PNW
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Science FINDINGS

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

WHEN THE FOREST BURNS: MAKING SENSE OF FIRE HISTORY WEST OF THE CASCADES

Peter Weisberg examines the total age and fire scar dates in a stump in the Oregon Cascade Range study site.

Using a hand lens, Fred Swanson counts compressed tree rings, in a 650-year-old stump at the same site.

IN SUMMARY

It is widely accepted that wildfire has been part of the Douglas-fir region for millennia, but the variations across space and time in frequency, severity, pattern, and influence of native people are poorly understood. With wildfire raging every summer across parts of the West, interest is growing in the roles of fire in ecosystems, the possible use of fire and fuels management, and the use of fire history in landscape management.

This Science Finding synthesizes the results of several tree-ring-based fire history studies carried out independently over the past two decades in a north-south transect along the Cascade Range and an east-west transect across the Oregon Coast and Cascade Ranges.

The work has involved cooperation among forest ecologists, climatologists, and geomorphologists to consider interactions of geophysical and biotic phenomena. Revealing the importance of fire and other disturbance agents in native forests of the region underpins the notion that absence of disturbance, including suppression of both fires and cutting, will create unnatural, and in some cases hazardous, forest conditions.

In short, forest disturbance is compatible with objectives of protecting ecosystems. But the questions are, how much disturbance, and of what types? History has some suggestions.

"Viewed from the vantage point of a different century, we might think of the extent and character of old-growth forests—or forests at any stage of growth—somewhat differently."

Fred Swanson

The fires that attack the West each summer seem overwhelming, frightening. Every few years they are declared the worst in history. Policies regularly get reevaluated around them. But viewed from a truly historical perspective, they're just details. Fire history details.

Researchers like the idea that we can glean useful lessons from the hundreds of thousands of acres burned hundreds and even thousands of years ago. What are the discernible patterns of fire occurrence, they ask, and what do they suggest about managing resources and landscapes today? About fire in the landscape tomorrow?

Some storylines are emerging, but they remain frustratingly fuzzy, intriguingly complex. Plot development is unclear. Human characters get mixed in with climate change scenarios, landscapes evolve relentlessly, and the fire stories lead in multiple directions.

"Fire history of the Oregon Cascades reveals a consistently sloppy and complex disturbance regime, ranging from zero tree-kill to total tree-kill, from a few acres singed to thousands burned to a crisp," says Fred Swanson, a geologist with the PNW Research Station. "Science tries to simplify the relationships down to a few controlling factors. Instead, we need to develop ways of appreciating how complexity itself plays a role in forest development, in landscape dynamics, in sustaining native species, and thus in management approaches we propose."

Historical disturbance regimes are recognized as integral components of native Douglas-fir forest ecosystems, and forest disturbance is now widely seen as being compatible with objectives of protecting ecosystems. Thus, understanding fire is important to understanding the risk to human life and property (as we recently saw in the fires across the West); basic ecosystem processes of the local environment; planning fuels management and coarse-filter habitat approaches to species protection.

"More specifically, if we try to remove disturbance by suppressing fire and eliminating cutting, we will be left with very unnatural forest conditions, which may make it ever more difficult to achieve conservation goals," says Swanson. Swanson and colleagues have recently completed analysis of a dozen fire history studies designed to wrestle some wisdom out of the trails and clues left by centuries of fire in western Oregon and Washington.

KEY FINDINGS

- Geographic patterns of historical fire disturbance exhibit both systematic properties and high variability. Local topography and vegetation types create some patterning of frequency and severity, but statistical relations are weak, suggesting high complexity.
- The AD 1500s and 1800s were periods of extensive fire and the 1600s, 1700s, and 1900s experienced less extensive fire. This probably represents climate signals in the 1500s and early 1800s, and actions of European settlers to increase fire in the late 1800s and suppress it in the 1900s.
- The extent and successional properties of contemporary old-growth forests are in part a result of a history of variation in climate and fire occurrence, especially the fires of the 1500s.

METHODS USED TO TRACK FIRE HISTORY

Fire history studies rely upon a number of methods to build their pictures of the past. The following are the most commonly used:

WRITTEN RECORDS. In the Pacific Northwest, records of fire ignition, fire suppression, and related forest conditions go back about 150 years, well before the Forest Service was established. Fire was then seen as a major destroyer of a valuable resource, a belief that played a central role in the beginning of the Agency.

TREE-RING RECONSTRUCTIONS OR DENDROCHRONOLOGY. When the cambium layer under the bark of a tree is heated and killed by fire, a lesion remains evident in the tree rings. Fires represented by the lesions can be dated by counting the tree rings and crossdating. Crossdating reveals wet and dry years that can be correlated with fire activity because tree rings are closer together because of slower growth during a drought. If trees across a large area show the same date of fire scar, the large size of the fire can be inferred. Likewise, tree rings reveal the fire return interval, or frequency of fires in an area. With European settlement grazing reduced fuels and fire suppression was widespread, and fire frequencies decreased at low and middle elevations, and fire return intervals increased across many landscapes.

CHARCOAL IN SEDIMENT. Fire leaves behind a clear record of charcoal and ash which can be discovered through sampling of soil and sediment and subsequent dating of the adjacent plant material. Charcoal deposits preserved in bogs or lakes can track fire dates back more than 40,000 years.

POLLEN AND FOSSIL RECORDS. Data on the presence of plant species in the past can be calibrated with fire history to suggest broad-scale landcover changes that affect and are affected by fire regimes.

Purpose of PNW Science Findings

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

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Sherri Richardson Dodge, Editor
srichardsondodge@fs.fed.us

Send new subscriptions and change of address information to
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Carlyn Mitas, Design & layout
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THE WELL-KNOWN NORTHWEST VANDAL

Wildfire has been a predominant agent of disturbance in Pacific Northwest forests; indeed, much of the world's forested area is witness to fire as a significant driver of change. The frequency and severity of fire has historically influenced every facet of forest dynamics: structure and composition, species dominance and distribution, wildlife habitat, watershed processes such as landslides, ecosystem processes such as nitrogen fixation and nutrient cycling, aquatic ecosystems, and carbon dynamics.

Stories that began centuries and even millennia ago come to us through exploration techniques, and seem relevant to our region's future. Archaeology, pollen and charcoal in ponds, tree rings, and archives all contribute to reconstructing forest and fire history

What is known about fire history in the Pacific Northwest, west of the Cascade crest, is that fire frequency and severity respond to such environmental variables as temperature, moisture, ignitions, and fire-driving winds across broad regional gradients. In the broadest sense, fire regimes run from no fire in over 6,000 years in the wettest coastal sites of British Columbia, to 10- to 15-year recurrence intervals in the Ponderosa pine types. Severity runs from stand replacement to quiet underburn; fire extent from very small fire patches to very extensive footprints across the landscape.

LAND MANAGEMENT IMPLICATIONS

- The complexity of influences of local landforms on fire regimes suggests that simple rules for forest management, such as fixed-width stream buffers, create quite unnatural landscape patterns, with potentially undesirable consequences.
- Historical fire regimes varied over time, so no single regime serves as a reference condition against which to measure effects of forest management systems.
- Discernible patterns in wildfire occurrence and behavior over space and time do exhibit some properties useful in designing coarse-filter approaches to species protection in areas of active management.
- Broad-scale synthesis suggests it is important to tailor interpretations of fire history to individual sites and not simply transfer an interpretation from one area to another, even between nearby sites.

Individual fire study sites have been selected over the years for a range of reasons. For example, fire studies at Blue River, Bear-Marten Creeks, Augusta Creek, and Little River in Oregon were originally selected to support landscape management planning efforts. Others were chosen to fill in transects along broad environmental gradients, running north-south along the Cascades, and east-west from the studies in the Cascade crest to the coast. Individual sites can have value in themselves, such as determining landscape history to understand ecological or watershed processes like erosion. Science learning and management planning both benefit from site-level studies.

The fire history studies recently completed span this range of objectives. Swanson describes the synthesis studies as somewhat opportunistic in design, capitalizing on the collective value of individual studies.

"There is not an overarching design to the recent studies, and a lot more needs to be done to flesh out the stories," he says. "But they do give some interesting clues as to past events at various scales, some guidance for future studies to test resulting hypotheses, and historical perspective on the issues we confront today."

SEEKING PATTERNS BY SYNTHESIS

First of all, and perhaps most importantly, the statistical relationships—the patterns of landform controls on historical fire regimes—are weak across landscapes. Broad geographic patterns of historical fire exhibit both systematic properties and high variability, Swanson notes. Fires in the dryer, warmer areas such as the Willamette Valley foothills and the southern Oregon Cascades tended to be more frequent, of lower severity, and smaller than in the central Coast Range and more northerly Cascades, for example. The weak relation to local topographic pattern suggests high complexity.

Across time, there are some patterns not widely recognized previously. "In the 10 study areas examined in one synthesis, the 1500s and 1800s were periods of extensive fire, and the 1600s, 1700s, and 1900s experienced less extensive fire," Swanson says. An 8-study synthesis found similar patterns, with slightly different details. "We believe that the shifts before 1800 represent climate signals, and effects in the latter part of the 1800s show the further effects of European settlers moving in. The effects of fire suppression, despite increased ignitions caused by more people in the woods, show up in the 1900s as reduced fire extent."

However, the high degree of variability reveals the importance of tailoring interpretations of fire history to individual sites and not simply transferring an interpretation from one area to another, even between nearby sites. "Are individual study sites operating independently, or is there a regional pulse to fire occurrence that tracks climate?" Swanson asks.

WRITER'S PROFILE

Sally Duncan is an independent science communications consultant and writer specializing in natural resource issues. She is currently a candidate for a Ph.D. in environmental sciences at Oregon State University in Corvallis, Oregon.

The challenge is, changing fire patterns through time could be a result of climate variability, changing anthropogenic influences, long-term patterns of fuel accumulation related to disturbance and stand development, or complex combinations of these influences. Swanson notes that interactions among the three factors may confound interpretation of the importance of any one factor, and hence the researchers' wish for further studies.

"It is difficult to separate anthropogenic, climatic, and stand development influences on the observed temporal patterns of the regional fire regime, as they have varied at nearly the same times," he says. "All have probably played roles."

Climate change research is helping researchers recognize that decadal patterns, periodic oscillations, and changes separated by centuries appear to be routine occurrences around the planet (see Science Findings, issue 44). Thus it is entirely feasible that the greater occurrence of fires during the 1500s indeed reflected a drier and possibly hotter period than the several centuries following, which are often dubbed the Little Ice Age. Tree-ring analyses of climate history could sharpen interpretation of the climate-fire link.

Questions arise, then, about the importance of climate change in shaping our forests. How apt are our current depictions of climatic and geographic gradients? Why might species, communities, and forest types be distributed the way they are across landscapes and through time? Is climate change larger than life right in front of us, in the guise of forests and habitat dynamics and species extinction, and we just haven't seen it clearly?

CHANGING THE VIEWPOINT ON FIRE

What emerges from the two recent syntheses is a crude regional synchrony—a possible set of patterns—in historical fire behavior. The patterns undermine several sets of entrenched ideas that have ruled the fire history world for some time.

It has long been believed that major fire events occurred about 450 and 125 years ago, because informal tree ring studies and general stand-age patterns found these age classes widespread. Further, some folks live with the notion of perpetual ancient forests, interrupted only in minor ways from time to time. Many still believe that Native Americans lived in a pristine wilderness, which was only peripherally changed at any scale by their burning practices. Others assert that native people set fires with widespread effect, greatly limiting the extent of old-growth forest.

"We need to get away from these kinds of dogmatic views, and towards some more rigorous analysis," says Swanson. "For example, it is becoming clearer that the effects of Native Americans on their environment varies enormously depending on location. Large, interior valleys like the Willamette were possibly quite heavily affected by intentional burning, more than remote areas where there were fewer attractive resources and snowy winters, therefore less human activity. In addition, the so-called 'pristine wilderness' to which new European settlers came was seen through the narrow lenses of where they came from."

What we do know about Native Americans is that they lived spread wide across the land west of the Cascades, they did burn land to manage resources, and their practices were unevenly distributed.

"In the western U.S., our understanding of the role of native people has switched from being founded on a notion of dwellers in a pristine environment, to a hotly debated issue including interpretations of thoroughly humanized landscapes through use of fire and other means," Swanson says. "Some of our sites appear to have had little influence by Native occupants, and others probably had a great deal." Key among further research needs is rigorous analysis of the geography of human use of the landscape.

Although the latter part of the most recent period of regional widespread fire is associated with warmer, drier climate beginning around 1840, Swanson points out that dramatic changes in human influences on forest patterns and fire regimes were also underway at this time. European settlers were moving rapidly west, in great numbers, in some cases preceded by disease that decimated the native populations. Native American influence was undoubtedly receding, but travel, settlement, forest clearing methods, and sheep herding practices were all on their way, and probably would have left their notable marks on the environment, with or without climate effects.

"It looks like climatic factors may have been important in initiating the 19th century period of widespread fire, but that changing human influences intensified it," Swanson notes.

MAPPING EFFECTS OF SUPPRESSION

Most of the study sites have shown limited fire occurrence since 1925, coinciding with warm, dry conditions, and the onset of fire suppression activities. The results do suggest a relatively ineffective period of suppression in the early part of the century, but a dramatic reduction in widespread fire starts in about 1950. This trend corresponds directly with the development of forest road systems and more effective fire finding and fire-fighting technology, Swanson explains.

Despite suppression activities, the rate of ignitions since the beginning of the 20th century appears to have gone up. A study completed in 1979-documented suppression efforts on 816 lightning-caused fires, and 621 human-caused fires between 1910 and 1977 in the central Oregon Cascade Range, indicating a 75 percent increase in ignitions of fires due to human influence.

However, Swanson notes that suppression has been widely successful during this period, despite warmer temperatures. There also is the possibility that suppression success during this period has been influenced in part by patterns of fuel accumulation through time. The extensive fires experienced in the study landscapes during early Euro-American settlement may have placed these areas into a period of "fuel recovery," thus reducing potential for widespread, severe fire.

Everything, in the end, is complicated by everything else, and that's why Swanson wants to pursue a direction in which complexity itself is recognized as the over-arching driver. Variable fire frequency, severity, and spatial pattern may create refuge for many species over long periods of time. Old-growth attributes may be sustained through numerous fires of low to moderate severity. The implications for forest planning are intriguing.

We are, like early European settlers, victims of our current mental images of the landscape, particularly old growth, Swanson believes. “While we have an emerging understanding of the full spectrum of successional development of forests leading to old-growth states, mental images of old growth are strongly conditioned by the particular, predominant age-class dating from extensive fires 400 to 500 years ago,” he explains. “Over certain intervals in the past, particular seral stages of forest may have been either widespread across the region, or rather scarce.” Our ideas of old-growth forest, in other words, could be strongly skewed in both age and geographic distribution. Drop in on the landscape in, say 1600, suggests Swanson, and you might see extensive areas of stands burned in the previous century. Some of these stands would have scattered, surviving old-growth trees. Stop by again in 1800 and you’d see widespread stands in early stages of old-growth development.

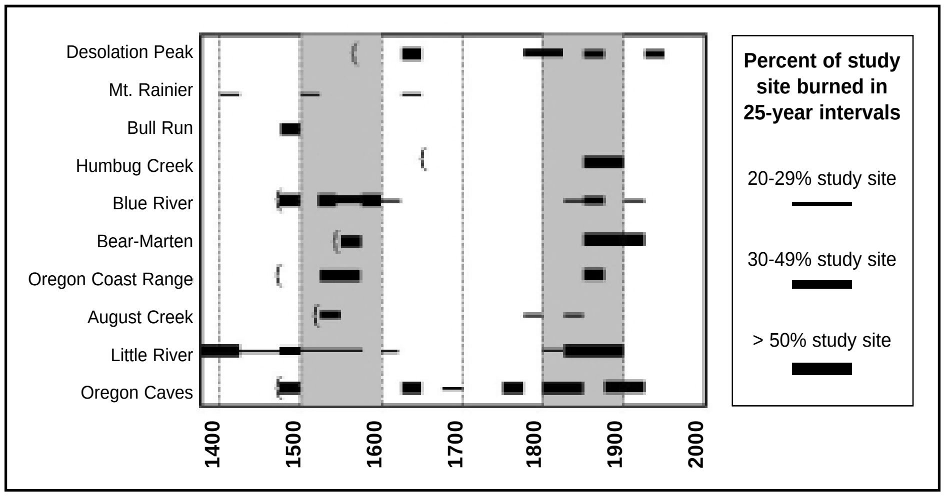
PLANNING AROUND FIRES

How to tackle landscape planning while recognizing the historic role of fire? One approach is to establish the historical range of variability (HRV) in landscape conditions, such as extent and pattern of different age classes. This method seeks to maintain landscape patterns and ecological processes within that range as a kind of “coarse-filter approach” to landscape management based on what is known of past patterns. The idea is to develop a plan providing structure, composition and habitat elements that were sufficient in the past to sustain native species and ecological processes.

So what does the emerging picture of fire history of Oregon and Washington west of the Cascades suggest about landscape-scale plans such as the Northwest Forest Plan? What of the fact that the Plan does not take climate change into account, for example, or the fact that it mandates buffers of certain sizes consistently across the whole landscape at the same time?

Historical variability of ecosystem conditions was high and therefore probably important. Understanding of that variability can be incorporated in real landscape management plans and tested through adaptive management. The Willamette National Forest and researchers are doing that with the Blue River Landscape Plan and Study. (See Science Findings 18.)

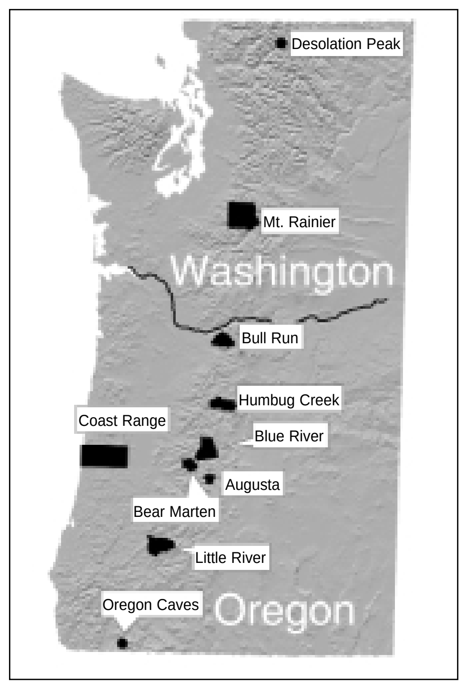
“The complexity of influences on fire regimes, and the complexity of their influence on the landscape, suggests that simple rules for forest management, such as fixed-width stream buffers, and single fixed harvest intervals, create quite unnatural landscape patterns,” Swanson observes. “Because historical fire regimes varied so greatly over time, no single regime serves as a reference condition against which to measure effects of forest management conditions. It is important to learn more about incorporating more variability in our management approaches.”



Time lines for 10 fire history study sites arranged from north to south down the page. Horizontal bars show extent of study area burned in 25-year intervals. Absence of a bar means that less than 20 percent of the study area burned in the 25-year period. The 1500s and 1800s, centuries of extensive fire, are shaded. Brackets show when adequate burn-estimate records started.

Any given summer, the notion of letting the landscape behave in a “natural” manner becomes fraught by the searing images of burned landscapes and homes, too often of loss of human lives. Added to the very complexity brought to the table by fires and their historical behavior, is the effect of human habitation, particularly the increasing encroachment of development into forested areas.

“So far we have exploratory stories only, enough to show us where the data holes are, and to begin more rigorous analysis and more informed debate,” Swanson says. “Our archetypes of what represents mature forest, of what represents relevant fire history—is the last 500 years enough to judge by? —are heavily influenced by the narrowness of our viewpoint. The effort to reconstruct the puzzle is only just begun.”



One fire history study used two transects from existing study sites in the western Cascade Range of Oregon and Washington. One transect runs north-south through both states; the other east-west across the Oregon Coast Range.

Science
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Pacific Northwest Research Station
333 S.W. First Avenue
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FOR FURTHER READING

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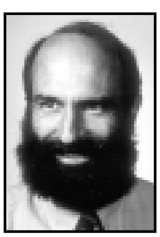
SCIENTIST PROFILE



FRED SWANSON, a research geologist with the USDA Forest Service, PNW Research Station, has been studying landslides, fire, and other disturbance processes in western Oregon for more than 30 years. Swanson is a leader of the National Science Foundation-sponsored Long-Term Ecological Research Program at the H.J. Andrews Experimental Forest. He is a leader of the Cascade Center of Ecosystem Management, a research-management partnership involving Forest Service Research, the Willamette National Forest, and Oregon State University.

Swanson can be reached at:
Pacific Northwest Research Station / USDA Forest Service
3200 SW Jefferson Way
Corvallis, OR 97331
Phone: (541) 750-7355
E-mail: fswanson@fs.fed.us

COLLABORATORS

Cathy Whitlock, University of Oregon
Patrick Bartlein, University of Oregon
John Cissel, Willamette National Forest, USDA Forest Service
Julia Jones, Oregon State University
Peter Weisberg, Swiss Federal Technological Institute