Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS

Willamette Valley in Oregon and Washington. Credit: Jane Kertis.

Tracing the History of Fire in the Willamette Valley

Summary

The Willamette Valley in northwestern Oregon and southwestern Washington is a fertile agricultural region that supports a variety of farming activities. It is also a densely populated region with extensive urban and suburban development, including residences in the wildland/urban interface. Over the millennia, the valley floor has been shaped by numerous forces, including flooding of the Columbia and Willamette rivers, naturally and human-ignited fires, Euro-American forest clearance, and most recently, agriculture. Over the past 18,000 years the regional climate has undergone major changes. From the big chill of the last great Ice Age, to a period of warming that reached a maximum in the early and middle Holocene (9,000–4,000 years ago), to the colder conditions of the late Holocene (4,000 years ago to present), including the Little Ice Age (1450–1850 AD). As a result, the vegetation of the valley has changed from a subalpine parkland, to a closed conifer-dominated forest, to the open, oak savanna and prairie habitat that greeted early settlers. Today, however, only remnant patches of the pre-settlement vegetation remain, including oak savanna. The indigenous people inhabiting the Willamette Valley are also assumed to have changed during this time, from hunter/gatherers at the end of the Ice Age to more sedentary groups in the late Holocene who used fire to maintain supplies of nuts, berries, and tubers. Many researchers believe that humans used fire to manipulate their environment with increasing frequency during the Holocene, but the extent of their burning and the ecological consequences are a matter of debate. Were past vegetation changes caused by deliberate burning, climate fluctuations, or a combination of both? Studies of fire and vegetation history using the pollen and charcoal found in lake sediments from sites in the valley indicate the answer is not simple.

Key Findings

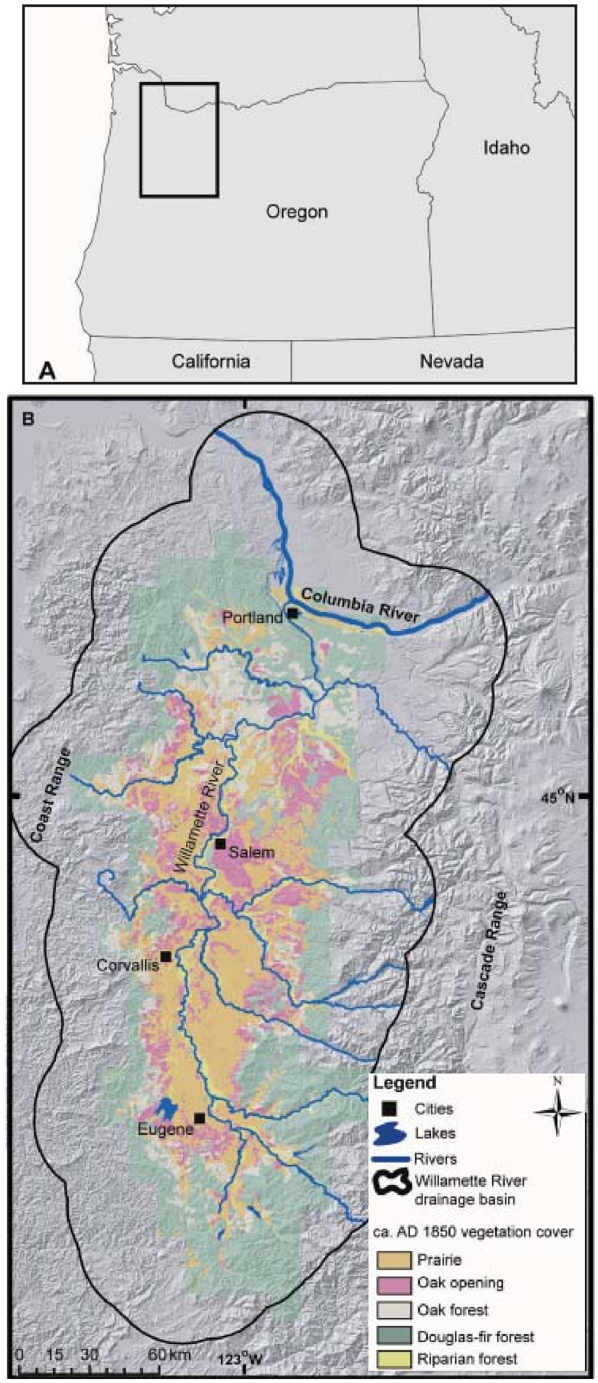
- Analysis of sediment cores from lakes in the Willamette Valley tells a complicated story of fire history in the Willamette Valley for the past 11,000 years.
- Significant climate changes, such as warming in the early and middle Holocene and cooling during the late Holocene, particularly in the Little Ice Age, contributed to changes in the frequency of fire and type of vegetation.
- Human activity has contributed to the fire history of the valley, but perhaps to a lesser degree than previously believed.

Introduction

The landscape that early explorers encountered in the Willamette Valley in the early 19th century bears little resemblance to the landscape today. In 1841, George F. Emmons, a surveyor with the United States Exploring Expedition, described the scene looking down into the valley from the adjacent foothills: "From the top of these [hills] at an altitude of about 1,000 feet—had a panoramic view…prairie to the south as far as the view extends—the streams being easily traced by a border of trees that grew up on either bank…white oak scattered about in all directions." Early surveys carried out by the General Land Office around 1850 confirm that the valley was a mosaic of vegetation types. The relatively flat valley floor was covered by Oregon white oak-dominated savanna and wet and dry prairie, wide strips of riparian forest grew along riverbanks, and the forests of the Cascade and Coastal Range foothills ranged from open oak woodland to closed, conifer-dominated forest of Douglas-fir, western hemlock, western red cedar, and Sitka spruce.

Early accounts of Native American activity suggest that frequent, large fires were used to manipulate the environment, enhance the growth of food resources, facilitate travel and hunting, and maintain the openness of the vegetation. Researchers reconstructing the history of fire, climate, and vegetation change in the Willamette Valley, however, are not so sure. "It has been assumed for a long time that the only way to create and maintain oak savanna and prairie ecosystems was if people steadily burned them," says Cathy Whitlock, a professor of Earth Sciences at Montana State University.

Whitlock and colleagues are challenging that assumption by examining pollen and charcoal contained in lake sediments dating back to the last glaciation, and tree-ring records of the last few hundred years. From these records, the team has tried to determine whether past changes in fire regime were predominantly caused by shifts in human activity, or whether instead they were driven by climate change. Although this study, supported by the Joint Fire Science Program, does not resolve the controversy, it does paint a more complex history of fire and vegetation in the Willamette Valley than conventional wisdom would suggest. "The idea that Native Americans burned from one end of the valley to the other is not supported by our data," says Whitlock. "Most fires seem to have been fairly localized, and broad changes in fire activity seem to track large-scale variations in climate. Moreover, the open vegetation that greeted early Euro-Americans was a result not just of fire, but also of soil characteristics and flooding."



(Top) Map showing locations of Willamette Valley in the Pacific Northwest and (bottom) map of the ca. AD 1850 vegetation cover of the Willamette Valley. Credit: Megan Walsh (2008). Data source: Hulse, D., Gregory, S., Baker, J., 2002. Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change. Oregon State University Press, Corvallis.

Climate and human history

The regional climatic history following the last Ice Age is one of an overall gradual, but non-linear, warming, culminating about 6,000–8,000 years ago. After that, cooler, wetter conditions developed, and the low-elevation forests of the Pacific Northwest became more closed and wet. Human populations became more sedentary in the late Holocene and presumably used fire to facilitate hunting, travel, and defense and also to promote edible plant resources such as the tubers of camas lily, nuts, and berries.

In recent centuries, conditions again cooled during the Little Ice Age, and this period extended to the mid-19th century when Euro-American settlers arrived in earnest over the Oregon Trail into the Willamette Valley. By then, the native Kalapuya had been decimated by European diseases—smallpox in the late 18th century and malaria in the early 19th century—that swept through indigenous populations ahead of the settlers. From an estimated maximum population of 16,000 at the time of European Contact in 1790 AD, the population had plummeted to as low as 600 by 1841 AD.

The Kalapuya are thought to have been semi-nomadic, foraging in summer and maintaining permanent winter settlements in the valley above the floodplain. Just how widespread was their use of fire is a matter of debate. The notion that they burned extensively each year has been based on journal entries by early explorers, trappers, and settlers, but no direct archeological or ethnographic evidence exists. “A lot of people have it fixed in their mind that Native Americans used fire all the time,” says Megan Walsh, a postdoctoral research associate at the University of Oregon. “We thought the paleoecological record could help us evaluate this assumption.”

Charcoal and pollen records

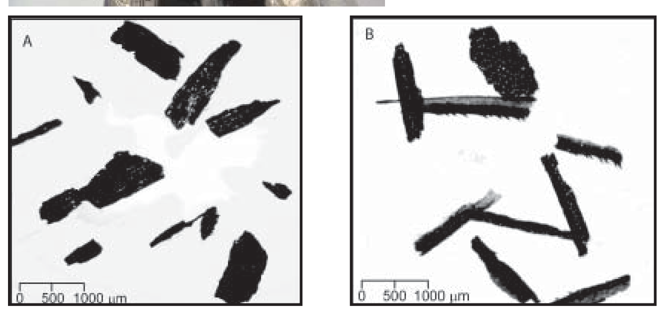
In the absence of recorded data or written accounts prior to settlement, information on vegetation change and fire occurrence in the Willamette Valley is obtained from proxy, or indirect, data gathered from the sediments of small lakes in the valley. The paleoecological record includes airborne charcoal particles from fire that settled into the sediment of lakes, and pollen grains from nearby vegetation that likewise were incorporated into the lake bottoms and buried.

Sediment cores were collected from a floating platform anchored in the deepest part of each lake. The samples were taken by lowering a hand-operated piston corer into the mud and recovering a vertical sequence of sediment cores. Going deeper meter by meter allowed the team to recover information further and further back in time. The sediments were extruded from the corer and wrapped for transport back to the lab for further analysis. “It’s like pushing toothpaste out of a tube,” says Whitlock “Lake sediments are semi-consolidated and full of pollen and charcoal.”

Using high-resolution macroscopic charcoal analysis, Walsh was able to reconstruct fire activity—how often ecosystems burned—back through time. She also distinguished between burned wood and grass particles, which helped determine whether the fires occurred in forests or grassland. “Visually it is easy to tell the difference between these charcoal types. At high enough magnification, grass charcoal is two dimensional with parallel veins and rows of pores,” says Walsh. “Wood charcoal is three dimensional, showing more complex anatomical structure.” The presence of grass charcoal likely indicates that fires near the lake were predominantly low-severity surface fires in oak savanna/prairie, whereas wood charcoal indicates higher severity fires from nearby forests. Pollen analysis of the same cores was used to identify changes in plant composition and vegetation patterns near the lakes.

Coring in Warner Lake. Paul Thompson, student field assistant (left), Megan Walsh (right). Credit: Jenn Marlon.

A sediment core from Battle Ground Lake is taken to the lab for analysis. Credit: Megan Walsh.



Photos of woody (left) and herbaceous (right) charcoal particles. Credit: Megan Walsh.

A tale of two lakes

Battle Ground Lake

The Battle Ground Lake record was key for understanding the long-term climate, fire, and vegetation history of the Willamette Valley. Located about 20 miles (30 km) north of present-day Vancouver in southwestern Washington, the lake sits within an ancient volcanic crater that has been in existence for at least 20,000 years. Today, the lake is surrounded by forest of Douglas-fir, western red cedar, and red alder, with agricultural fields and rural residential development nearby. Early pollen work by Whitlock suggests that the climate near Battle Ground Lake was colder and drier during the last glaciation, and as a result the region supported an open parkland of Engelmann spruce, western white pine, and lodgepole pine. Walsh determined that fire activity was low during this period, probably because the open parkland provided only limited fuel to support fires. "It was cold, with low precipitation and little or no fire," says Walsh. With post-glacial warming, the subalpine parkland was replaced by closed forest with abundant alder, Douglas-fir, spruce, and true firs (*Abies*), and later by fire-tolerant oak and prairie taxa in the early and middle Holocene. Fire frequency increased as a result of these vegetation changes and was highest during the middle Holocene when oak savanna and prairie were widespread near Battle Ground Lake. The vegetation and fire conditions were most likely the result of warmer and drier conditions compared with the present, not from human use of fire. Subsequently, fire frequency dropped during the late Holocene as the regional climate became cooler and wetter.

Battle Ground Lake. Credit: Megan Walsh.

Thus, the charcoal record at Battle Ground Lake shows a strong link between changes in climate, vegetation, and fire occurrence. The fire regime shifts during the late-glacial period and the Holocene seem to be explained by climate-driven vegetation shifts, and there is little evidence that humans altered natural fire regimes near the site. Battle Ground Lake, however, lies at the northern and wet margin of the Willamette Valley, and the investigators worried that its record might not be characteristic of the history of more fertile, productive areas to the south.

Beaver Lake

The Beaver Lake record provided a very different fire-history record for the central Willamette Valley than at Battle Ground Lake. Located in a former meander bend of the Willamette River approximately five miles (7.5 kilometers) east of present-day Corvallis, Oregon, this oxbow lake is over 11,000 years old and in a setting where prehistoric occupation, and therefore human impact on the landscape, likely would have been greater.

Coring in Beaver Lake. Credit: Jenn Marlon.

Similar to Battle Ground Lake, the pollen record from Beaver Lake suggested the presence of open, fire-adapted plant communities of oak, Douglas-fir, and red alder in the early Holocene when conditions were warm and dry. This finding was supported by the charcoal record, which shows that fires were relatively frequent at that time.

Also similar to Battle Ground Lake, fire frequency at Beaver Lake decreased at the beginning of the middle Holocene, when the vegetation indicated a shift to cooler wetter conditions than before. Unlike Battle Ground Lake, however, fire frequency at Beaver Lake increased rather than decreased during the late Holocene. This increased fire activity seems to suggest deliberate burning by humans, perhaps as a tool to maintain open vegetation in the face of cooler, wetter conditions. "Unfortunately archaeological evidence from the floor of the Willamette Valley is relatively rare, probably because repeated flooding of the Willamette River washed away most artifacts," says Walsh. "There is no archaeological evidence from the immediate area surrounding Beaver Lake; however, several ancient hearths used to cook acorns and camas root that date to the last few thousand years have been found in ecologically similar areas nearby." This evidence suggests that greater seasonality in the last 4,000–5,000 years would have required people to maintain more-permanent settlements and store food so that they could survive the winter when resources were limited. The use of fire would have enhanced food resources in the Beaver Lake area, including promoting the growth of camas bulbs and acorn development.

About 200–300 years before Euro-American settlement, however, fire activity declined at Beaver and Battle Ground lakes, as well as at other sites in the region. Walsh explains this as a combination of cooling during the Little Ice Age and depopulation of Native Americans. Comparing fire and pollen records throughout the Willamette Valley, Walsh has been able to examine the influence of climate and humans over the last 1,200 years at both the local and regional scale. The fire history at some sites implies a strong response to past climate variations, whereas others suggest local anthropogenic burning.

Post-settlement: Rapid change

The record of dramatic change from extensive local burning during settlement to little fire in current times was confirmed by tree-ring studies led Jane Kertis, an ecologist, and Emily Heyerdahl, a research forester, with the Forest Service, in response to a need expressed by the Bureau of Land Management (BLM) for a baseline of information on the history of fire. Because most of the valley floor was cleared for agriculture, and the uplands were heavily logged, the researchers found it difficult to locate old trees. Kertis and Heyderdahl examined stumps of harvested trees on the upland forest fringe on BLM land. "Our sites are above the valley floor, in the foothills, so in some cases we were above the area dominated by oak," they say. They found variations in the severity of fire, from low-severity to mixed- and high-severity events. Kertis and Heyerdahl cannot say with certainty whether the source of ignition on plots from presettlement times was human caused or lightning caused. "There is no hard evidence."

Fire scars and tree rings on a Douglas-fir sample.
Credit: Jane Kertis.

"Our research supports Megan Walsh's findings. Past fires were very localized, and there was not a lot of synchrony among fires." In other words, the plots do not share the same fire dates. The information will help determine management scenarios working within the range of conditions that occurred historically.

Planning the future from the past

"The history of fire and vegetation change in the Willamette Valley is more complicated than anyone thought," says Walsh. "Our records show a wide variety of past fire regimes, ranging from high severity forest fires to lower severity grassland fires." These temporal and spatial variations make managing the Willamette Valley challenging. The paleoecological record implies, however, that native riparian woodland, oak savanna, and conifer forest can tolerate a wide range of fire and climate conditions, and some of the native species, because of their resilience, may be better candidates for restoration projects than others.

"We don't have all the answers, yet," says Walsh, "but this research goes a long way towards showing that a combination of natural and human factors helped create the landscapes we see today." Walsh finds her favorite places in the valley are the few remnant oak savannas and prairies. "Our research shows that fire, whether it was human-set or naturally ignited, has been part of the ecosystems of the Willamette Valley over the last 14,000 years. Therefore any management effort aimed at recreating or protecting these areas must include fire in that plan."

Management Implications

- Knowledge of historical regimes and patterns of structure is important in making land management decisions.
- No single fire management strategy will cover the range of ecosystems in the Willamette Valley. Each plan must be tailored to the specific environment and management objectives.
- Knowledge of the short-term and long-term history of fire in the valley can help guide management decisions, but aesthetic values should also be considered in decision making.

A field with camas lily in the foreground, oak in the midground, and Douglas-fir in the background.
Credit: Megan Walsh.

Further Information: Publications and Web Resources

Walsh, M.K. 2008. Natural and Anthropogenic Influences on the Holocene Fire and Vegetation History of the Willamette Valley, Northwest Oregon and Southwest Washington. Dissertation. University of Oregon.

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Whitlock, C., S.L. Shafer, and J. Marlon. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern US and the implications for ecosystem management. Forest Ecology and Management 178, 3-21.

Scientist Profiles

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Acknowledgement

We would like to thank **Jane Kertis**, an Ecologist with the Suislaw and Willamette National Forest in Oregon, and **Emily Heyerdahl**, a Research Forester with the Rocky Mountain Research Station, Fire Sciences Laboratory, in Missoula, Montana, for their contributions of information on tree-ring studies, funded by the Bureau of Land Management, which were included in the final report to the Joint Fire Science Program.

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The information in this Brief is written from JFSP Project Number 04-2-1-115, which is available at www.firescience.gov.

An Interagency Research, Development, and Applications Partnership

JFSP *Fire Science Brief* is published monthly. Our goal is to help managers find and use the best available fire science information.

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