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A Pleistocene Low-Elevation Subalpine Forest in the Western Cascades, Oregon

Abstract

A boulder diamicton exposed in the low Lookout Creek valley, western Cascades, Oregon, contains fossil wood, needle, and pollen material representative of a Pleistocene flora > 35,500 radiocarbon years in age. The deposit was probably formed by a debris torrent from a tributary watershed. Some of the wood fragments are abraded and randomly oriented, suggesting transport from upslope areas. *Abies* sp., *Pseudotsuga menziesii*, and *Thuja plicata* are represented in these wood specimens. Other materials, including unabraded wood, needles, and pollen occur in a continuous, horizontal layer that may represent a small piece of locally formed forest floor litter. This valley bottom flora contained abundant *Picea* cf. *englemannii* and *Abies* cf. *lasiocarpa*. These fossils suggest the occurrence of *Picea englemannii*/*Abies lasiocarpa* forest in a cold valley bottom with more xeric forest communities on adjacent hillslopes.

Present arboreal vegetation at the site is dominated by *Tsuga heterophylla*, *Thuja plicata*, and *Pseudotsuga menziesii*. Modern examples of the community represented by the fossil assemblage occur at elevations over 1000 m higher than the Lookout Creek site. The Lookout Creek assemblage probably represents a flora of an early Wisconsin or previous glaciation under conditions significantly drier than those prevailing during late Wisconsin glaciation.

Introduction

Preservation of Pleistocene plant fossil material of pre-late Wisconsin age is rather rare, particularly in the steep, rapidly eroding mountainous terrain of the Pacific Northwest. Previous work on materials of this age in western Washington has centered in the Puget Lowland (Hansen, 1938; Hansen and Mackin, 1940, 1949; Easterbrook *et al.*, 1967; Hansen and Easterbrook 1974) and along the coast of the Olympic Peninsula (Heusser, 1964, 1972; Florer, 1972) in areas where the stratigraphy is well known. There have been no reports of known pre-late Wisconsin Pleistocene assemblages in western Oregon, although several undated samples (Hansen and Allison, 1942; Hansen, 1947) may represent this period. We use the term late-Wisconsin to indicate the

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time period between approximately 10,000 and 35,000 years before present (B.P.) when extensive glaciation was occurring in the Northwest, as indicated by the Evans Creek (Crandell and Miller, 1974), Cabot Creek (Scott, 1977), and other drifts. The term early-Wisconsin is used to indicate earlier Wisconsin time, which may be represented in part by Hayden Creek (Crandell and Miller, 1974), Jack Creek (Scott, 1977), and other drifts.

During geomorphic studies in the vicinity of Lookout Creek, H. J. Andrews Experimental Forest, western Cascades, Oregon, we have located an assemblage of wood fragments, conifer needles, and pollen more than 35,000 radiocarbon years in age. In this report we offer an analysis of this assemblage and its implications regarding the magnitude of vegetation displacement in response to major episodes of climatic change. Species identification of the plant material is aided by the presence of both macro- and microfossils.

Location, Nature, and Age of the Deposit

The Lookout Creek assemblage is exposed in a streambank at an elevation of 425 m along Lookout Creek, about 1.2 km upstream from its confluence with Blue River (NW ¼ SE ¼ Sec. 31 T15S R5E). The site is within the H. J. Andrews Experimental Forest approximately 55 km east of Eugene, Oregon (Fig. 1). The general geologic and geomorphic settings of the site have been described by Swanson and James (1975a, b).

Plant fossil material is contained within the dense clayey matrix of a bouldery diamicton up to 4.5 m in thickness which is overlain by varved lacustrine sediments (Fig. 1). The lake sediments were presumably deposited in the lower Blue River drainage while the mouth of the river was dammed by glacial ice in the McKenzie River valley (Swanson and James, 1975b). Coarse well-rounded gravel deposited by Lookout Creek rests on both the lacustrine sediments and the diamicton.

The diamicton is exposed at the distal end of a massive debris fan constructed at the mouth of experimental Watershed 2 (Swanson and James, 1975b). Fans constructed of debris torrent deposits occur commonly at the mouths of 5 to 100 ha watersheds in the study area (Swanson and James, 1975b).

Clasts within the diamicton are subangular and up to 80 cm in diameter. No evidence of striations or faceting was observed. The matrix material is a dense compact of blue-gray clay and angular to subangular, unsorted rock fragments. The proportion of rock types in the deposit indicates a source area in nearby watersheds tributary to Lookout Creek, probably Watershed 2. Modern gravel in Lookout Creek includes a variety of rock types not observed in Watershed 2 or in the fossil bearing deposit.

The probable origin of the deposit was a debris torrent which originated at a middle to upper elevation site (600 to 900 m) in Watershed 2. Glaciation would be an alternative means of forming such a deposit. However, the lack of glacial landforms and striations and facets on stones argues against glacial processes as the mode of origin of the deposit. There is no clear evidence of the presence of glaciers along this section of valley floor anywhere within a kilometer of the site.

The fossil material occurs in two different patterns within the diamicton. At locality LOK-1 (Fig. 1), a matted, irregular but continuous layer of twigs, needles, and wood fragments up to several centimeters in thickness extends for more than 4 m

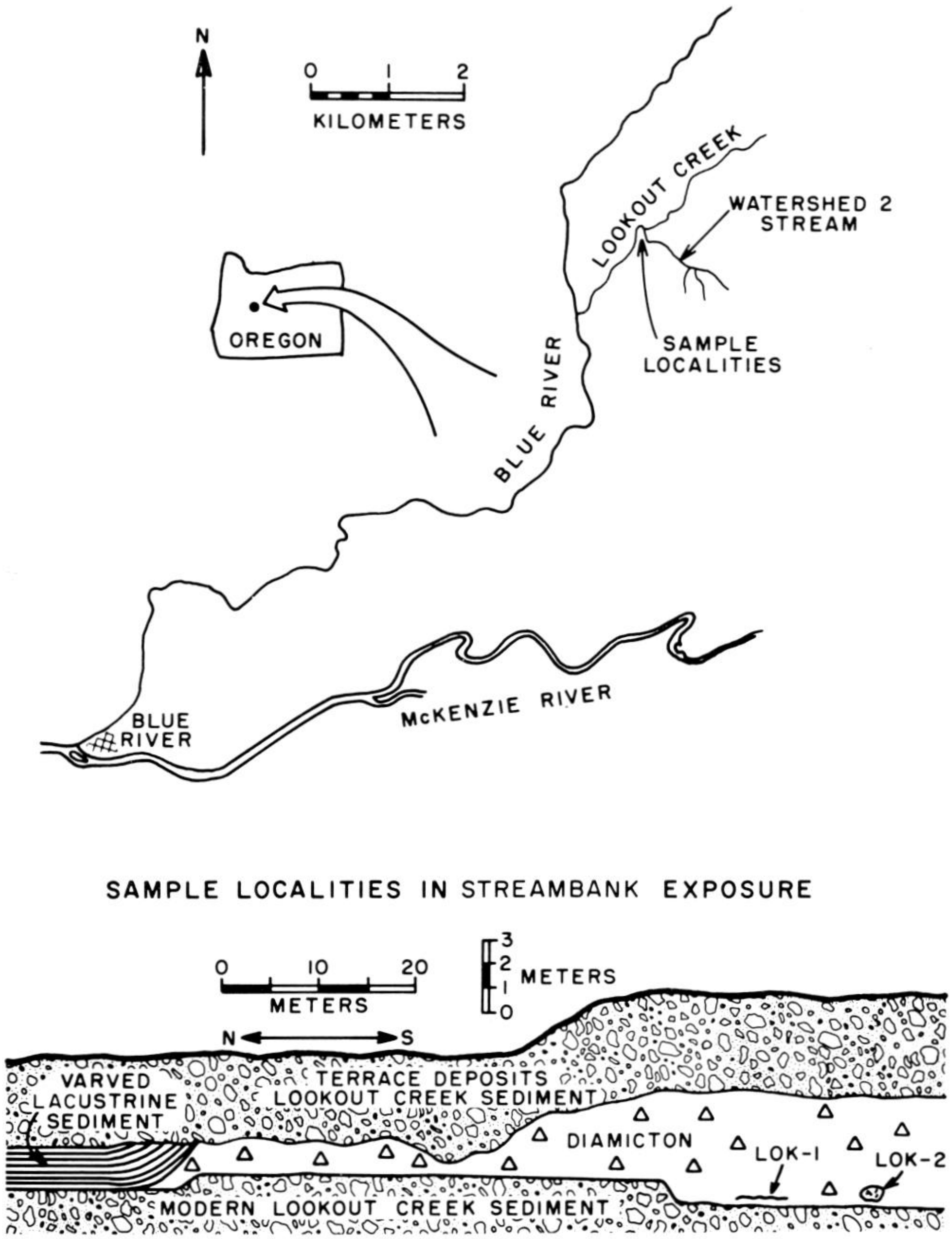

Figure 1. Location of sample localities and sketch of Lookout Creek streambank exposure showing LOK-1 and LOK-2 sites. The modern Lookout Creek sediment is deposited against the base of the exposure which shows terrace deposits unconformably overlying varved lacustrine and diamicton deposits.

horizontally. This fossil bearing horizon does not occupy a noticeable break in lithology or a weathered zone. However, the thin, continuous, horizontal nature of the band, the occurrence of needles arranged along twigs as they were in life, and lack of abrasion and rounding of the wood fragments suggest that the deposit represents a piece of intact forest floor which was not subjected to transport in a mass movement event.

Locality LOK-2 (Fig. 1) yields isolated pieces of wood scattered through a zone about 1 m thick within the diamicton. These wood fragments are randomly oriented and rounded and abraded, indicating possible transport in a mass movement event from an upslope area.

Based on these observations and geomorphic studies in Watershed 2 (D. N. Swanston and F. J. Swanson, unpubl. map), we hypothesize that the following sequence of events led to preservation of plant materials at LOK-1 and LOK-2. A debris torrent originated in Watershed 2 at an elevation between 600 and 900 m. In its downstream movement the torrent entrained, transported, and then deposited wood at LOK-2. The wood, twigs, needles, and pollen in LOK-1 appear to have been directly deposited by litterfall onto fresh debris torrent material and soon thereafter covered with similar material. Small scale slumping of debris torrent material, perhaps at a bank eroded by high stream flow, may have covered and preserved the LOK-1 material.

A sample of wood from the diamicton (I-7287) was C^{14} dated at > 35,500 years [B.P.]. The exact stratigraphic position of this specimen relative to the two sample localities is uncertain, but it probably derives from LOK-2. The presence of these deposits at the base of a deeply incised, rapidly eroding watershed suggests that they are not older than Pleistocene and are probably of late Pleistocene age.

Analysis of Macrofossils

On 3 June 1976 wood samples, needles, and bulk maceration samples were collected from locality LOK-1, and on 3 June and 7 December 1976 wood samples were collected from locality LOK-2. Ten wood samples from LOK-1 have been determined as *Abies* sp. by Allan Doerksen (Forest Research Lab, Oregon State Univ., Corvallis). The specimens include large diameter stems as well as branches as small as 1 cm. Examination of the leaf material discloses matted needles draped over numerous small twigs. Many of the needles are arranged in parallel clusters or along small twigs. Preservation of the needles is excellent and three dimensional. Disaggregation of the matrix with detergent solution allows intact needles to be separated from the matrix. Bulk maceration of several kilograms of material has not yielded any plant material not referable to *Abies*.

The needles are stomatiferous above and below, shallowly depressed to mildly convex above, flattened, with revolute margins and blunt apices, some of which are minutely notched. The needles are commonly falcate and short, and most are bent at the petiole. The twigs have conspicuous leaf scars. Comparison of these needles and twigs with all species of northwestern *Abies* shows they are clearly referable to *Abies lasiocarpa*. Examination of additional material from LOK-1 by Art McKee (School of Forestry, Oregon State Univ.) disclosed small amounts of *Tsuga heterophylla* and *Picea* sp. (cf. *englemannii*) needles in addition to abundant *Abies lasiocarpa* material.

The wood specimens from LOK-2 appear abraded and rounded. Specimens are referable to *Thuja plicata* (4 specimens), *Pseudotsuga menziesii* (2 specimens), and *Abies* sp. (1 specimen). The *Pseudotsuga* specimens are fragments of large diameter stems and are unusual in their minute growth increments, 0.14 and 0.10 mm/year

(0.005 and 0.004 inch/year). The C^{14} date of > 35,500 B.P. reported above is based on a specimen determined as *Tsuga heterophylla* (or *Libocedrus decurrens*).

Analysis of Microfossils

Abundant but generally compressed and poorly preserved pollen and spores have been recovered from locality LOK-1. A pollen count of 250 grains is given in Table 1. Percentages are calculated excluding indeterminate grains, which are those too poorly preserved for positive identification. Shown in Table 2 is a pollen count of 500 grains from a modern stand several hundred meters upslope from the Lookout Creek locality. The modern pollen rain was sampled by collection of 1 cc fragments of five moss polsters within the 50 m x 50 m of Reference Stand 7 (Dyrness *et al.*, 1974; Zobel *et al.*, 1976). These polsters were collected on logs of decay class 4, which have a mean residence time on the forest floor of 82 years (P. C. MacMillan, pers. comm., 1977).

In the pollen counts, *Pinus* species have been provisionally separated using a technique similar to Hansen and Cushing (1973). The basic separation is by cappula ornamentation. Among the diploxylon pines (types with smooth cappulae), the separation of *Pinus ponderosa* from *Pinus contorta* by morphology and size is believed to be reasonably reliable. The separation of haploxylon pines (rough cappulae) *Pinus*

TABLE 1. Pollen analysis of sample from LOK-1. Percentage figures calculated on basic sum, excluding indeterminate grains. Total count = 250 grains. Basic sum = 195.

Abies lasiocarpa type	10.8%
Abies procera-amabilis type	3.1%
Abies concolor-grandis type	2.6%
Abies indet.	5.1%
Total **Abies**	21.5%
Picea	7.7%
Pinus diplox. (**contorta** type)	6.1%
Pinus haplox. (**monticola** type)	3.6%
Pinus haplox. (**albicaulis** type)	5.6%
Pinus indet.	8.2%
Total **Pinus**	23.6%
Cupressaceae	5.1%
Tsuga heterophylla	2.1%
Tsuga mertensiana	2.1%
Quercus?	5.6%
TOTAL ARBOREAL POLLEN	67.7%
Artemesia	4.6%
Ribes	0.5%
Alnus	0.5%
Acer circinatum	0.5%
Compositae, hi spine	6.1%
Compositae, low spine	6.1%
Cruciferae	3.6%
Cruciferae, cf. **Erysimum**	0.5%
Umbelliferae	1.5%
Saxifragaceae?	1.0%
Rosaceae	0.5%
Malvaceae?	1.5%
Cyperaceae	0.5%
Other herbs	3.0%
Unknown	2.1%
Total shrubs	6.1%
Total herbs	24.1%
TOTAL NON-ARBOREAL POLLEN	30.2%

TABLE 2. Pollen analysis and stand data for Reference Stand 7, H. J. Andrews Experimental Forest (Zobel et al., 1974). Pollen analysis based on count of 500 grains. Stand data are in percent cover for mature (M) and reproduction (R) tree species (G. M. Hawk, pers. comm.).

Pollen Analysis-Reference Stand 7		
Tsuga heterophylla		35.4%
Pseudotsuga menziesii		24.2%
Abies spp.		0.2%
Pinus diplox. (**contorta** type)		1.4%
Pinus haplox. (**monticola** tyye)		2.4%
Pinus indet.		0.8%
Total **Pinus**		4.6%
Cupressaceae		5.6%
Taxus		1.2%
Alnus		2.8%
Acer circinatum		0.4%
Acer macrophyllum		0.2%
Ceanothus		0.2%
TOTAL ARBOREAL POLLEN		70.0%
TOTAL SHRUBS		5.0%
Polystichum munitum		15.8%
Polypodium glycyrrhiza		0.2%
Athyrium?		0.2%
Other fern		5.0%
Liliaceae		1.2%
Malvaceae		0.2%
Graminae		0.2%
Compositae		0.8%
Cheno-Am		0.2%
Unknown		1.2%
Indet.		0.6%
TOTAL NON-ARBOREAL POLLEN		26.6%
Stand Data-Reference Stand 7		
Tsuga heterophylla	M	55.0%
	R	30.0%
Pseudotsuga menziesii	M	25.0%
Thuja plicata	M	30.0%
	R	10.0%
Total Tree Cover		150.0%
Acer circinatum		8.3%
Cornus nuttallii		2.9%
Vaccinium parvifolium		1.8%
Taxus brevifolia		1.3%
Total Shrub Cover		14.3%
Gaultheria shallon		1.5%
Rubus ursinus		1.3%
Berberis nervosa		0.5%
Rubus nivalis		present
Total Low Shrub Cover		3.3%
Oxalis oregana		24.4%
Polystichum munitum		6.7%
Linnea borealis		5.1%
Coptis laciniata		2.0%
Tiarella unifoliata		2.0%
Viola sempervirens		0.6%
Goodyera oblongifolia		0.1%
Vancouveria hexandra		0.1%
Galium triflorum		0.1%
Total Herb Cover		41.1%

albicaulis, P. monticola, and *P. lambertiana* is more difficult, but with care seems practical. Although the reported percentages may be open to some question, both *Pinus monticola* and *P. albicaulis* are represented in the LOK-1 pollen sample. A grain referable to *Pinus lambertiana* was observed scanning the modern comparative material from Reference Stand 7 near the Lookout Creek locality.

Abies species determinations are more perplexing than those of *Pinus* largely because of the apparent great variability of pollen morphology among species of *Abies* and the difficulty of securing adequate comparative material. Most distinctive of the six northwest *Abies* species is *Abies lasiocarpa*. It is characterized by a relatively thin cappa with fine infrastructure and conspicuous proximal thinning, finely reticulate sacci, and relatively small overall size (Hansen, 1947; Heusser, 1964). *Abies amabilis* and *A. procera* are also distinguishable by their greatly thickened cappae and characteristically thick and dense saccus infraornamentation.

Pollen tentatively determined as *Quercus* (Table 1) resembles the pollen of modern *Q. saddleriana* and *Q. vaccinifolia*, but is considerably larger, generally 45-55 μ, and may represent some other taxon.

Pollen of Cupressaceae in Reference Stand 7 is likely from *Thuja plicata*. Cupressaceae in LOK-1 may be from *Chamaecyparis nootkatensis, Thuja plicata, Juniperus communis*, or perhaps *J. occidentalis*. More probably one or several of the first three species are represented.

Reference Stand 7 typifies the *Tsuga heterophylla/Polystichum munitum-Oxalis oregana* (TSHE/POMU-OXOR) community of Dyrness *et al.* (1974) and may be taken as representative of the modern vegetation of the Lookout Creek locality. Species composition data for the stand (Table 2) are available for comparison with the pollen count. Observations of Zobel *et al.* (1976) indicate that this community occupies the warm moist extreme of environments in the central western Cascades of Oregon as shown by indirect (Dyrness *et al.*, 1974) and direct (Zobel *et al.*, 1976) gradient analysis.

Interpretation and Discussion

The fossil assemblage from the diamicton at Lookout Creek stands in sharp contrast to the present vegetation. Today the site is at the warm moist extreme of the spectrum of forest community environments in the central Oregon Cascades. The modern pollen rain reflects the present vegetation composition fairly well (Table 2). The rank order of dominant trees, *Tsuga heterophylla, Pseudotsuga menziesii, Thuja plicata*, is repeated in the pollen frequencies. Among the shrubs, *Acer circinatum* and *Taxus brevifolia* are found in the pollen sample. *Alnus rubra* grows in an area near Reference Stand 7. The importance of *Polystichum* is duplicated in the pollen assemblage; however, other herbaceous species are not present at detectable levels. Present at low levels in Reference Stand 7 are *Trillium ovatum, Disporum hookeri*, and *Smilacina stellata*, probable sources of the Liliaceae pollen type, and *Bromus* sp., a possible source of the Graminae pollen.

The LOK-1 pollen assemblage is characterized by a low pine component (24 percent), compared to other glacial period records, high *Abies* (22 percent), moderate *Picea* (8 percent), low *Tsuga* spp., and no *Pseudotsuga*. Comparable Pleistocene pollen assemblages are not common. Only the basal layers of the Scotts Mills and Lake

Kachess cores reported by Hansen (1947) approach that of the Lookout Creek assemblage. The Lake Kachess core from the Central Washington Cascades has much higher *Picea* and *Abies*, about 40 percent pine, and some *Pseudotsuga* and both species of *Tsuga* in low abundance. The basal levels of the Scotts Mills core also contain higher pine and high *Abies* (40-60 percent) and *Tsuga mertensiana* is apparently absent. These cores were studied before the advent of radiocarbon dating and the precise chronological position of their lowermost levels can only be inferential. Here they are interpreted as late Glacial.

The absence of *Pseudotsuga* pollen in the LOK-1 sample is noteworthy. It is generally believed that *Pseudotsuga* pollen is greatly underrepresented in pollen assemblages. However, the sample from Reference Stand 7 indicates that in at least some stands in the Cascades, *Pseudotsuga* pollen is represented in proportion to its coverage. The high settling velocities of *Pseudotsuga* pollen result in impact of virtually all of the pollen within a few hundred meters of the source tree. However, its complete absence in the LOK-1 sample probably indicates that it was not important or vigorous in the area at that time interval. The climate on surrounding upland slopes may have been too extreme for abundant pollen production by *Pseudotsuga*. The extremely low growth rate of the *Pseudotsuga* specimens favors this interpretation. Furthermore, there is some evidence from modern stands to suggest that *Pseudotsuga menziesii* is proportionally underrepresented in the pollen rain in higher elevation stands as compared with low elevation stands (A. S. Gottesfeld and L. M. J. Gottesfeld, unpubl. data).

The fossil assemblage contains macrofossil material of subalpine fir, and the pollen assemblage, containing 8 percent *Picea*, suggests that stands including *Picea englemannii* were nearby. Jonassen (1950) reports that the proportion of *Picea excelsa* pollen in Denmark drops from 59 percent to 7 percent within 200 m of the edge of a spruce forest. *Picea englemannii* wood has been collected 1.8 km south of the LOK locality in glacio-fluvial deposits probably correlative to the varved sediments which overlie the LOK diamicton. The *Picea* wood occurs with wood of *Taxus brevifolia* and *Pinus* cf. *contorta*. *Picea englemannii* wood has also been recovered from a diamicton similar to the LOK sediments 1 km north of the sample locality. The LOK-1 pollen assemblage contains other indicators of subalpine conditions; e.g., *Pinus contorta, P. albicaulis, Tsuga mertensiana*, and high levels of non-fern herbaceous pollen (21 percent in LOK-1 vs. 2 percent in Reference Stand 7).

Today *Picea englemannii* is generally rare in subalpine communities of the western Cascades, being more characteristic of the eastern slopes of the Cascades and interior ranges. Franklin and Mitchell (1967) find *Picea englemannii* as an important associate of *Abies lasiocarpa* only on the eastern slope of the Washington Cascades, where the forests are transitional to the spruce-fir subalpine forests of the Rocky Mountains. In this area, *Tsuga mertensiana* is generally only a minor associate of *Abies lasiocarpa*, a situation similar to that shown in the LOK-1 pollen assemblage. On the east side of the Cascade Range, especially in Washington, *Abies lasiocarpa* and *Picea englemannii* are also important constituents of forests of deep glaciated valley floors and frost pockets, particularly at elevations above 800 m (Franklin and Mitchell, 1967; Franklin and Dyrness, 1973; Daubenmire and Daubenmire, 1968). In such sites, well developed *Abies lasiocarpa-Picea englemannii* stands may exist below slopes supporting trees of higher temperature requirements (topographic reversal of vegetation zonation).

This finding may be analogous to the situation at LOK-1 where the LOK-2 wood specimens indicate proximity of trees with higher thermal requirements.

The occurrence of pollen of *Picea englemannii* in the western Cascades as well as pollen of *Quercus?*, *Artemsia*, and Compositae at levels much higher than at present suggests a relatively dry as well as cold climate during this glacial event. Pollen records of the Willamette lowland such as those of Lake Labish, Onion Flats, Fargher Lake (Hansen, 1947; Heusser, 1965), show a major expansion of *Picea sitchensis* during the last glacial period, which suggests moist and cold conditions at that time. Such conditions are also proposed by Heusser (1964) for the corresponding late Glacial of the Olympic Peninsula. However, it is possible that *Picea englemannii* spread to the west side of the Cascades during the last glacial as well, as Hansen (1947) has identified this as the species of *Picea* abundantly represented in the basal levels of the Scotts Mills profile in the Cascade foothills east of Salem, Oregon, and at Lake Kachess in the central Washington Cascades at an elevation of 670 m. Heusser (1964) interpreted the high grass levels of his GL-2 Zone at Humptulips, Washington, which probably represents early Wisconsin glaciation, as being indicative of cold, dry conditions. This zone is interpreted by Heusser as marking the most intense glacial conditions of the past 50,000 years. It seems likely that the LOK-1 assemblage derives from this event or one of similar magnitude, since geomorphic and palynological observations together indicate an intense glacial event accompanied by probable drier climatic conditions.

The record of *Quercus?* pollen is problematic. Its occurrence in a spectrum otherwise clearly subalpine may be explained either as a) *Q. garrayana*, which normally occupies lowland dry sites such as Willamette Valley, but is also found at elevations up to about 1500 m on dry south facing cliffs and rocky slopes near the top of Lookout Mountain (G. M. Hawk and J. F. Franklin, pers. comm.) approximately 15 km east of the LOK-1 site; or b) as evidence for past occurrence in the Cascades of one of the subalpine oaks, *Q. saddleriana* or *Q. vaccinifolia* now restricted in Oregon to the Siskiyou Mountains; or c) as representing another taxon.

Gold Lake Bog Research Natural Area (Franklin, 1972) at 1463 m elevation in the Willamette Pass area of the central eastern Cascades may provide a modern analogue of the type of vegetation which produced much of the pollen rain to LOK-1. This *Abies lasiocarpa-Picea englemannii* dominated stand is located approximately 60 km south of the Lookout Creek drainage. Low lying forests bordering marshes and bogs are typically dominated by *Picea englemannii* and *Abies lasiocarpa*. However, reproduction is mostly *Abies amabilis* (J. F. Franklin, pers. comm.) and adjacent upland sites (1650 m elevation) are mixed with *Tsuga mertensiana, Abies magnifica* var. *shastensis, Pseudotsuga menziesii*, and *Pinus monticola* (Franklin and Dyrness, 1973).

Although the forest at Gold Lake Bog differs in several respects from a forest which would yield a pollen assemblage like that of LOK-1, such as the low importance of *Pinus contorta* and *P. albicaulis* and the high importance of *Tsuga mertensiana* in that area, it is useful as a site for evaluation of minimum vegetation displacement in the central Cascades of Oregon. This site, which is low in the subalpine zone (*Tsuga mertensiana* Zone of Franklin and Dyrness, 1973), is 1040 m above the LOK locality.

Carver (1973) and Scott (1977) present data for changes in equilibrium line altitude (ELA) during the late Quaternary glaciations in the Cascade Range based on study of glacial deposits and landforms. They conclude that the maximum late glacial ELA depression was 950-1000 m in the Mt. Jefferson area (Scott, 1977) and 1025 m in the Mt. McLoughlin area (Carver, 1973). The more extensive presumed early Wisconsin glaciation depressed the ELA 1100 to 1150 m in these areas. These data are in good agreement with the magnitude of altitudinal displacement of vegetation inferred from analysis of the Lookout Creek assemblage.

Summary

In the valley of Lookout Creek, a diamicton of presumed debris torrent origin contains a variety of plant macro- and microfossils representative of valley bottom and upslope Pleistocene forests. Locality LOK-1 within the deposit appears to have preserved a small piece of forest floor litter consisting of abundant leaves, twigs, and wood of *Abies lasiocarpa.* It has yielded a pollen and spore assemblage rich in *Picea* cf. *englemannii* and *Abies* cf. *lasiocarpa.* Dispersed in the deposit at locality LOK-2 are other wood specimens, some of which show abrasion and rounding indicative of transport. These have been determined as *Abies* sp., *Pseudotsuga menziesii*, and *Thuja plicata*, the latter two being species of generally warmer requirements than the other species represented in the deposit. These fossils suggest the occurrence of *Picea englemannii/Abies lasiocarpa* forest in a cold valley bottom surrounded by more xeric communities on adjacent hillslopes. Similar ecological situations commonly occur today in the eastern slopes of the Washington Cascades.

A somewhat similar localized association in the Oregon Cascades is found in the Gold Lake Bog Research Natural Area at an elevation 1040 m above the Lookout Creek localities. This estimate of vegetation displacement is consistent with estimates of maximum equilibrium line altitude depression during glaciations in the Oregon Cascades. The Lookout Creek assemblage is probably of Late Pleistocene age and may have formed during Early Wisconsin or a previous glaciation under conditions significantly drier than those prevailing during late Wisconsin glaciation.

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