PNW
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# Science
FINDINGS

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INSIDE



*"Science affects the way we think together."*
Lewis Thomas

## PRESCRIBED FIRES ARE NOT CREATED EQUAL: FIRE SEASON AND SEVERITY EFFECTS IN PONDEROSA PINE FORESTS OF THE SOUTHERN BLUE MOUNTAINS

*Changes in forest structure, such as increased tree regeneration and shifts in composition to more fire-intolerant conifers, such as the grand fir tree shown in this picture, are a few of the reasons practitioners use prescribed fire as a management tool.*

*"Silviculture is an art that should base its practices on the proven findings of many sciences. It must be practiced consistently over a long term of years. It should not be swayed by considerations of passing expediency or popular appeal."*

—T.T. Munger, First director of the PNW Research Station, 1940

In the early 1990s, foresters working on the Malheur National Forest in central Oregon started getting nervous. Black stain root disease appeared to be spreading, threatening the ponderosa pine forest. In particular, the foresters thought they saw more diseased trees in stands treated with spring-season prescribed fires, compared to those burned in the fall.

The fungus that causes black stain root disease can be a real problem for foresters. It infects and kills several species of western conifers and can cause significant losses. Infected trees wilt and can die within a few years. Managers on the Malheur needed to find out if their springtime prescribed burning program was contributing to disease spread.

Why might season matter? In the first place, ponderosa pine forests evolved with frequent late-summer and early-fall burns. In contrast, there is little historical precedent for spring fires. Could the trees be more vulnerable in the spring, when their buds are opening and the annual growth spurt is just getting underway? Perhaps pines are simply not adapted to spring fires. It is a plausible theory, and one, the foresters thought, that might extend to other plant species, such as understory grasses and forbs. Although black stain root disease is not an issue for grasses and forbs, these plants could

### IN SUMMARY

*In the mid-1990s, forest managers on the Malheur National Forest were concerned about their prescribed fire program. Although they have only a few weeks of acceptable conditions available in the spring and fall, they were worried that spring-season prescribed burning might be exacerbating black stain root disease and having negative effects on understory plants.*

*Working closely with forest managers, PNW Research Station scientists designed an experiment tailored to the problem. Prescribed fires were set in the fall and spring. The stands were then monitored for several years to determine the response of understory plants, black stain root disease development, and ponderosa pine tree mortality. Although more trees died in fires set in the fall, the season of burn did not really matter. What did matter was the severity of fire and the amount of damage to the trees. There was also no evidence that burn season influenced the understory native perennial (long-lived) grasses and forbs. However, exotic and native short-lived species were more abundant in the areas burned in the fall. As with tree mortality patterns, fire severity is probably driving this pattern. Short-lived native plants showed postfire invasion and spread patterns similar to exotics, but exotics were more abundant than natives.*

be more vulnerable to burning in the spring when they are actively growing.

The managers had legitimate concerns but they didn't want to give up on spring burning. There is only a short window in the spring and the fall when prescribed fires can safely be used. Most of the year, it is either too wet to carry fire or so dry that fire is difficult to control. If spring burning were eliminated, then fire managers would be left with only a few weeks in the fall. Given the thousands of acres needing to be burned, cutting the available days in half would effectively double the challenge.

"They had interesting questions stemming from their observations. In response, several of us in the research branch designed a program of study tailored to their questions," says Walt Thies, a research plant pathologist at the PNW Research Station in Corvallis, Oregon. What resulted was synergy between the managers on the Malheur National Forest and researchers in the Station.

*In this area burned in fall 1997 (photo taken in 2002), tree mortality was higher, creating a large gap in the canopy. These areas can quickly be invaded by invasive exotic species such as the bull thistle and cheatgrass shown.*

*Not all postfire canopy gaps were dominated by exotic invasive species. This area was carpeted with a native annual* Epilobium *species. Whether an area will be dominated by exotics vs. natives after prescribed fires depends on complex interactions among site conditions, seed sources, disturbance intensity (e.g., fire severity), and operational conditions.*

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## KEY FINDINGS

- Prescribed fires conducted in fall were more severe and more ponderosa pine trees died after fall burns than after spring burns. But predictive models showed that fire severity and tree damage were more important predictors than season of burn.
- Although black stain root disease was present in some trees, there was no evidence that burn season influenced mortality of these infected trees.
- There was no difference in abundance or diversity of native perennial grasses and forbs 5 years after the fires. But areas burned in fall had greater cover of short-lived plants compared to spring and unburned areas. Although both exotic and native short-lived species showed similar postfire invasion and spread patterns, exotics such as cheatgrass and bull thistle were much more abundant than natives.
- Indirect localized fire effects, associated with fire behavior and intensity, were important for explaining tree mortality and understory vegetation patterns. However, decoupling seasonal and environmental fire effects is difficult because burn season greatly influences fire behavior owing to weather and fuel conditions.

## *Purpose of PNW Science Findings*

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

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## FIGHTING FIRE WITH FIRE

Prescribed burning is a valuable tool for land managers in fire-prone ecosystems. For thousands of years, ponderosa pine forests, like those on the Malheur, burned frequently, every 2 to 10 years. Fires were frequent enough that fuel accumulation was limited and fires rarely killed the bigger trees. It is not surprising that forests began to change when Euro-Americans began settling the West. Fires were either excluded or actively suppressed starting in the 1920s and 1930s. Although it seemed like a logical approach at the time—after all, fire burns up the forage needed by livestock and kills the next generation of trees—over the long term, fire exclusion and suppression has threatened the health of many forests.

*Some areas with heavier fuel loads will burn up into the tree crowns and this tree may not survive.*

"The idea that ecosystems benefit from the reintroduction of historic processes, like fire, is a central tenet of ecological restoration," says Becky Kerns, a research ecologist who specializes in understory plant communities and works in the Corvallis PNW lab. "Reintroducing fire into dry Western forests is considered key for a variety of management objectives."

The chief objective is often fuel reduction. Prescribed fires reduce fuel loads that, if left to accumulate, may result in severe, stand-replacing fires. Burning also thins out young trees, which compete with larger trees for water and nutrients. Potentially important is that prescribed fires may also promote reproduction of understory plants. Virtually all of the plant biodiversity in these forests exists in the understory; these plant communities regulate conifer regeneration, soil retention, nutrient cycling, and provide critical wildlife habitat.

The benefits of burning are complicated by all the other changes that have occurred during the past century. Live and dead vegetation have accumulated—meaning there is now a large amount of fuel to stoke the fire. In addition, fire suppression has rearranged some plant communities, and many native species now have tenuous populations with few seed stores left in the soil. And, to make matters even worse, there is now the threat of exotic species, which regularly out-compete desirable, native species.

In the mid-1990s, Thies and Chris Niwa worked with the Malheur National Forest to lay out a replicated study design. Niwa is a research entomologist with the PNW Research Station in Corvallis, Oregon. "We decided on six stands, all larger than 100 acres, that were relatively homogenous in terms of tree composition and density," they explain. "Each stand was divided into thirds and randomly assigned treatments: spring burn, fall burn, or no burn."

Right on schedule, foresters on the Malheur conducted the burns on the appropriate units. "They took care of all the logistics and the prescribed burning. Not once did they stray from the design," notes Thies.

The fires were ignited in strips with drip-torches (think flaming napalm in a tea pot), then allowed to burn. Depending on the available fuel, they periodically flared up and went out. What was left behind was a mosaic of burned and unburned patches. Overall, the fires blackened about 56 percent of the ground.

## TAKING THE PULSE OF SCORCHED TREES

At first, it looked to Thies and Niwa like the managers might be on to something. Many of the spring-burned stands did have disease symptoms. But, after taking a closer look at the data, they determined that there was no difference in black stain root disease abundance between spring and fall burned plots. It seems that at least some of the manager's fears regarding spring burning were eased. In fact, significantly more trees died—from burning, not disease—after the fall burns when compared to the spring.

But, is it really that simple? Is tree mortality really a greater risk during the fall? Maybe not. It is also true that the fall burns were more severe. In this regard, the findings about season of burn are nuanced and require a deeper understanding.

After monitoring tree mortality for several years, Thies found that by using two simple features of a fire damaged tree—the percentage of crown-scorch and height of scorch on the trunk—he can quickly estimate the probability of survival. The probability of mortality is only affected by the amount of tree damage: it does not depend on the season of burn.

Thies shed some light on the season of burn question and created a set of equations that can estimate the likelihood of tree mortality. "This is a simple tool that foresters can take into a burn and quickly estimate the probability of survival for individual trees. It should be a great help when evaluating if the objectives of a prescribed burn were met, or when planning the postfire management strategy after a wildfire," says Thies.

*Prescribed fire intensities are controlled, in part, by how close together the lines of ignitions are set.*

Thies is in the process of validating these predictions by examining additional stands on the Malheur and other National Forests.

Thies also kept records of "lion's tails" as he monitored tree mortality over several years. Some foresters have associated black stain root disease in ponderosa pine with a symptom referred to as a "lion's tail," which is a stunted branch, bare until the very tip, where a bunch of needles splay out looking rather like—you guessed it—a lion's tail. Thies found no relationship between the disease and the lion's tail pattern. "The reliability of using the lion's tail as an indicator for black stain root diseases is questionable," says Thies.

## LAND MANAGEMENT IMPLICATIONS

- A predictive tool was developed that uses easy-to-measure features—such as the percentage of crown scorch and height of scorch on the trunk—that can assist managers in determining which trees might be likely to die as a result of prescribed burns in areas similar to our study area. Predictive tools were also developed for different understory plant life-form groups.
- Expectations for increased native plant diversity and abundance following prescribed burns, especially for perennial native forbs and grasses, may not necessarily be met.
- Prescribed fires can introduce or spread exotic and noxious weed species into forest ecosystems. Areas burned by prescribed fires may be more vulnerable to such invasions compared to large wildfires because small burns can be well positioned for exotic species invasion and spread.

## AN EXOTIC PROBLEM

Kerns joined the research team in 2002 to measure understory plant response to the burns. Exotic invasive plant species were a special concern. Cheatgrass and bull thistle are two aggressive exotics on the Malheur. Both plants originate from Europe. They are short lived, can be fierce competitors for water and nutrients, and have been a scourge to land managers for several decades. Cheatgrass, in particular, has become ubiquitous throughout the West. Both species are aggressive colonizers after disturbances, such as fire or grazing.

On a more positive note, "Although these exotics are spreading into many ponderosa pine forests, there are still areas that are not heavily invaded. Proactive land management, such as native seeding or weed control, may yet prevent their expansion. Other species like dalmation toadflax, Canada thistle, and knapweed are just showing up in this ecosystem, and we still have a chance to ward them off," says Kerns.

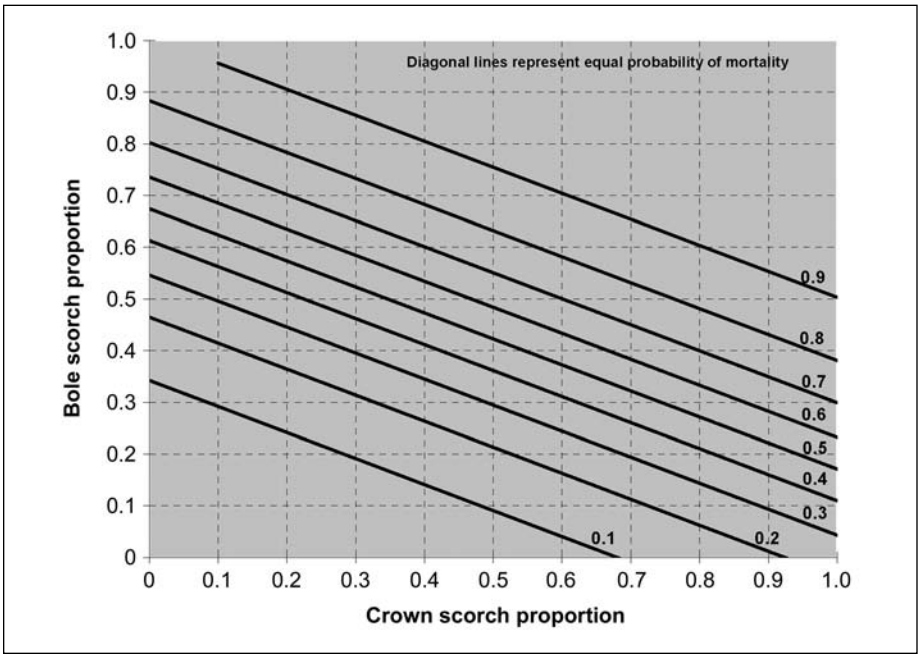
These exotics are all aggressive colonizers, and this has put foresters working in ponderosa pine in a bind. They must address the fuels problem, or face potentially huge and severe wildfires. But, by using fuel reduction treatments and prescribed fires, they open themselves to a host of exotic species. This potentially no-win situation emphasizes the importance of research into the timing and severity of prescribed fires on understory plant response.

Kerns evaluated the composition and abundance of understory plants five growing seasons after the burns on the Malheur. "Although both exotic and native short-lived species showed similar postfire invasion and spread patterns, exotics such as cheatgrass and bull thistle were much more abundant postfire than natives, suggesting that the exotics were more successful at capturing resources for growth in these areas after fires," she says.

Although it is true that there were more exotics in the fall-burn sites compared to the spring-burn sites, it is also true that the fall burns were more severe. Just like their findings about tree mortality, interpreting season of burn is not so simple.

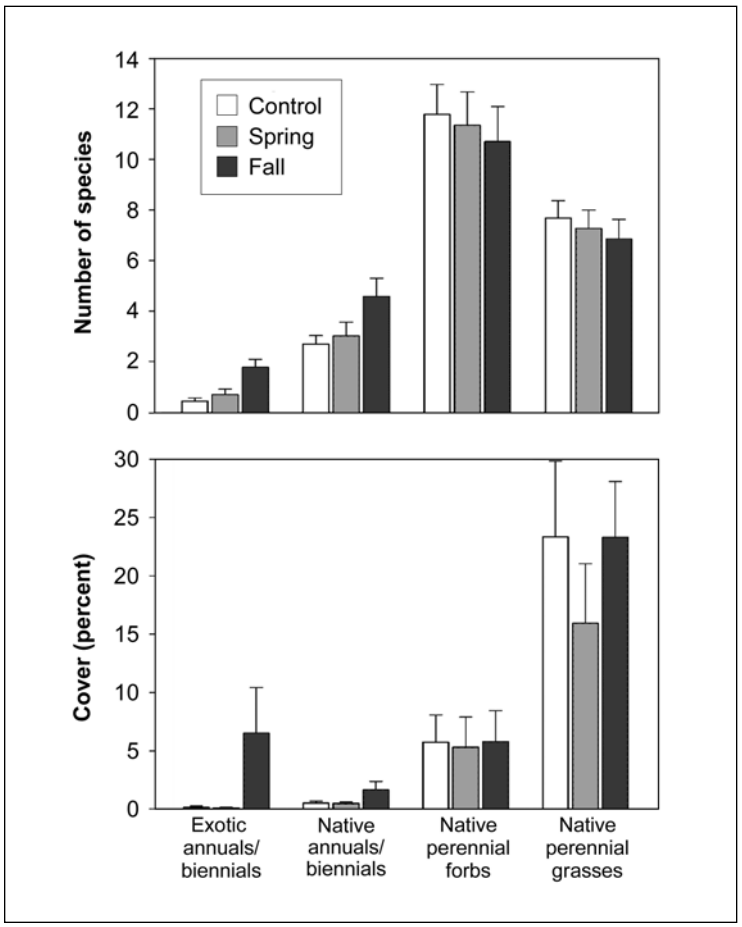
From the manager's perspective, there was good and bad news related to Kerns' findings: Areas where prescribed burns were more severe had more exotics, irrespective of the season of burn. But spring burning did not reduce the abundance or diversity of native perennial (longer lived) plant species. In fact, there was no difference in the abundance of native perennials 5 years after the fires. But there was also no evidence that the fires stimulated the native plant community.

"Expectations for increased native plant diversity and abundance following prescribed burns, especially for perennial native forbs and grasses, may not necessarily have been met," says Kerns.




*This chart can be used to estimate the probability of survival for fire-damaged trees. To use it, measure both the bole and crown scorch proportions from the ponderosa pine of interest. Find the corresponding bole scorch proportion on the left vertical axis then move horizontally to the right finding the corresponding crown scorch proportion. Then interpret the probability of mortality from the diagonal lines of equal mortality probability. As an example, assume a pine with 0.40 bole scorch proportion and 0.80 crown scorch proportion. The corresponding probability of mortality will be 0.7.*

*Small microplots (1 by 1 meter) are used to visually estimate plant cover. The grid pattern can increase the accuracy of these measurements.*




*Areas burned in the fall had greater abundance and richness of short-lived plants compared to spring and unburned areas. These species were associated with gaps in the tree canopy and higher fire severity areas, conditions more common to fall burns.*

## NOT SO SIMPLE: SEASON OR SEVERITY?

Kerns, Thies, and Niwa all stress that when we consider the effect of burning season on tree mortality and understory vegetation, we need to separate the effects of fire behavior associated with season (it may simply be hotter and drier in some seasons) from the direct effects related to burn timing and plant growth status (plant physiology differs by season).

Although there were differences between the fall and spring burns, it is hard to tell if season or severity was the primary driver. If the spring fire had been more severe, would the differences remain?

"An important factor controlling the understory response was the severity of the fire. In our case, the fall burns were more severe: the fuels were drier, there was more litter consumption, and more tree scorch. This led to more exposed soil and, thus, more available habitat for both exotic and native understory plants," explains Kerns. The same type of phenomenon seemed to be happening with regard to tree mortality. It is severity expressed through greater tree damage, not the season of burn, that is the primary driver.

With questions remaining, the research isn't done yet. Working with the Malheur National Forest, they reburned half of each of the units burned earlier to address questions related to the frequency of burns. Kerns added a cattle grazing component to examine how cows influence fuels and understory. Stay tuned for more findings from the next round of this unprecedented fire study.

*"Conservation is the application of common sense to the common problems for the common good."*

—Gifford Pinchot, founder of the USDA Forest Service

## FOR FURTHER READING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WALT THIES has been a research plant pathologist at the Station since 1975. He received his B.S. in forest management from the University of Missouri at Columbia and his Ph.D. in plant pathology at the University of Wisconsin at Madison studying root diseases in forest tree nurseries. He began his Forest Service career in the former Timber Management Division of the Pacific Northwest Region. His work at the Station is focused on developing management strategies for laminated root rot and other root diseases of western conifers.

CHRIS NIWA is a research entomologist at the PNW Research Station. She received an A.B. in physical anthropology from the University of California at Berkeley, M.S. in forest resources from the University of Idaho, and a Ph.D. in entomology from Oregon State University. Her research has included the use of semiochemicals for monitoring and control of native and exotic forest insects, management of cone, seed, and regeneration pests, biological diversity of soil and litter arthropod communities, and the interaction of wildland fire and bole infesting beetles.

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