MyDonald Forest

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Reprinted from

THE AMERICAN MIDLAND NATURALIST

Vol. 42, No. 2, pp. 473-479, September, 1949

The University Press
Notre Dame, Ind.

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"The American Midland Naturalist"
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Pollen Content of Moss Polsters in Relation to Forest Composition

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Introduction

Perhaps one of the most important problems in the reconstruction of prehistoric vegetation from pollen profiles of organic sediments is the degree of over- or under-representation of the several species recorded in the sedimentary column. There are several major factors that cause distortion of the picture of forest composition as manifested by the pollen profiles. These include the relative radius of pollen dispersal of the several species, the relative degree of pollen preservation, the direction of wind during the period of anthesis, and the relative amounts of pollen produced by the several species concerned. Yet other factors and conditions, too numerable to mention, are responsible for discrepancies in the accurate representation of species in adjacent forests. While all these sources of error are readily admitted by the pollen analyst, their distortion of the pollen record may be partially lessened by the slow rate of disposition of sediments and the number of years represented by the sample used for pollen analysis. Thus, annual variation in the amount of pollen produced may be nullified by a sample of peat representing several years of accumulation, predominance of one species due to wind direction one year may be offset by different wind direction the following year, and factors affecting reception and preservation may vary from year to year with a representative average over a period of several years. In the Pacific Northwest, the proximity of several associations to the sediments may tend to invalidate interpretation upon the basis of direct pollen proportions. Some of these errors may be reduced or eliminated by conservative interpretation. In the Pacific Northwest the writer has interpreted pollen profiles largely on the basis of long range and sustained trends. Fluctuations back and forth from level to level have been discounted or ignored with the feeling that they represent changes in local conditions due to external forces rather than to any widespread changes in forest composition. It is realized that fire and disease, particularly the latter when it is specific, may radically alter composition within a few years or less. This may change the relative abundance, increasing the proportion of the species that survive, but not actually increasing their abundance until the absence of competition by the former species has permitted them to expand.

The degree of distortion of the pollen profiles resulting from sources of error cannot be evaluated to any degree of accuracy. They are largely im-

1 The author is grateful to the John Simon Guggenheim Memorial Foundation for a fellowship during the year 1947-48 which enabled him to devote the time necessary to work out this project.

measurable and in some cases intangible, and consequently pollen analysts have been loathe to qualify their interpretations in the light of the known possibilities. Comparing the pollen proportions of the several species represented by recent pollen deposition with the forest composition, may shed some light upon the amount of error in limited areas. A device to trap the atmospheric pollen from day to day which has been set up within an area of known forest composition, pollen analysis of the living *Sphagnum* at the surface of a bog, or the analysis of moss polsters in favorable areas may help to give us an idea as to the degree of aberration in prehistoric pollen-bearing sediments. The kinds and proportions of pollen present should denote the radius of pollen dispersal of outlying species, the relative abundance of pollen produced, and the effect of wind direction at the time of anthesis. In regions of prevailing winds and different associations leeward and windward to the site of pollen accumulation, this influence may be evaluated.

METHODS

The purpose of this study is to show the degree of correlation between the present forest composition of a given area, and proportions of recently accumulated pollen preserved in moss polsters. So far as is known, only one comparative study of forest composition and recent deposition has been made in this country. Carroll (1943) found a fair degree of correlation between pollen content of bryophytic polsters and composition of a spruce-fir community in the Great Smoky Mountains. The area of the present study is in the McDonald Forest, located in the east foothills of the Oregon Coast Range, a few miles northwest of the city of Corvallis. The moist, warm climate of the Willamette Valley and Coast Range of western Oregon during the winter is favorable for a luxuriant growth of mosses, liverworts, and lichens. Trees, logs, and ground surface in the woods are literally covered with a dense layer of many species of bryophytes. The mosses continue to thrive until the dry weather of midsummer and are favorable for the reception and preservation of pollen from the surrounding forests.

A series of moss polsters was collected about the middle of May from various sites within the area of the forest in which the sample plots were taken. The polsters were about 6 inches square and consisted largely of the current year's growth, although in some cases the entire mat down to the tree trunk, log, or ground surface was included. The polsters were collected in a widespread pattern over the sample plot area, but with no regard to the location of the sample plots. Some were taken from logs, some from tree trunks, and others from the ground. They were taken in dense woods, in the open, in ravines, on knolls, on the south slope and on the north slope. Ten polsters were prepared for pollen analysis.

In preparation for microscopic analysis, the pollen and other fine material were removed from the moss polsters by violently agitating in about 1 liter of water. The moss polster was then dried and saved for reference. The pollen and other detritus were permitted to settle in the rinse-water, and about half of the water was decanted. To the remaining water, a few drops of potassium hydrate and gentian violet stain were added, and it was boiled for about 10 minutes. The sediment was then strained, washed, and centrifuged, and the pollen-bearing detritus mounted in glycerine jelly. From 75 to 255 pollen grains were counted from each polster (table 3).

FOREST COMPOSITION

The chief dominant on the east slope of the northern half of the Oregon Coast Range is Douglas Fir (*Pseudotsuga taxifolia*), with western hemlock (*Tsuga heterophylla*), lowland white fir (*Abies grandis*), and western red cedar (*Thuja plicata*) locally abundant on favorable sites. Less common, but occurring on a few isolated sites are noble fir (*Abies procera*) silver fir (*A. amabilis*), and western white pine (*Pinus monticola*). The only one of the last three that occurs near the area of this study is noble fir, which forms dense forests at upper timberline on Mary's Peak, about 10 miles southwest of the McDonald Forest. In the Willamette Valley Oregon white oak (*Quercus garryana*) is the most common broadleaf tree. It extends into the foothills, occupying the dryer south slopes and clearings on north slopes, and forms dense, pure stands on the valley floor.

In the immediate area of study, which involves the contiguous parts of 4 sections, Douglas fir and lowland white fir form the uppermost canopy, while bigleaf maple (*Acer macrophyllum*) and white oak form the next lowest stratum. On floodplains adjacent to the area red alder (*Alnus oregona*), Oregon ash (*Fraxinus oregana*), and cotton wood (*Populus trichocarpa*) are predominant. The lowest arborescent stratum in the area consists of western yew (*Taxus brevifolia*), madrona (*Arbutus menziesii*), and the flowering dogwood (*Cornus nuttallii*). The highest shrub layer is composed of cascara (*Rhamnus purshiana*), bitter cherry (*Prunus emarginata*), black haw (*Crataegus douglasii*), and vine maple (*Acer circinatum*). A second, lower frutescent stratum is also present, but pollen of the lower arborescent and the two frutescent layers is largely absent in the moss polsters analyzed.

In the northeastern part of the McDonald Forest about 4 miles from the area of this study is an arboretum in which there are many species of conifers not native to the Willamette Valley, including 22 species of pine. Also in the city of Corvallis and on the Oregon State College campus a few miles away are hundreds of species of trees not native to western Oregon. There are also many orchards in the adjacent Willamette Valley, including wind-pollinated species such as filbert and English walnut, but apparently the prevailing westerly winds have largely prevented the pollen of these trees from reaching the area where the moss polsters were collected.

RESULTS AND CONCLUSIONS

The statistical data to determine the quantitative relationships of the principal arborescent ~~species~~ were obtained by taking 100 sample plots, 25 feet square over the area ~~(Sprague and Hansen, 1946).~~ A box azimuth compass was used and plots taken at 3-chain intervals. The data obtained from the quadrats include frequency, abundance, basal area, and size classes, the first three based upon trees 1 inch and over DBH (table 1). Douglas fir is the most homogeneously dispersed with a freqeuncy of 76 per cent, while white oak is next with a frequency of 71 per cent. Big-leaf maple and lowland white fir are next with frequencies of 20 and 15 respectively.

With respect to abundance, oak constitutes almost 47 per cent and Douglas fir is second with 42 per cent of the trees over 1 inch DBH. White fir and bigleaf maple follow with about 6 and 4 per cent respectively (table 1). When trees under 1 inch DBH are included, Douglas fir is by far the most abundant with a total of 976 as compared to 505 for oak. Observation

TABLE 1.—Data from sample plots for trees 1 inch DBH and over.

Species	Frequency	Abundance No.	Abundance Per cent	Basal area in sq. ft.	Basal area in per cent	Average per cent of pollen
Pseudotsuga taxifolia	76	378	42.0	156.9	68.2	76.39
Quercus garryana	71	420	46.7	53.9	23.4	4.14
Abies grandis	15	60	6.6	3.0	1.2	2.87
Acer macrophyllum	20	40	4.4	16.7	7.2	0.36
Totals		898	99.8	230.5	100.0	83.76

has shown, however, that little or no pollen is produced by smaller trees, especially those under 3 inches. Douglas fir comprises about 50 per cent of the trees over 3 inches while oak tallies about 42 per cent (table 2). The pollen-percentage average for the ten polsters reveals about 76 per cent for Douglas fir and slightly more than 4 per cent for oak (table 3). Abundance of trees over 3 inches, then, correlated with the average pollen proportions shows that Douglas fir is over-represented by 26 per cent and oak is under-represented by 38 per cent. Of trees over 10 inches, Douglas fir constitutes 80 per cent and oak about 12 per cent (table 2). The latter size-class is more correlative with the pollen averages, with Douglas fir under-represented by 4 per cent and oak by 8 per cent. The basal areas of Douglas fir and oak are somewhat correlative with the pollen statistics. The former constitutes 68 per cent of the total basal area of trees 1 inch and over, while oak composes about 23 per cent (table 1). In this respect, Douglas fir is over-represented by 8 per cent and oak is under-represented by 19 per cent. Data from the sample plots show that lowland white fir is over-represented in basal area and correctly represented by abundance (tables 1, 2). Bigleaf maple, however, is definitely under-represented both from the standpoint of basal area and abundance. This is to be expected because maple is not anemophilous and its pollen is probably sparsely disseminated. The four principal species of the area, then, are represented by pollen-percentage averages in order of their abundance, but white oak and bigleaf maple are under-represented while Douglas fir is slightly over-represented.

The four species discussed above are represented by a total average of about

84 per cent of the pollen in the ten polsters (table 3). Eight other woody species, mostly large shrubs, that occur in the quadrats are not represented by pollen, while at least 9 species, represented by pollen, do not appear in the quadrats. In fact some of them do not occur in the McDonald Forest, except one or two in the arboretum 4 miles away. Of these nine species, red alder is best represented with an average of more than 7 per cent (table 3). Alder is abundant along stream courses and produces a tremendous amount of pollen. Also it is abundant on burns in the main Coast Range a few miles to the west. The next best represented exotic species is western hemlock, with an average pollen percentage of 3.6 (table 3). Although hemlock was not encountered on the sample plots, there are a few specimens in the McDonald Forest and it is abundant on Mary's Peak 10 miles to the southwest. Apparently the prevailing westerly winds were instrumental in disseminating its pollen to the east. Lodgepole pine (*Pinus contorta*) is represented by an average of almost 2 per cent, although it does not occur in the sample plot area, but is present in the arboretum. Pollen identified as pine may include that from many species that are used ornamentally in Corvallis or in the Willamette Valley. Noble fir, another exotic, tallies an average of 1.28 per cent, but apparently the source of its pollen is Mary's Peak, where it is the upper timberline tree. Pollen identified as that from white pine and ponderosa pine (*Pinus ponderosa*) constitutes less than 1 per cent and spruce (*Picea*) tallies .66 percent. The source of this is unknown, but it probably came from ornamentals. The other broadleaf species are represented by a trace, namely Oregon ash and hazel (table 3). The latter may have come from cultivated filberts in the valley and the former from stands of ash along the stream courses.

TABLE 2.—Number of trees in pollen-producing size classes.

Species	3″-10″	10″ and over	Per cent of 3″ and over	Per cent of 10″ and over	Average per cent of pollen
Pseudotsuga taxifolia	154	130	49.4	80.2	76.39
Quercus garryana	220	19	41.6	11.7	4.14
Abies grandis	18	4	3.8	2.4	2.87
Acer macrophyllum	19	9	4.8	5.5	0.36
Totals	411	162		99.8	83.76

The order of abundance and importance of the principal species in the area agrees with the order of their average pollen-percentages. White oak is under-represented to a greater degree than Douglas fir is over-represented. Pollen analysis of three sedimentary columns in the Willamette Valley reveals an influx of oak with pollen proportions as great as 65 per cent in the upper-third of the sections (Hansen, 1942). The chief other species represented during this period is Douglas fir, so it seems probable that oak is under-represented in the sections, and that it was more abundant than the pollen statistics would indicate.

TABLE 3.—Number and per cent of pollen grains obtained from moss polsters.

Species	Douglas fir log		Ground under Douglas fir		On knoll in open		Stump on top of hill		Top of hill		On oak in Douglas fir woods		Top of hill, Douglas fir and maple		Open, south slope		Oak woods		Log in damp ravine		Average
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Pseudotsuga taxifolia	166	83	60	60	180	70.6	156	78	90	75	160	80	153	76.5	68	90.6	100	76.9	110	73.3	76.39
Quercus garryana	3	1.5	12	12	19	7.4	8	4	3	2.5	8	4	6	3			4	3.0	6	4.0	4.14
Abies grandis	12	6	4	4	8	3.1	1	0.5	1	0.6	8	4	6	3	2	2.7	3	1.5	5	3.3	2.87
Acer macrophyllum					1	0.4			3	2.5							1	0.7			0.36
Alnus oregona	6	3	10	10	35	13.7	10	5	17	14.1	4	2	13	6.5			13	10	14	9.3	7.36
Tsuga heterophylla	5	2.5	2	2	9	3.5	4	2	3	2.5	12	6	8	4	2	2.7	7	5.3	8	5.6	3.61
Pinus contorta	2	1	4	4	2	0.8	8	4			4	2	6	3	1	1.3	1	0.76	3	2	1.88
Abies procera			2	2			7	3.5	2	1.3	4	2	4	2			1	0.7	2	1.3	1.28
Pinus monticola	2	1	4	4	1	0.4	4	2	1	0.8					1	1.3					0.75
Picea sp.			4	4									4	2					1	0.6	0.66
Pinus ponderosa							2	1							1	1.3	1	0.76			0.4
Fraxinus oregana																			1	0.6	0.06
Corylus spp.	4	2																			0.2
Totals	200		100		255		200		120		200		200		75		130		150		99.96

SUMMARY

A comparison of the composition of a Douglas fir-white oak community with the modern pollen deposition in the area reveals the degree of over-and-under-representation of the anemophilous arborescent species present and the influence of exotic species in distorting the pollen statistics.

On the basis of the number of trees 1 inch and over DBH, Douglas fir constitutes 42 per cent and is recorded by about 76 per cent of the pollen. White oak comprises almost 47 per cent and is represented by slightly more than 4 per cent of the total pollen. Further correlation with abundance shows that trees 10 inches and over are more accurately represented. In this respect, Douglas fir constitutes 80 per cent while oak comprises 12 per cent. On this basis Douglas fir is under-represented by about 4 per cent and oak by about 7 per cent.

When basal area is considered, Douglas fir constitutes 68 per cent and oak 23 per cent, resulting in over-representation of oak by 19 per cent. Lowland white fir with a basal area of 2.4 square feet of trees 10 inches and over and a pollen average of 2.8 per cent is fairly accurately represented. Bigleaf maple is well under-represented on all bases of comparison, probably because it is not wind-pollinated.

Arborescent species not in the area of sampling are represented by an average of about 16 per cent of the total pollen. Among these, the pollen proportions of western hemlock and noble fir reflect the influence of the prevailing westerly winds, carrying their pollen from the Coast Range a few miles to the west. Pollen of other exotic species probably came from ornamental plantings with the exception of red alder which is abundant on floodplains in the area.

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