Vegetation History of the Southern Willamette Valley

by Megan K. Walsh

Since the end of the Last Glacial Maximum (LGM), approximately 18,000 calendar years before present (cal yr BP), changes in climate, hydrology, fire activity, and human land-use have continuously influenced and shaped the vegetation of the southern Willamette Valley. To understand why the current landscape looks the way it does, it is necessary to examine and understand the record of past vegetation change in the Valley. In doing so, we learn that the Valley's vegetation has varied in both kind and distribution, and that today's landscape is a legacy of the major environmental changes and anthropogenic (human) activities that have taken place in the region. Additionally, we gain an understanding of how the vegetation changed most recently as the Valley became settled by Euro-Americans, and how it continues to change today.

Records of Past Vegetation

In the Pacific Northwest, the character of previous natural environments, namely the type of vegetation that grew in an area, can be reconstructed several ways. The most recent history of a forested area can be reconstructed using historical maps (see the following chapter) or through dendrochronological methods, which include tree-ring and stand-age analyses (Agee, 1993). By analyzing the composition (i.e., the species present and their abundance), age, and structure (i.e., the number of trees of a certain species in each age class) of a forest today, inferences can be made as to when the forest established and how the forest has changed since that time. The fire history of many Pacific Northwest forests can also be established using these methods, through the identification of fire-scars in the tree-ring records, and post-fire cohorts in the stand reconstructions. These vegetation records give us insight into the influence that climate and disturbance have had on the most recent forests of an area. The approach, however, is limited by the availability of old trees and the age of the remaining trees, typically only a few hundred years.

Long-term records of vegetation and fire activity can be reconstructed through the extraction and identification of fossilized pollen and charcoal. Pollen, which is the male gametophyte of seed-producing plants, occurs naturally in large quantities and can become incorporated into the organic sediment of bodies of water. By extracting sediment cores and analyzing the pollen contained within them, it is possible to determine the type of vegetation an area once supported (Faegri *et al*., 1989). Pollen are typically unique to the family level, but occasionally to the genus or even species level. Pollen identification is done visually, using light microscopy at a magnification of 400-1000X, and is based on the characteristics of the individual grains, such as size, shape, structure, and surface features. The pollen types contained within a sediment sample are quantified and used to reconstruct the vegetation change of an area over hundreds or even thousands of years. The identification and quantification of macroscopic fossil charcoal (i.e., particles larger than 125 µm) also found in these sediments can be used to reconstruct the fire history (i.e., the frequency of burning) in a watershed (Long *et al*., 1998). Through these analyses we can begin to comprehend how past vegetation and fire activity have been influenced by former climatic conditions and human activities.

Records of Past Vegetation in the Willamette Valley

Suitable depositional environments for pollen accumulation are rare in the Willamette Valley, mainly due to the fact that it was not glaciated during the last Quaternary glaciation. In the adjacent Cascade Range of Oregon, numerous glacially derived lakes contain organic, pollen-bearing sediments. In the Valley, however, environments containing fossil pollen are limited for the most part to floodplain depressions, sloughs, and oxbow lakes (i.e., former river meanders). These environments, which are susceptible to drainage and summer desiccation, are typically either quite young in age or contain disturbed and/or incomplete sediment records. To compound this, many of these former wetlands have been drained or otherwise converted since Euro-American settlement of the Valley, ca. 1850 AD. Existing information on the vegetation history of the southern Willamette Valley is discussed below and can help us understand major changes in the vegetation over the past 18,000 years.

The Late-Glacial Environments of the Southern Willamette Valley (18,000 to 11,000 cal yr BP)

Following the LGM, the regional climate was cool and dry from the influence of the northward retreating ice sheet, but became increasingly warmer into the Late Glacial (Thompson *et al*., 1993). During this period, the vegetation on the hillsides of the southern Willamette Valley was most likely forest dominated by lodgepole pine (*Pinus contorta*), spruce (*Picea* spp.) and fir (*Abies* spp.) (Hansen, 1947). Western hemlock (*Tsuga heterophylla*) was probably a component of these forests as well, although it was likely more abundant in the Coast and Cascade Range foothills and decreased toward the dryer Valley floor. Nearby high-resolution pollen records provide evidence of how forests surrounding the Willamette Valley responded to changes in regional climate following the LGM. The pollen record from Little Lake (44º10'N, 123º35'W, 210 m elev), OR, in the Coast Range suggests that this area, which was not glaciated, supported a parkland of spruce, lodgepole pine, and mountain hemlock (*Tsuga mertensiana*) during the full-glacial (Worona and Whitlock, 1995). The vegetation then developed into a forest of pine, fir, and mountain and western hemlock by 15,000 cal yr BP as the climate warmed. Similarly, in the Cascade Range, subalpine parkland dominated by spruce (*Picea engelmannii*) and lodgepole pine was the initial vegetation at Gordon Lake (44º21'N, 122º15'W, 1177 m elev) following deglaciation, until it was replaced by a forest of Douglas-fir, fir, western white pine (*Pinus monticola*), and western hemlock at 14,500 cal yr BP as the climate warmed (Grigg and Whitlock, 1998).

At the northern extent of the Willamette Valley, the pollen record from Battle Ground Lake (45º48'00"N, 122º29'30"W, 154 m elev), WA, provides evidence of vegetation change in the Valley during the Late Glacial. The record suggests that this non-glaciated site was a parkland/tundra ecosystem dominated by spruce during the full-glacial, and became a more open parkland/forest of Engelmann and Sitka spruce (*Picea sitchensis*), grand (*Abies grandis*) and silver fir (*Abies amabilis*), and mountain hemlock by about 18,000 cal yr BP as the climate warmed (Barnosky, 1985; Whitlock, 1992). By about 13,000 cal yr BP, the vegetation at Battle Ground Lake became a closed forest dominated by temperate, lowland taxa like Douglas-fir (*Pseudotsuga menziesii*) and western hemlock, at the expense of the cooler-climate taxa, such as spruce, pine, grass, and sagebrush (*Artemisia* spp.). The low-elevation forests of the southern Willamette Valley probably responded as this site did to the warming climate of the Late Glacial, but perhaps did so sooner as they were farther away from the retreating ice sheet. Throughout the south-Valley, Douglas-fir likely increased in importance to become the dominant species throughout the forests, as the abundance of lodgepole pine, spruce, and fir decreased.

The Willamette Valley was inundated many times from approximately 18,000 to 12,000 cal yr BP by massive, glacial meltwater floods (Loy *et al*., 2002). These floods resulted from the repeated failure of the ice dam on glacial Lake Missoula, which held back the immense amount of water that was created as the continental ice sheets melted (Waitt, 1985). As many as 50-100 floods barreled down the Columbia River, scouring out the Channeled Scablands of eastern Washington as they went (Allen *et al*., 1986). Many of these floods filled the Willamette Valley with standing water, at least as far south as Harrisburg. As a result, an enormous amount of sediment was deposited across the Valley floor (Gannett and Caldwell, 1998). This sediment, known as the Willamette Silts, covers approximately 3,100 km^2 and is as thick as 40 m in the northern part of the central Willamette Valley (Allison, 1978). It was only after the cessation of the Missoula Floods that the depositional environments, which contain the vegetation record of the Valley floor, began to develop.

The Holocene Environments of the Southern Willamette Valley (11,000 cal yr BP to 1850 AD)

Into the early Holocene, the regional climate continued to warm and dry, peaking during the early Holocene warm/dry period (ca. 9,000-7,000 cal yr BP) (Whitlock, 1992; Thompson *et al*., 1993). Although there is little evidence of how the vegetation of the south-Valley responded to this, Douglas-fir and western hemlock probably continued to dominate the foothill forests, though their relative abundance to one another certainly varied as the climate warmed in the early Holocene and then cooled and became progressively wetter into the middle to late Holocene (Hansen, 1947). High-resolution pollen records from the Coast and Cascade Range again provide evidence of how forests surrounding the Willamette Valley responded to climate changes in the early Holocene. The pollen record at Little Lake shows that in the early Holocene, warm, dry conditions helped support open, xerophytic (dry-adapted) vegetation near the lake (Worona and Whitlock, 1995; Long *et al*., 1998). Similarly, the pollen records from Gordon Lake and Indian Prairie Fen (44º38'N, 122º02'W, 1465 m elev) show that during the early Holocene, the vegetation at both sites changed from a pine-dominated forest to one dominated by Douglas-fir, as a result of increased summer warmth and decreased effective moisture (Grigg and Whitlock, 1998).

Following the warm, dry conditions of the early Holocene, cooler, more-humid conditions of the middle and late Holocene allowed for the establishment of the modern forests in the region (Whitlock, 1992). The Little Lake record shows the establishment of the modern, closed forest supporting mesophytic (moist-adapted) taxa after 6850 cal yr BP. The Indian Prairie Fen record as well shows the development of the modern, mountain hemlock, Douglas-fir, and fir forest after about 6000 cal yr BP (Sea and Whitlock, 1995). It is likely that at approximately the same time, the modern forests of mostly Douglas-fir and grand fir, with some western hemlock interspersed in the more moist areas, established on the southern Willamette Valley foothills.

The vegetation of the Valley floor also responded to major shifts in the regional climate throughout the Holocene. The early Holocene warm/dry period was marked by an increase or a dominance of Oregon white oak (*Quercus garryana*). An 11,000-yr long pollen record from Beaver Lake (44º33'01"N, 123º10'40"W, 69 m elev) suggests that this area supported a xerophytic woodland of oak, Douglas-fir, hazelnut (*Corylus)*, and red alder (*Alnus rubra*) during the early Holocene (before 7250 cal yr BP) (Pearl, 1999). Undated sediment records from sites in the northern Valley as well show the appearance and abrupt increase in oak pollen, presumably during the early Holocene warm/dry period (Hansen, 1947). It is suggested by these records that xerophytic vegetation, predominantly oak, expanded and possibly dominated the vegetation of the Valley floor during the early Holocene warm/dry period.

Into the mid-Holocene, the regional climate began to cool and moisture increased. At Beaver Lake, after 7250 cal yr BP, oak declined and the vegetation became more mesophytic, evidenced by an increased pollen abundance of willow (*Salix)*, ash (*Fraxinus)*, hardhack (*Spiraea)*, horsetails (*Equisetum)*, and members of the sedge (Cyperaceae) family (Pearl, 1999). Grass pollen, although present in the entire record, increased slightly after 8,000 cal yr BP and remained at fairly constant levels until the time of Euro-American settlement. If the vegetation record of Beaver Lake is representative of the rest of the southern Willamette Valley, then it is likely that throughout the mid- to late Holocene, willow/ash forests dominated riparian areas, oak/Douglas-fir savannahs or forests grew on the surrounding upland areas, and prairie/grassland was widespread across the Valley floor.

The vegetation change that accompanied Euro-American settlement of the Willamette Valley is captured in the very top of the sediment records from the Valley. In the southern Valley, the Beaver Lake record shows a marked decrease of willow and a rapid increase of grass pollen as the area surrounding the lake became used for grass and wheat production, as well as livestock grazing (Pearl, 1999). The presence of walnut (*Juglans)* pollen and elevated levels of pollen from the mustard (Brassicaceae) family mark the continued conversion of the area surrounding Beaver Lake to an agricultural landscape, ca. 1945 AD. More records are needed, however, to understand the timing and the total impact of Euro-American settlement on the vegetation of the southern Valley.

Holocene Fire Activity

Fossil charcoal in the sediments of the Willamette Valley provides evidence that fire was occurring in the Valley's ecosystems throughout the Holocene, a result of both natural and human ignitions. The only high-resolution charcoal record from the Valley, Beaver Lake, varies in fire frequency over the last 7,000 cal yr BP (Pearl, 1999). The changes, however, are neither clearing linked to major changes in climate, nor to know changes in human activity/land-use in the Valley during this time period. At this point, no clear conclusion can be drawn as to what exactly was controlling fire in the Willamette Valley prior to Euro-American settlement.

Limited dendrochronological studies conducted in the foothills of the Willamette Valley are helpful in elucidating changes in the fire regimes of the Valley's forests from pre- to post- Euro-American settlement. The conclusion is that fire activity was more frequent in the period prior to Euro-American settlement (ca. 1650-1850 AD) as opposed to the period following settlement (ca. 1850 AD-present) (Sprague and Hansen, 1946; Teensma *et al*., 1991; Impara, 1998; Weisberg, 1998). Additional studies at higher elevation in the Cascade Range reinforce this pattern of more frequent pre-settlement fire activity and the almost complete absence of fire in the 20th century (Morrison and Swanson, 1990; Weisberg, 1997; Cissel *et al*., 1998; Weisberg and Swanson, 2003). For further information on the fire history and ecology of the Willamette Valley, see "Fire on the Mountain: History, Ecology, and Politics" by Chandra LeGue in this guidebook.

The Vegetation of the Southern Willamette Valley at the Time of Euro-American Settlement (ca. 1850 AD)

The vegetation of the southern Willamette Valley at the time of Euro-American settlement is known from the land survey records of the Federal Land Office, which described the vegetation of the Willamette Valley in 1854. Other vegetation/dendrochronological studies carried out in the Valley over the past several decades also describe the vegetation patterns of the southern Valley prior to Euro-American settlement (Habeck, 1961; Cole, 1977, Hulse *et al*., 2002). This information provides us with a means to assess the amount of change in the vegetation since that time. The major vegetation zones of the southern Valley, along with their general distribution ca. 1850 AD, are discussed in Ed Alverson's essay "Ecological History of Mt. Pisgah and the Southern Willamette Valley" in this guidebook.

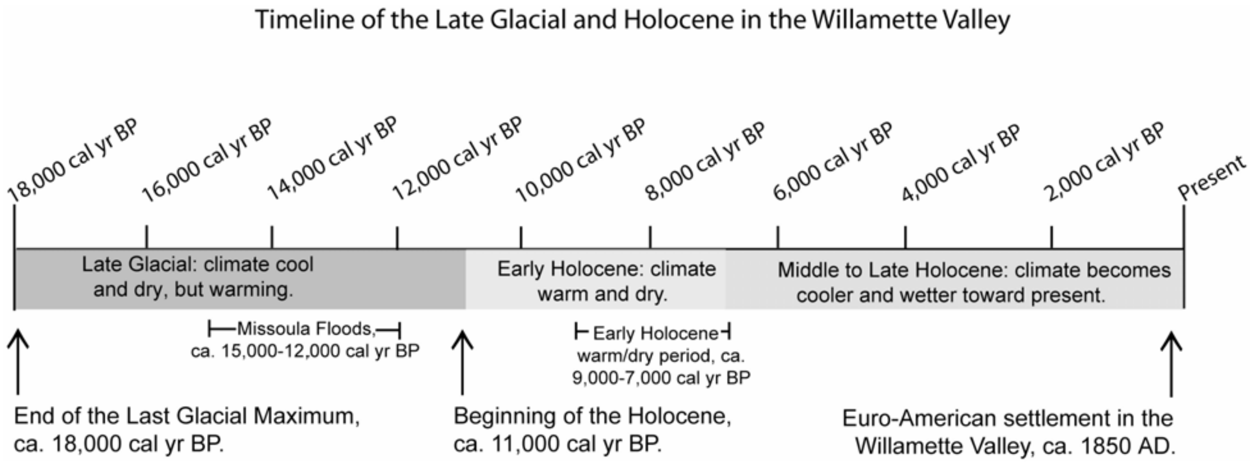
Vegetation Change in the Southern Willamette Valley since Euro-American Settlement (ca. 1850 AD)

The vegetation of the Willamette Valley has changed greatly since Euro-American settlement, slightly more than 150 years ago. Most change is a result of human land conversion (i.e., land clearance from logging and agriculture), although the reduction/removal of fire from the Valley's ecosystems has created change as well (see Sprague and Hansen, 1946; Habeck, 1961; Thilenius, 1968; Johannessen *et al*., 1971; Cole, 1977; Towle, 1982; Franklin and Dyrness, 1988; Dykaar and Wigington, 2000; Hibbs *et al*., 2002). Bottomland prairie, in the absence of fire, has become increasingly dense with shrubs and trees and in many areas is no longer considered prairie. Upland prairie has all but disappeared in the absence of fire, as well as a result of land-use changes. Oak savannas are now sparsely scattered along the Valley edges and on steep hillsides where other trees cannot establish. Fire once kept oak reproduction in oak savannahs to a minimum, but now most former oak savannahs have become closed oak or oak-conifer forests. Former oak forests now support only scattered oaks under dense forests of either Douglas-fir or big-leaf maple, depending upon the local moisture conditions. With the lack of burning in the forests, many Douglas-fir forests of 1850 AD, today, are dominated by grand fir (a fire-intolerant species). With changes in the hydrology of the Willamette River and the expansion of cultivation in the valley, most riparian forests in the Valley are gone, and many of those that remain contain introduced species.

Future Vegetation Change in the Southern Willamette Valley

With the continued absence of fire from the Valley's ecosystems, it is likely that the forests will continue to mature and become increasingly dense with conifers. Unless fire is reintroduced, the few remaining oak savannahs in the Valley will not persist for much longer, except in the most unique areas where other trees cannot establish. These areas will likely become increasingly dense with oaks. Future climate change, the result of increasing greenhouse gas emissions, will certainly impact the vegetation of the Valley (Shafer *et al*., 2001). It is possible that if regional temperature increases and precipitation decreases, fire occurrence in the Valley could increase as well. More frequent fire could help re-establish the "original" vegetation of the Valley, or at least open up some areas that today are densely forested. Large enough change in the temperature and precipitation patterns of the region could force the migration of certain species or even whole communities out of the Valley and lead to the introduction of species or communities not yet present. As uncertain as the future changes may be, it is likely that climate change will not simply result in a shift of the Valley's vegetation northward and upward in elevation, but in all directions.

Humans will have the greatest impact on future changes in the vegetation of the southern Willamette Valley. Continued pressure from anthropogenic activities (e.g., agriculture and logging) will keep the Valley's forests and bottomland areas from responding naturally to future climate change. Clear-cutting and re-seeding areas with a single tree species will aid in the conversion of the Valley's forests to ones dominated by a single species (e.g., Douglas-fir) and compound the Valley's loss of biodiversity. Additionally, forests will be extremely vulnerable as the southern Willamette Valley becomes more densely populated and housing development pushes farther into the Valley's foothills (Hulse *et al*., 2002). Thus, the future of the southern Willamette Valley's vegetation precariously rests in the hands of the Willamette Valley's present and future inhabitants.



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