusion negatively affects those adapted to frequent fire. “Wildfire



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Fire is a natural disturbance factor, but large, uncharacteristic fires can be destructive to ecosystems and create public health concerns from unhealthy smoke emissions.



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In the past 5 years, nearly every western state has seen a wildfire of record-breaking size.

is the single most essential process for maintaining western forest and rangeland health,” Hessburg said.

Learning to coexist with wildfire means we will have to learn to coexist with some amount of smoke. “In reality, we don’t get to decide whether there will be lots of fire and smoke,” Hessburg said. “There will be fire and smoke, and

lots of it. Our choice is how we want that fire and smoke. We can live with weeks and weeks of smoke released by large, destructive wildfires in the summer, or we can take it in smaller doses that accompany prescribed burns or managed wildfires.” A managed wildfire is a naturally ignited fire allowed to burn as long as it stays within well-defined perimeters and safe conditions.

“Prescribed burns and managed wildfires can help managers reduce the risk of even larger and more destructive wildfires,” Hessburg said. “You can get significantly less smoke from prescribed burns than from wildfires.”

In 2015, when a million acres burned in wildfires in Washington state, only 7,000 acres were treated with prescribed fire. This was partly because smoke fatigue from those wildfires made decisionmakers reluctant to plan controlled burns. To avoid having this situation become the new norm, Hessburg has a message for land managers, regulatory agencies, and communities around the Intermountain West: we can do better. He enlisted the help of documentary filmmakers at North 40 Productions and created a 70-minute, multi-media presentation called *The Era of Megafires*. He has taken this presentation on the road, touring major western cities and towns as small as Lincoln, Montana (population 1,100). At more than 60 events so far, his live presentation has reached more than 12,000 people.

In his presentation, Hessburg describes the implications of continuing at the current pace of forest restoration. “Restoration” is a land management concept that refers to improving a forest’s resilience to disturbances such as wildfires or climate warming, typically through prescribed burning treatments, sometimes coupled with forest thinning and managed wildfire. Large areas of the Intermountain West



Paul Hessburg



Landscape ecologist Paul Hessburg studies forest health and wildfire dynamics. “We need to learn to coexist with wildfire,” he says.

are in need of some sort of landscape restoration to change fuel patterns, forest age and forest-density conditions.

“If we do nothing, wildfires will do the work. And we won’t like the results,” Hessburg said. “Fire managers in eastern Washington burn far fewer acres than they could be burning with prescribed fire. One of the limitations to increasing the pace and scale of intentional burning is smoke management.”

Continued on page 6

Prescribed fire is different from wildfire

Wildfires are unplanned. With prescribed burns, fire managers can predict and plan for the fire's behavior, ignite it under safe conditions, and minimize the smoke impact to communities. There are other more specific differences as well. Prescribed fires and wildfires don't burn in the same way, or give off the same kind or amount of smoke. The Forest Service's Pacific Northwest Region air quality program manager, Rick Graw, explained that much of this difference has to do with the time of year.

"Let's say you burned 100 acres of land with a prescribed burn versus the same 100 acres with a wildfire," he said. "The wildfire would typically burn in mid- to late summer here in the Northwest. The fuels are drier. You get a lot more consumption of some fuels, like the duff layer, maybe the heavy logs, tree stumps, things like that. Whereas if you burn those same fuels during a prescribed burn in the spring, they are still pretty moist. You don't get the consumption of those fuels nearly as much. They tend to smolder a lot. So you would get a lot more emissions from those fuels if they burned under a wildfire scenario because they are drier and more available to burn. Also, with a wildfire

you might torch your canopy, which adds that much more fuel than you get with a prescribed burn. I estimate maybe a third more."

Fuel moisture level is not the only difference. Fire ecologist Morgan Varner is with the Pacific Northwest Research Station's Pacific Wildland Fire Science Laboratory. He is working on fire models that incorporate the unique ignitions patterns of prescribed burns to help land managers understand what to expect. Current fire models are based on wildfire.

"Prescribed fire is different. It has an explicit ignition," said Varner. "Our current fire behavior models show a big blob spreading over the landscape. Prescribed fire is not



Claudia Romero

Morgan Varner collects data on the effects of prescribed fire.



Morgan Varner

Prescribed fire such as this is a valuable tool for fuel management and ecosystem restoration.

an unfettered fire running across the landscape—it's typically a series of strips. We need to be able to better model prescribed fire behavior to give managers the decision support they need. Therefore, we are modeling backing fire (the slower spreading part of a fire moving windward or downslope) and we have 5 years of research planned on fire behavior focused on how trees survive or perish. For prescribed fire, you want to burn certain trees and not others."

Alert to the information needs of fire managers, Varner has his eye on helping them respond to the health concerns of communities. 🌿

Human health is paramount

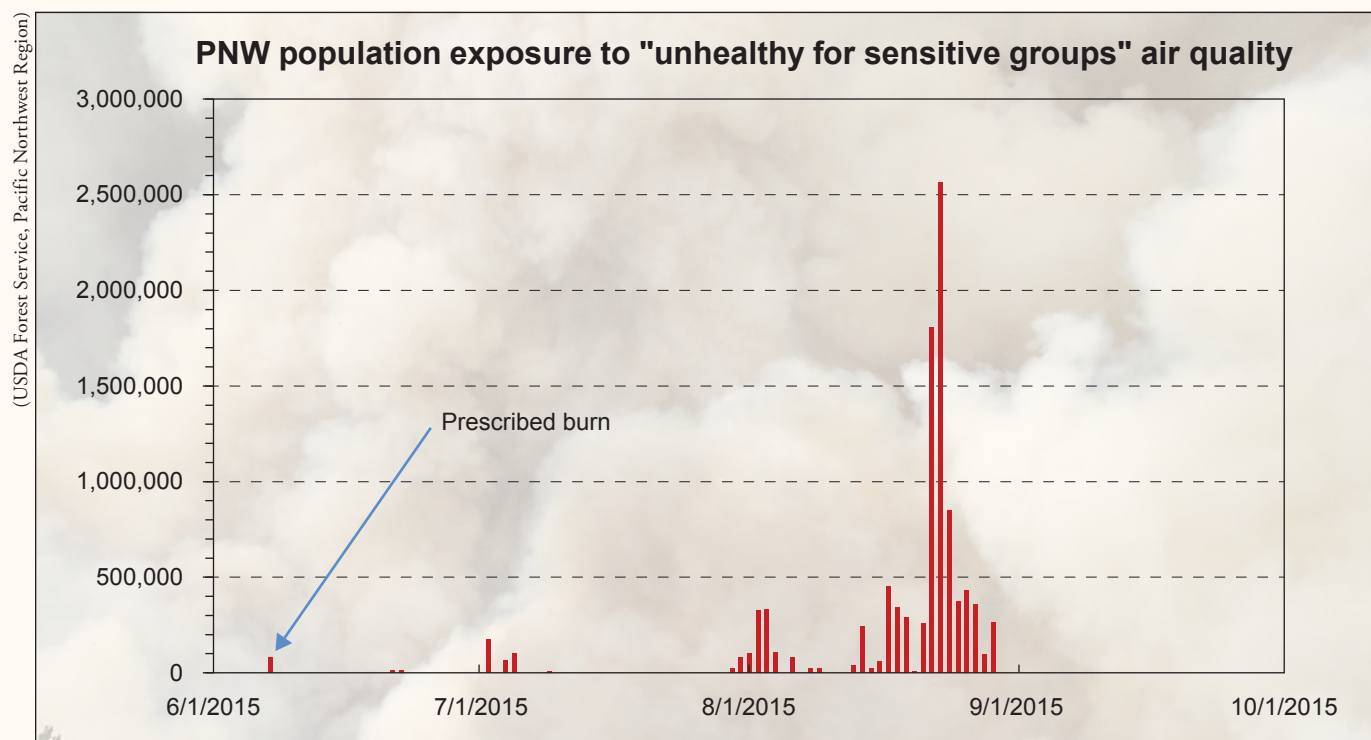
As Ironman Lake Tahoe officials were well aware, smoke is a human health concern. Smoke, whether from wildfire or prescribed fire, can sharply reduce air quality by releasing particulate matter (PM)—a mixture of microscopic solids and liquid droplets. Particulate matter is one of the most dangerous types of air pollution for human health. Some particles, like dust and pollen, are large enough to see. Particles larger than 10 micrometers (PM10) easily catch in our noses and throats. Fine particles smaller than 2.5 micrometers, known as PM2.5, are small enough to inhale all the way into our lungs, where they can cause much more harm.

The World Health Organization reports that the PM2.5 level with demonstrated adverse health effects is not much above the background concentration. For the 26 million Americans with asthma, putting additional PM2.5 into their air is a concern. Asthma is already responsible for 2 million emergency room visits each year, and is the third leading cause of hospital stays for children.

Besides asthma, the health effects of air pollution include increased heart attacks and stroke, long-term lung and cardiovascular disease, and premature death in seniors and infants. The World Health Organization reports that air pollution is also the leading environmental cause of cancer deaths.

The people most at risk from air pollution include the elderly; children, especially infants, because their lungs are still growing; and people with asthma, chronic obstructive pulmonary disease (COPD), or an underlying cardiovascular issue or diabetes. Exposure to air pollution increases for those who work or exercise outside. Just about every family has someone who fits one of these criteria.

Smoke affected the entire Pacific Northwest region in 2015. Wildfires released approximately 130,000 tons of fine particulate matter (PM2.5) in Washington. In Oregon, fires released approximately 90,000 tons of PM2.5. During the last two weeks of August when it was especially smoky, more than 8 million people in the region were exposed to air pollution that exceeded the level that the Environmental Protection Agency (EPA) deems unhealthy for sensitive groups. In 2017, as this Science Update was being prepared for publication, the region again experienced long periods of smoke. In Portland and Seattle, several days spread over multiple weeks had daily averages of PM2.5 levels in the “unhealthy for sensitive groups” category in which children, pregnant women, the elderly, and those with compromised breathing are advised to limit their exposure. Conditions even spiked into the “unhealthy” category in which the EPA recommends that all people should take mitigating actions.



Air Quality Summary Report for the 2015 Pacific Northwest fire year: Between June 1 and September 30, 2015, millions of people in the Pacific Northwest were exposed to air quality deemed unhealthy for sensitive groups because of wildfire smoke.

Where will the smoke go?

When Sim Larkin started working at PNW Research Station's Pacific Wildland Fire Science Laboratory in Seattle in 2001, his expertise was immediately applied to address pressing questions about smoke. As a climatologist, he studies wildfire smoke emissions, huge complicated climate systems like El Niño, and the interactions of wildfire and climate. In the early 2000s, air quality was starting to become a political issue in Washington state. An environmental group had filed lawsuits against the state over air pollution from agricultural grass burning. Land managers and policymakers had concerns about whether prescribed fire also should be restricted because of smoke impacts on human health and public safety.

"The question was how to conduct prescribed burning in a way that won't cause an impact. If you want to do that, you need to have some idea of where the smoke will go. And that leads to the idea of a predictive smoke model" Larkin said. "There were some tools available back then, but they were relatively crude."

He eventually took the lead on a project to build a system that could predict where the smoke from various prescribed burns would go. Smoke can travel hundreds of miles, sometimes remaining aloft for long distances and then collapsing far downwind from the source fire. Smoke forecasting requires data on weather, terrain, fires and fuels. To create a prediction framework, Larkin's team had to link a complex series of processing steps sequentially together, starting with fire information and fuel loading (the amount of combustible material available per unit area), progressing to fuel consumption, and ending with smoke emissions.

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The size of wildfires in the West has been growing, leading to smoky summers for many communities..

"In 2003, the station ran the first smoke model for prescribed burns. By 2005, the director of the EPA, Mike Leavitt, had seen our outputs and asked if we could do this for wildfires across the West. It turns out we can," Larkin explained. "We realized there is a lot of demand on wildfire incidents to understand where smoke goes, and a need to communicate with local public health agencies and communities that are going to be affected."

The efforts of Larkin and his team, known as the AirFire Research Team, culminated in the BlueSky Modeling Framework, a program integrating existing datasets and models that can create predictions about where smoke will travel. BlueSky can be used during a wildfire incident—for example, if a fire manager wants to conduct a back burn,

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Smoke can travel hundreds of miles, affecting communities far away. Scientists have developed a modeling framework called BlueSky that predicts where the smoke will go.



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Although wildfires can cause significant disruptions to communities, prescribed burns can be carefully controlled and conducted when conditions are less risky.

Larkin's team could customize a model run based on the specifics of that fire. They did this type of custom run recently for a pilot study near Bend, Oregon (see "Smoke modeling supports prescribed burning near communities" on page 9). They also developed a web-based application that allows any user to input information about a fire or proposed fire, pick their fuel beds through a web interface, and then let the smoke dispersion model run while they wait. This is frequently used by practitioners implementing prescribed burns. If they model a burn for today and it looks bad, they can come back the next day and rerun the same fire using updated winds, and in the same fashion keep checking for an optimal ignition time.

BlueSky enabled the first comprehensive nationwide smoke forecasts and formed the basis for smoke prediction systems and tools used across the country and internationally. BlueSky's customized smoke projections and analyses have now guided public health outreach during major wildfires across most of the West, including California, Colorado, Utah, Washington, and Wyoming.

Rick Graw is the air quality program manager with the Forest Service's Pacific Northwest Region, which covers Oregon and Washington. Tools like BlueSky help Graw

reduce uncertainty as his program monitors national forests for the harmful effects of air pollution, and assists forest managers in conducting prescribed burns. "The smoke modeling helped us to document our wildfire response in 2015 and 2017 and quantify the emissions and air quality impacts for what were really bad fire years in the Northwest," Graw said. "As you would expect, many people were exposed to smoke and there were a lot more unhealthy days from wildfire."

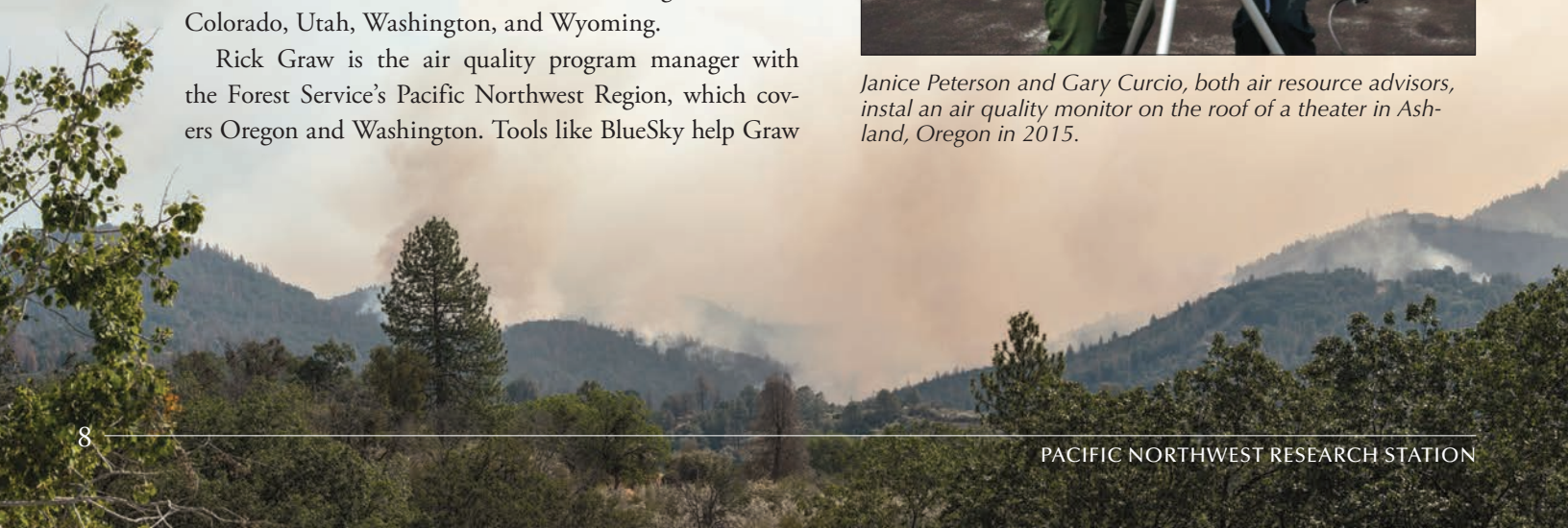
Smoke models also facilitate communication about smoke impacts to the public. In addition to customized smoke projections, BlueSky produces daily predictions of surface PM_{2.5} concentrations for the continental U.S., Alaska, and Canada (see <https://www.airfire.org/data/bluesky-daily/>); it is available to the public in real time, and often used by journalists reporting on fire impacts.

Ten years ago, there were no national smoke model forecasts. BlueSky and other tools are a tremendous boost for making good decisions about when to use prescribed burns. "I think it's critical to keep improving our smoke, plume, and exposure models," Larkin explained. "Our toolkit helps land managers better plan burns, and in a way that can build trust in communities. When you have lots of uncertainty it's important to build up that trust, which is a critical piece."



Bert Erling.

Janice Peterson and Gary Curcio, both air resource advisors, install an air quality monitor on the roof of a theater in Ashland, Oregon in 2015.



Smoke modeling supports prescribed burning near communities

In June 2015, a prescribed burn five miles west of Bend, Oregon, exposed 100,000 people to air quality conditions deemed by the Environmental Protection Agency to be unsafe for sensitive groups.

The prescribed burn was actually a test, part of a project to study different approaches toward accomplishing fuel treatments in the West Bend Vegetation Management Project area. Keeping smoke out of Bend from this area is particularly difficult. Nighttime temperature inversions trap smoke from smoldering fuels, which then flows along the Deschutes River into downtown Bend. Bend has seen nine smoke intrusions over the past 2 years due to prescribed fires, raising concerns regarding health, visibility, and livability.

Pacific Northwest (PNW) Research Station scientists took measurements during prescribed burns in 2014 and 2015, using portable weather stations, air quality monitors, and automated cameras. This improved understanding of some of the challenges in managing smoke in complex terrain, such as the river drainage that transports smoke into town during nocturnal inversions. They are also analyzing how smoke emissions vary depending upon the types of fuels, burning, and fuel loading.

“This work showed us how complex the air flows are around Bend, and made us realize we need more accurate, higher resolution operational models than the ones we currently use,” said Rick Graw. Ultimately, the smoke modeling, along with other PNW Research Station studies on fuel types, is helping facilitate the use of prescribed fire as a restoration tool, while also protecting air quality in communities like Bend. 🌿

Morgan Varner



Prescribed fire (above) behaves differently than wildfire. Morgan Varner is working on computer models that incorporate the unique burning patterns of prescribed fire.



Prescribed fire's role

Not relying on Mother Nature

In 2016, after back-to-back record-breaking fire seasons in 2014 and 2015, the Washington state legislature passed House Bill 2928 to encourage prescribed fires in the central and eastern parts of the state. Their intention was to use prescribed fire to help control the timing and conditions of subsequent wildfires so that communities would ultimately experience less smoke.

A report developed jointly by the National Association of State Foresters and the Coalition of Prescribed Fire Councils in 2015 supports this idea. It states: “By managing the extent of wildfire through prescribed fire and using fire for resource benefit in controlled situations, the impact of smoke on public health can be greatly reduced. The ability to place prescribed fire on the ground under planned circumstances and weather conditions can greatly outweigh responding to unexpected wildfire emergencies. Proactive use of prescribed fire has shown the ability to minimize smoke impacts compared to emission from wildfires.”

The Washington Department of Natural Resources (DNR) is tasked with enforcing air quality regulations

in the state. As the assistant wildfire division manager at Washington DNR, Karen Arnold helps oversee the state's air quality rules pertaining to silviculture, which includes smoke from prescribed fires. Washington DNR reviews prescribed burn requests and makes daily approval decisions based on weather forecasts and projections of smoke emissions. Arnold and her team work to thread the needle of getting the most prescribed burning done with the least effect on people as possible.

“Prescribed fire is not the right answer in all places at all times,” Arnold said. “If it's a wildfire situation and we are responding to the incident and communicating with people with asthma or the elderly—they know we are doing our best. However, when you are affecting them with a prescribed burn, they know the fire is intentional. For someone who has COPD and has to constantly monitor air quality, if we miss the forecast and put smoke into their home, we're on the hook for the mistake and we take that very seriously.”

Although prescribed burning won't eliminate wildfires, she added, land managers can increase the pace and scale of

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The sun sets through smoke-filled skies at the Happy Camp Complex Fire in the Klamath National Forest in California.

restoration, using it as a tool where it works. She does caution, however, that with a significant backlog of area that needs restoration treatments with prescribed fire, there will be more smoke from prescribed fire than in the past.

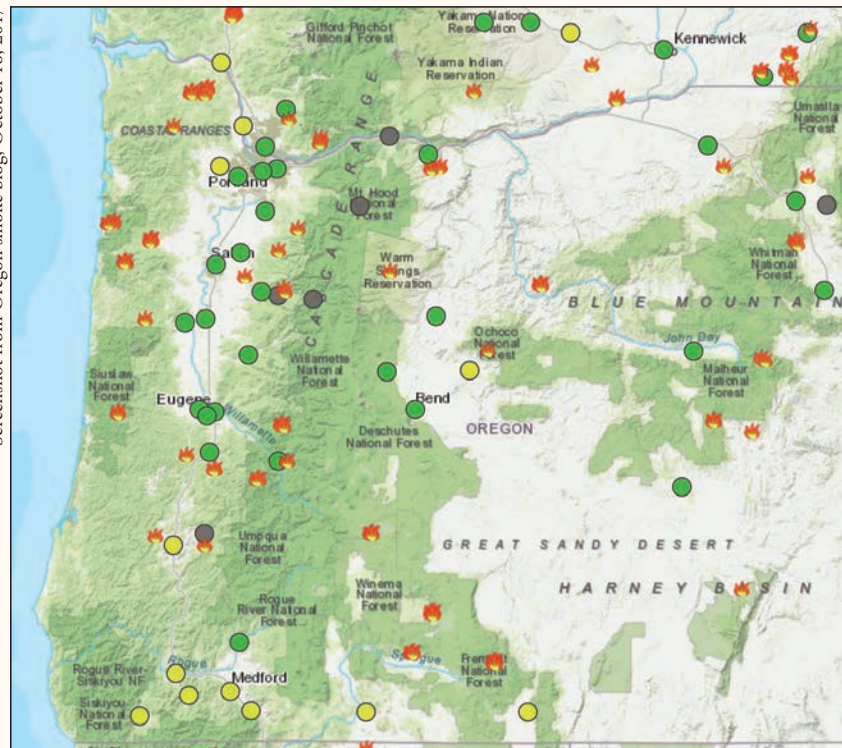
The U.S. Forest Service also employs air quality experts. Janice Peterson is an air resource specialist stationed at the Pacific Wildland Fire Science Laboratory in Seattle. Her job focuses on helping decisionmakers understand the potential air quality impacts of various land management activities, including prescribed burning. Part of her job also includes helping inform communities during wildfire smoke events. Monitoring the smoke is important, as is messaging. Peterson sometimes acts as a go-between, helping people in the field understand how to use BlueSky, or helping develop communication products, such as getting smoke information translated into Spanish for a local community.

With prescribed burning, the focus is on keeping the smoke from reaching a community in the first place. “I think we have pretty good evidence that we can use prescribed fire to help reduce damage from catastrophic wildfires and to help protect communities,” Peterson said. “For our prescribed fire program, it’s about controllability, and about having fire do in ecosystems what we want it to do and when, and not relying on Mother Nature to choose the timing and the placement. Generally, the goal of prescribed fire is that no one sees or smells smoke.”

Larkin echoes the idea that a benefit of prescribed fire over wildfire is that you can plan for it, predict, and minimize the smoke impacts. “Prescribed burns don’t necessarily cause significant smoke impacts,” Larkin said. “A prescribed burn can be designed in most cases to loft the vast majority of the smoke up so that it can move downwind. You might get a low level of impact over a larger area,” he said. “The prescribed burn is more controllable in terms of when it’s going to happen and how we can plan to have the least impact on the community. Being able to warn communities, put signs up on the roads that warn people to drive slower because there might be smoke, all these things cause less collateral issues than with a wildfire.”

When a wildfire sends high levels of smoke into a community, people can reduce their exposure by staying indoors or leaving town. Unfortunately, by that point there are usually significant disruptions to the community, such as economic declines from reduced tourism as people avoid the impacted area.

Screenshot from Oregon smoke blog, October 16, 2017



Air resource advisors regularly disseminate information through state smoke blogs that describe smoke conditions from wildfires such as those in 2017.

Sarah McCaffrey



Communication is key. Researchers and Sisters Ranger District staff take a field trip near Sisters, Oregon amid smoke from a nearby wildfire.

Risks other than smoke

Washington has 3.2 million acres in need of restoration. In Oregon, 7.2 million acres are in need of restoration. “When you talk about risks with prescribed burning, it’s not just air quality risk,” said Graw. “There’s also fire transmission risk—burning up property, homes, burning up private forest timber. Maybe someone was planning to sell that timber to pay for their kid’s college education. It’s a multiple-risk scenario.”

Impediments to prescribed burning, such as managing multiple risks, are a particular interest of Morgan Varner. He studies fire ecology and management, including fuels, prescribed fire, and the effects of fire on various forest types at the PNW Research Station’s Pacific Wildland Fire Science Laboratory. “Broadly, I am a fire ecologist, but I was intellectually raised on prescribed fires,” he said. “I have seen my clients as fire managers and prescribed burn managers, and I have done some social research on prescribed fire because I care about their needs.”

In a study of the constraints on prescribed fire, Varner and his colleagues surveyed land management organizations in northern California. They found that prescribed burning annually covered only 38 percent of the area

needed to fulfil land management objectives. Sixty-six percent of managers reported dissatisfaction with levels of prescribed fire activity. The survey also asked respondents to rate their major barriers to increasing their use of prescribed fire. What was holding them back?

“The answers differed by affiliation and also by how much they burned,” Varner said. The timber industry and large private landowners said the barrier was neighbor issues, such as wildland urban interface or risk of escape. For federal agencies, including the National Park Service, Fish and Wildlife Service, and Forest Service, the major impediment was operational. The burn window was so narrow that they couldn’t pounce. Second on the list for federal fire managers: air quality regulations. Social constraints, such as public intolerance of smoke, were much lower on the list.

Escaped burns receive a lot of media attention, but in reality more than 99 percent of prescribed fires stay within their planned perimeters. A review of prescribed fire use in North America coauthored by Varner stated: “Managers often receive public praise for suppressing wildfires but receive little recognition when conducting successful prescribed burns or allowing wildfires to burn for resource benefits.”

U.S. Air Force, Mike Kaplan



Sim Larkin conducted a study to model where very large future fires, similar to this, are likely, and what the potential smoke impact will be. This information can help managers focus restoration efforts in places likely to have the biggest positive impact.

Communities downwind

Social scientist Sarah McCaffrey, from the U.S. Forest Service's Rocky Mountain Research Station, has built a career studying the social dynamics of fire management, including public trust in wildfire practitioners, public acceptance of fire management, and community preparedness for wildfire. In her research across the fire-prone West, she found most people understand the ecology of fire and its beneficial role. Her work has revealed that smoke is not a concern for the majority of the public and there is a general recognition among people living in natural settings that they will have to tolerate some smoke.

"By and large, people get it," McCaffrey said. "Studies show that the more people understand the ecological benefits of prescribed burning, the fewer concerns they have about its use and that includes concerns about smoke. They tend to prefer smoke from a prescribed burn because 'You guys can control the smoke.' So there is a sense that the smoke is not going to be as bad for as long."

In other words, understanding leads to acceptance. "Understanding the ecological benefits is particularly important" she added. "Most people care way more about the land around them being healthy than about reducing the fire risk."

For some people, however, the effects of smoke are impossible to shrug off. "A third of households have someone that has a health issue that's going to be affected by smoke, like asthma or emphysema," McCaffrey said. "For that group, the smoke will be highly salient. It's not just an inconvenience; it can be life or death, depending on how sick you are. And, quite reasonably, that group is probably going to be fairly vocal about their concerns."

For communities downwind of wildfires, the Forest Service has created a new technical specialist position specifically to address smoke: the air resource advisor (ARA). The ARA position evolved out of collaboration between Larkin's AirFire team and fire managers. Now coordinated through the national level Wildland Air Quality Response Program, ARAs are available to serve on the incident command teams that coordinate firefighting activities. ARAs use BlueSky and other tools developed by the PNW Research Station to provide information on smoke dispersion and air quality effects. They collect and disseminate monitoring data, and work closely with state and local air quality and health agencies to communicate potential health and transportation safety impacts for firefighters and the public.

Morgan Varner



Prescribed fire like this can be planned to reduce smoke impacts.

As certified ARAs, the Forest Service's Graw and Peterson have been dispatched in that capacity on several wildfires. "ARAs are specially trained, they kind of combine knowledge of fires and air quality regulations, air quality protection, and health standards," Peterson said. "And they translate for the public affected by the fire and smoke what the health effects could potentially be, whether they need to take any actions to protect themselves, and what those actions might be."

When smoke from the King Fire started encroaching on the Ironman triathlon course at Lake Tahoe, ARAs were part of the decision to cancel the event. "As an ARA, we don't have the authority to cancel anything, but we work

with the local department of emergency management and the race organizers or whoever needs to make that decision,” Peterson explained. “They might ask us, ‘What’s going to happen this weekend? We have triathletes coming from around the country. What can we expect?’ And we can help do the dispersion modeling and say this is what we predict and these are some of the implications of that prediction, and now you guys make the call.”

ARAs are a resource for wildfire management and have not been widely used on prescribed fires. But they provide a good example of the ways research tools like smoke forecast models can help communities plan and protect themselves from smoke. They are also a model of good communication practices.

McCaffrey has heard from communities in fire-prone areas how important communication is, whether the incident is a wildfire or prescribed fire. “Some of the advice we have heard from focus groups is, ‘Tell us who you are, what you are doing, and why you are doing it—and please make decisions based on science.’ I’ve been to communities where they have done a really good job of identifying the people in the community who have major health issues. They make an extra effort ahead of time, notifying them that we’re going to be doing a prescribed burn so people can make plans. If necessary, they can get out of town or they can cancel the family picnic. A lot of it comes down to consideration.”



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The Pioneer Fire located in the Boise National Forest near Idaho City, ID, began on July 18, 2016 and consumed more than 118,000 acres.

A big-picture look at future smoke impacts

A few decades ago, decisions about prescribed fire did not include considerations of smoke and smoke management in the context of human health effects or compliance with the Clean Air Act. Other changes include more people living in fire-prone forested settings, and wildfires that grow beyond our capacity to manage easily. In the past 5 years, almost every state in the Western U.S. has had a wildfire of record-breaking size.

Land managers and policymakers are appealing for an increase in the pace and scale of fuel treatments, including prescribed fire. In 2009, acknowledging that the current “postage stamp” level of fuel treatment barely makes a dent in the West’s 277 million fire-prone acres of public lands, Congress passed the Collaborative Forest Landscape Restoration Program to encourage large-scale, long-term fuel reduction projects.

Thinning and prescribed burning alone will not be enough to keep pace with wildfire risk, given climate change and the scale of the forest density problem. Hessburg talks about this in his *Era of Megafires presentation*: “Managed wildfire is another important tool in the toolbox. When fuel and weather conditions permit, this practice allows us to ‘herd’ naturally ignited wildfires through the landscape to thin out trees and burn up deadwood. We can become smarter and influence our local environment. We need to put some of those ignitions we currently douse back to work.”

Larkin led a recent study to look at the potential for megafires and then further analyzed where the smoke from those fires might go. Unsurprisingly, the study found the areas that ranked highest for overall large wildfire risk are in the Western U.S., including the Rockies, Cascades, Sierra Nevada, and Great Basin regions.

“We ran models to see where the atmosphere is likely to take the smoke from those very large future fires, and what populations are underneath where that smoke is likely to go,” Larkin said. “This gave us an indication of the smoke impact potential.” Although overall megafire risk is high in many parts of the Western U.S., Larkin’s team found that the potential human-population exposure to smoke is heavily concentrated in California, Minnesota, and along the eastern seaboard.

Their modeling results assume no management action—in other words, they show us the risk of megafire smoke potential if we do nothing to try to fix the problem. The point of identifying and ranking locations with the highest potential for large-scale smoke impacts in our future is that

now we know where our management actions are likely to have the biggest positive impact.

Likewise, as Hessburg tours western towns, his intention is to inspire hope. “It’s actually not to scare people,” he said. “I am a father and I have raised my kids here. I worry about what I am leaving behind for my kids. This is a story about why megafires have come our way. But it is also a story of hope, that we can change the way fire comes to us.” It is a story that Sheila McCann, the triathlete who was unable to compete when Ironman Lake Tahoe was canceled due to smoke, can appreciate.

When McCann trained for a 2017 triathlon in Alaska, which will feature a cold swim in the waters of Resurrection Bay and a marathon course that climbs more than 6,000 feet, she knew she needed healthy lungs and appreciated the cancellation of the 2014 triathlon. Although she was disappointed that she couldn’t compete at Lake Tahoe, she says the cancellation was the right thing to do.

“It was a bad situation and they did the best they could. It would have been ugly if they hadn’t canceled,” she said. “I don’t think you would have had that many people dropping out of the race on their own. Ironman people are very competitive, and we all were focused and ready for that day. I probably would have still done it, even in the smoke. I mean, you are signing up for pain. What’s a little smoke on top of that?”

USDA



The Happy Camp Complex Fire in the Klamath National Forest in California.

Science Update

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW Third Avenue, Suite 1400
P.O. Box 3890
Portland, OR 97208-3890

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S U M M A R Y

Smoke from fire can sharply reduce air quality by releasing particulate matter, one of the most dangerous types of air pollution for human health. A third of U.S. households have someone sensitive to smoke. Minimizing the amount and impact of smoke is a high priority for land managers and regulators. One tool for achieving that goal is prescribed fire. Prescribed fire can be controlled and planned carefully to minimize smoke impacts and warn communities in advance. It can also help reduce decades worth of vegetation buildup from past fire exclusion and help restore dry, fire-adapted forests. Forest Service research is helping decisionmakers plan for, predict, and control smoke from fires and communicate smoke impacts to the public.

More information:

BlueSky Modeling Framework: <https://www.fs.fed.us/pnw/airfire/>

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Contacts:

Paul Hessburg, research landscape ecologist, U.S. Forest Service, Pacific Northwest Research Station, phessburg@fs.fed.us

Sim Larkin, climate scientist, U.S. Forest Service, Pacific Northwest Research Station, larkin@fs.fed.us

Morgan Varner, fire ecologist, U.S. Forest Service, Pacific Northwest Research Station, julianvarner@fs.fed.us

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