

and, as more research was conducted on the base, they gained site-specific solutions to some of the problems. At the same time, scientists and managers experienced fire together on the fire line, and individuals who had never been on the line were able to see what managers faced, including the practical constraints of conducting research.

This collaboration also assisted with putting in place a burn prioritization process. There was not enough capacity in the fire management program on the base to burn the target amount of area each year. Therefore, Furman and Hiers focused on the worst habitat and, rather than disaggregating fuel treatments, they worked with fire managers, fire researchers, and wildlife biologists to aggregate treatments. They hoped that by burning and maintaining the best quality habitat, the fire-dependent ecosystems in these locations would slowly grow capacity over time. Ten years later, the treatment capacity had tripled, and the goal of burning over 40,000 hectares (100,000 acres) a year is frequently met.

Regional solutions with innovative, dynamic, and robust fire management–science partnerships can play a key role in addressing the policy management fire trap. More fire is needed on the landscape, not less, and national policies will not work as well as regional policies to introduce that needed fire. Shared experience is the bridge between management and science.

ADAPTING TO WILDFIRE: MOVING BEYOND HOMEOWNER RISK PERCEPTIONS TO TAKING ACTION

Patricia Champ, U.S. Forest Service

Champ's presentation focused on how to get homeowners to take action to protect their properties from fire. She framed this challenge as a last-mile problem, which is a concept from the literature on supply chain. The last mile is the end of the supply chain where a product is transferred to the customer. The last mile is often the most difficult part of the entire supply chain, and for that reason, it should not be thought about last.

Champ used a bridge to nowhere (based on a TED talk idea by Harvard University economist Sendhil Mullainathan) as a metaphor for the last-mile problem in fire science and management. A great deal of engineering has gone into building the bridge, yet it leads nowhere. Likewise, a century's worth of fire science has been conducted, resulting in a better understanding of fire behavior and home ignitability. Yet there are still homeowners who do not take action to mitigate the risk posed to their property by fire.

Research finds that, generally, homeowners in the WUI understand that they live in a fire-prone landscape and that they are vulnerable to losing their home. However, taking action is not simple, Champ said. First, as Paveglio discussed, community context matters. Second, homeowners need specific information to take action. Therefore, the general concept of the home ignition zone (Figure 5-4) needs to be made applicable to the particular hazards on an individual homeowner's parcel, such as the trees near a wood deck. Third, multiple interactions with the homeowner are required to induce action; one message to a homeowner about defensible space will not lead to behavioral change. The homeowner needs to interact on his or her property with someone he or she trusts, such as a volunteer from the fire department, a local wildfire council member, or a state forest service representative.

To find ways to solve the last-mile problem of homeowners taking action, Champ is part of an interdisciplinary research collaboration team called Wildfire Research (WiRē), which focuses on homeowner wildfire risk mitigation and community wildfire adaptedness. WiRē serves as a model of joining research and practice. The personnel come from three different federal agencies: the Forest Service, the U.S. Geological Survey, and the Bureau

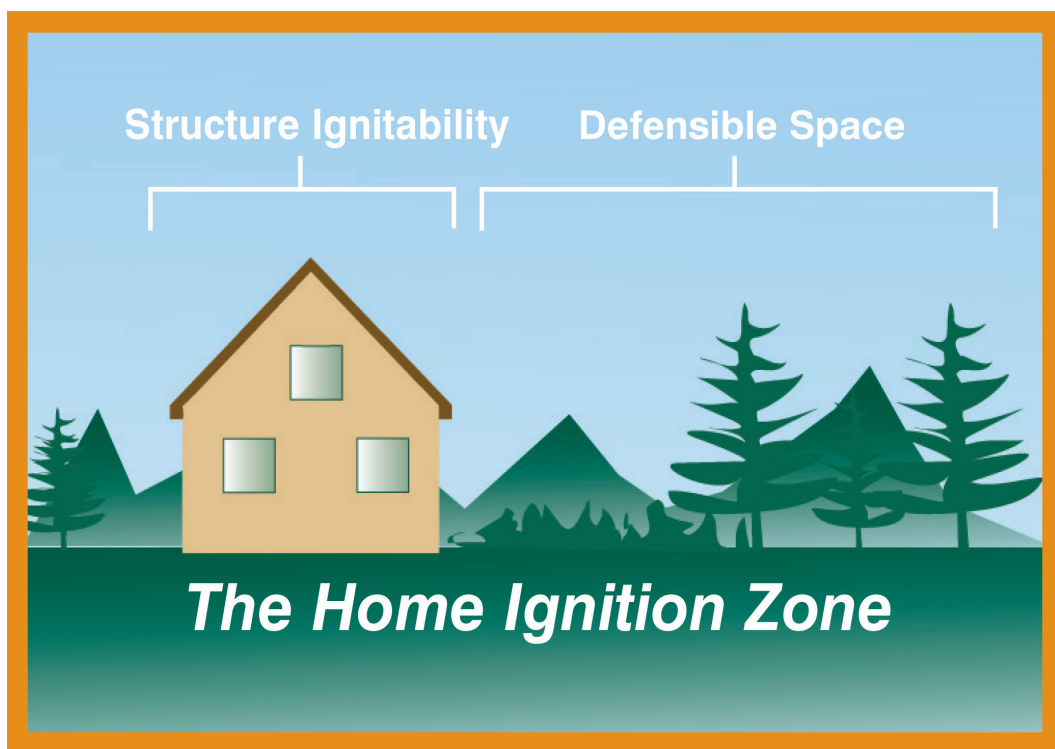


FIGURE 5-4 The home ignition zone.

SOURCE: Champ, slide 4. Image courtesy of the Colorado State Forest Service.

of Land Management. The University of Colorado, Boulder, is also a partner as are two wildfire councils in Colorado. As of early 2017, most of WiRē's work had been conducted in Colorado, but the team expected to work in other locations soon.

As of March 2017, WiRē had collected systematic data in 87 Coloradan communities. To generate the data, the practitioners conduct a rapid risk assessment for every parcel that has a structure in the community. This assessment is based on 11 attributes, such as where the parcel sits in the landscape and the vegetation on the parcel. Some of the attributes relate to the structure that is on the parcel. At the same time, the local community conducts social surveys. These surveys help WiRē learn about the people who live on the assessed parcels.

WiRē has used the collected data to understand the effectiveness of different kinds of nudges. Nudges are messaging efforts that seek to encourage behavioral change. The WiRē team designed an experiment with three nudges and ran it in a Coloradan community where homeowners had not taken mitigation measures to protect their homes. The community had a cost-share program in place for years to encourage such measures, but no one had taken advantage of it.

In each nudge in the experiment, a letter was sent out to homeowners in the community. In the first group, homeowners were told in the letter about their community level of wildfire risk. That information comes from the century of research on how to conduct risk assessment. In the second group, homeowners were told about their community level of risk and their parcel level of risk. That information builds on the pioneering work that Jack Cohen

did within the Forest Service's research arm on the home ignition zone.⁴ In the third group, a social norm piece was added to the letter. Homeowners were told about their community level of risk, their parcel level of risk, and the level of risk of their 10 nearest neighbors. Homeowners could respond to the letter in one of three ways: (1) they could go to a website that was individualized with risk assessment data for their parcel of land so they could see how their parcel was rated on the 11 attributes; (2) they could call the West Region Wildfire Council, the practitioner part of this venture; or (3) they could attend a community meeting.

WiRē's results had not been published at the time of the workshop, but the preliminary data suggest that response rates were good across all three groups. More importantly, when it comes to the last-mile problem, community members undertook more defensible space projects in the last 4 months of 2016 (after the letters were mailed) than they had in the 5 previous years combined. Though the absolute number of projects was small (17 as of the end of 2016), this increase was a substantial change in the community compared to the years before the nudge experiment. Champ and the rest of the WiRē team planned to follow up with homeowners in 2017.

In closing, Champ posed the question: How can a century's worth of fire science be used to help homeowners adapt and live with wildfire? One way is to unite research and practice, which might look different depending on a scientist's wheelhouse. Another way is to understand the importance of personal relationships. The relationships matter within the WiRē team; for example, Champ has been working with BLM for over 12 years. Relationships also matter when working with homeowners to build their trust and induce action. Finally, Champ reminded the audience not to think of the last mile last.

MODERATED DISCUSSION

A participant asked if messaging to the public should communicate that mechanical treatment (such as thinning) is needed along with prescribed burning and whether that message needs to be communicated at the middle mile, not just the last mile. Champ responded that often when the fire science community talks about the public, their notions of who or what the public is are not supported by data. Once the social piece has been investigated, it frequently turns out there is more support for fire on the landscape in fire-prone communities than was originally presumed or at least there may be a foothold of support that may grow with more communication from fire scientists and fire managers. However, there has been little research that looks closely at public support for fuels treatments in a specific sense, that is, fuels treatment next to a homeowner's house or in his or her community. Champ was not sure what the optimal message would be, but that messaging needs to be different depending on the place. For example, there are rural landscapes where burning is used regularly for land management; prescribed burning may not bother the people in these landscapes as it might elsewhere.

Paveglio added that the 22 characteristics in his framework aim to discover different communities' comfort level with fire on the landscape. In working landscapes, his research has found that people are generally on board with the idea of prescribed burns, but that will not be the case in all places. The tailored message would include planning for where mechanized fuel treatment should occur and where prescribed burning should be done. In another location, depending on the type of people, how they are situated, what their ownership patterns are, and whether or not they work together, a large break in vegetation across

⁴See The Jack Cohen Files. Available at <http://www.firewise.org/wildfire-preparedness/wui-home-ignition-research/the-jack-cohen-files.aspx>. Accessed July 3, 2017.

an area with wildland fuel might be the correct course of action, and prescribed fire might play a background role in that location. Paveglio and his colleagues are testing tailored incentives for different scenarios, with the hope to develop from this work a range of options that people can choose from to address fire issues. That data will also help researchers understand why a fire-prone community selects a particular course of action. Different approaches can be taken by communities to get to the same ends of fire adaptation, for example, Community Wildfire Protection Plans, fuel reduction, evacuation planning, and land-use planning. In the end, fire-prone communities need to learn how to live with fire; that will look different in each location.

A viewer of the webcast asked how legislation like the Endangered Species Act or the Wilderness Act affects fire management. Steelman did not anticipate that there would be much appetite in the 115th Congress or in the Trump administration to revise the Endangered Species Act. The situation with greater sage grouse—which was recently a candidate for the endangered species list—will be interesting to watch because managing for species abundance has constrained management of wildfire; however, Steelman did not think the balance of policy objectives currently in place would change in the near future. With regard to the Wilderness Act, Steelman thought that there would be less funding available to protect new areas, either under the jurisdiction of the Forest Service or the U.S. Department of the Interior. Rural communities derive benefits from having federal lands like wilderness areas near them. Ownership of those lands has been contentious in some states but less so in others, which relates to Paveglio's point that effects are differentiated depending on the community. Steelman doubted that there would be pressure to turn ownership of all the federal lands back to the states simply because it would be too expensive for the states to fight fires on these lands. Therefore, whereas such pressure existed during the Reagan administration, Steelman did not think it would resurface because the states cannot afford the management costs.

Hiers noted that, for fire management at Eglin Air Force Base and several other military installations in the Southeast, the Endangered Species Act was an extremely beneficial tool for reducing wildfire risk on those properties. Fire-dependent endangered species like the red-cockaded woodpecker had large populations on U.S. Department of Defense (DOD) land. The use of prescribed fire was a win-win proposition because it reduced wildfire risk and it managed for the habitat of those endangered species; the management approach can serve as an example for similar situations on land not managed by DOD. Paveglio added that a converse example has occurred in critical greater sage grouse habitat, where the Endangered Species Act was used to protect habitat for sage grouse that was threatened by fire. The use of such a policy tool may not always lead to a fire-resilient landscape, but it directs the actions people take. Communities have some agency⁵ within the policy space to work toward an end goal however they want and to plan for that goal in ways that meet their needs.

Another participant noted that a lot of research is done on how forests and wildlands burn and on how to improve fire-management practices. However, he has heard little discussion or research about better community planning to address fire risk. What work is being done with regard to community planning, and what agency or group should be encouraging such work? Steelman offered the first response. She said Community Wildfire Protection Plans are one tool available to help communities plan for fire risk. These plans were included in the Healthy Forests Restoration Act of 2003. They are a way for the community in the

⁵In social science, *agency* is the capacity of individuals or a collective entity to act independently and to make their own free choices.

WUI to come together with the state and federal agency representatives to do comprehensive planning in that interface and prioritize areas where they would like fuel treatment as well as prioritize the values at risk that they would like protected during a large wildland fire. Having been in place for over a decade now, the benefits of those plans are starting to be seen. They demonstrate the importance of putting such types of opportunities in place at many different scales (local, regional, and national) because the desired outcomes take time to come to fruition. Another tool available is a Good Neighbor Agreement, which is a way for federal forest lands to be mechanically treated by state agencies. The state agency can conduct the environmental impact assessment and treat that area right in the WUI. The funding for this program makes it possible for treatment done on the urban side of the interface to be matched by treatment on the federal side of the property. This tandem work creates a fuel break, leading to a landscape that is more fire resilient overall.

Paveglio added that his group has conducted research in which they have taken modeling outputs and created different social vulnerability maps at the parcel level. Those maps are then matched up with some of the barriers to overcoming the last mile that Champ discussed. The result provides information about the perspectives of people in the community, how long they have lived in the area, and from whom they get their information. One of the findings of that work is that most of traditional social vulnerability indicators—both demographic and structural—were not well matched to the western communities included in their research. This mismatch shows a need to look again at how planning might be structured and how those people might set up a system in their communities to address their most important concerns. As an example with regard to values at risk, if an incident commander from out-of-state arrives at a location, he or she may be unfamiliar with the values that community may deem important. There needs to be a system or set of steps in place so that when such an incident commander arrives, the community can communicate that they, for example, want to emphasize protection of the grasslands and the forest lands that they (the community) have invested in whereas structures like an old farmhouse can be deprioritized. When this process occurs, most incident commanders prioritize the values that matter to the community as long as the associated actions do not cause any harm to firefighters. Land-use planning can be done in a similar way so that community social norms are prioritized.

Craig Allen asked what is known about public acceptance of smoke from the prescribed burning in the Southeast. Hiers said that smoke clearly is a tremendous impediment to conducting prescribed fire. For example, at Eglin Air Force Base, burning can often only occur when the wind blows to the south (toward the Gulf of Mexico) because of coastal housing developments to the base's east and west. However, rural communities in the South have grown accustomed to some chronic exposure to smoke, particularly at certain times of the year. In the Red Hills area of Georgia and Florida, the end of quail season (the beginning of March) is followed by 6 weeks of smoke. Everyone in the area knows it is a part of the season. However, the Southeast does not commonly get dense, thick plumes that settle in for days or weeks. Hiers thought communities likely prefer 6 weeks of light smoke to such intense plumes. Some recent large wildfires in the Okefenokee Swamp, particularly the fires of 2007, gave Southeast residents a western-type experience with fire, which is something the region would like to avoid repeating in the future.

Allen followed up on Hiers' answer, asking if the type of fuels burned in the Southeast contributes to the acceptance of smoke in that region. Paveglio replied that some recent work has been done on that question by Troy Hall at Oregon State University and colleagues, including the development of a photographic guide to assist smoke management (Hyde et al., 2016). Social science needs these types of tools and heuristics, which exist for biophysical science. Just as Stephens had a number of pictures in his presentation of fuel

types that can be quickly recognized, Paveglio wondered if tools and heuristics could be developed so that social conditions or the types of prescriptions for the smoke that people are willing to accept could be quickly recognized. In essence, the same kind of systematic data collection for social science is needed to turn it into usable science.

Champ added that some of her research has looked at the economic cost of wildfire smoke exposure. She has found that the social cost of a large fire can swamp suppression cost, yet much more intellectual energy is devoted to talking about suppression cost. The toolkit available in economics to measure the social costs of smoke is inadequate because the costs that people incur to avoid being exposed to smoke are not considered. Only one economics study in the United States has been done on the cost of averting behavior for wildfire smoke (Richardson et al., 2013). The issue has not received the attention it deserves from researchers. The U.S. Environmental Protection Agency is starting to explore these economic and behavioral costs and is developing an app to help the agency get a better understanding of the choices people make to avoid or not avoid smoke. That kind of information will help researchers, managers, and policymakers better understand the risk–risk tradeoffs of prescribed fire smoke, which include: when people know smoke is coming, will they leave the area, stay indoors, or choose to be exposed to the smoke?

Paveglio added that the way social impacts of fire are understood is not well developed. In general, the metrics are quantitative, such as the number of structures burned and the cost of suppression. In a 2015 paper (Paveglio et al., 2015), he and his colleagues compiled a list of all the different potential social impacts that could occur; the list was extensive and could be broken down into several categories. More thought needs to be directed at assessing the social impacts of fire on different communities, which includes smoke and health risks. A more comprehensive understanding is needed of what the benefits and the detractions are from fire events.

CONCLUDING REMARKS FROM MORNING SESSION

Dar Roberts, University of California, Santa Barbara

As the chair of the planning committee, Dar Roberts offered some summary thoughts about the morning's presentations and discussions. Clearly, a great deal has been learned about fire over the last century. However, there is still a need to improve fire management. As Chief Tidwell noted, that includes working to get more fire back on the landscape, learning to live with more smoke, and improving fire safety. The workshop also featured a great deal of information about the anthropogenic link to today's fire problem. Humans start most fires. The consequences of fire are not always negative; the challenge is to get the right fires burning in the right places so they can be used to improve ecosystem management. This balance will be increasingly important as climate change puts pressure on ecosystem resilience.

Living with smoke will continue to be a major issue. Even when fire is managed well and prescribed burning is used successfully, mitigating the smoke or getting the public to accept a certain amount of smoke is a challenge connected to fire.

With regard to Chief Tidwell's call to identify the missing science, Roberts said that one area highlighted in the presentations and discussions was the lack of knowledge about how fires spread. The largely empirical model developed by Rothermel is still the core of almost all work involving fire spread, but there are many metrics that probably could be incorporated into fire spread models. That was just one example of many areas of research identified.