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Orcas Island

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A POLLEN STUDY OF TWO BOGS ON ORCAS ISLAND, OF THE SAN JUAN ISLANDS, WASHINGTON[1]

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INTRODUCTION

The San Juan Islands lie between the mainland of the state of Washington and the southern end of Vancouver Island, about 75 miles from the Pacific Ocean through the Strait of Juan de Fuca. Orcas Island is one of the largest and most northern of the group. It is about 11 miles in extent from east to west, and about 9 miles from north to south. The highest point is Mt. Constitution with an elevation of about 2400 feet. The San Juan Islands were glaciated during the Pleistocene (Bretz 1913), and the higher areas are rocky with little soil. Lower areas near sea level are covered with glacial drift and glacio-lacustrine and glacio-fluviatile deposits. The climate of the San Juan Islands is mild and somewhat drier than that of the Puget Lowland to the east and south. The mean annual precipitation at Olga, at the southern tip of Orcas Island, is about 29.5 inches, and at the north end of East Sound it is slightly over 30 inches. (Climatic Summary, U. S. D. A., 1936.) At San Juan, on San Juan Island, a few miles to the west and south, the mean annual precipitation is about 22.5 inches, while at Anacortes on the mainland to the southeast it is about 27 inches. About 15 per cent of the precipitation occurs during the growing season. In some areas the porosity of the soil permits rapid drainage, whereas in others the absence of much soil results in rapid run-off. The prevailing winds are from the west.

LOCATION AND CHARACTERISTICS OF THE BOGS

One of the bogs is located near the summit of Mt. Constitution on the northeastern part of the island, while the other is situated near sea level at the southern end of the island. There are several bogs on Mt. Constitution, one of which has been described by Rigg and Richardson (1934). The one of this study is several acres in extent and is covered largely with sedge (*Carex* spp. and *Cyperus* sp.) and Labrador tea (*Ledum groenlandicum*). Other of the more common plants are hardhack (*Spiraea douglasii*), salal (*Gaultheria shallon*), cottongrass (*Eriophorum chamissonis*), sundew (*Drosera rotundifolia*), and twinflower (*Linnaea borealis americana*). Trees on the bog in their apparent order of invasion are lodgepole pine (*Pinus contorta*), western hemlock (*Tsuga heterophylla*), and Sitka spruce (*Picea sitchensis*), the first being the most abundant.

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The lowland bog is situated at the west end of Killebrew Lake, about three-quarters mile north of Grindstone Bay, and about 10 miles southwest of Mt. Constitution. The lake supports various stages of hydrarch plant succession, including submerged, floating, and cattail-bulrush associes. On the bog grow purple marshlocks (*Potentilla palustris*), buckbean (*Menyanthes trifoliata*), spike-rush (*Eleocharis acicularis*), and *Dulichium arundinaceum*. Many other species of bog and marsh plants are present, but those mentioned seem to be characteristic of the associes.

Peat samples were obtained at quarter-meter intervals with a Hiller peat borer. The depth of the Mt. Constitution bog is 9 meters in the area of sampling, and the Killebrew Lake bog is 9.5 meters deep. A stratum of volcanic ash occurs between 7 and 7.5 meters in the montane bog, and at 7 meters in the lowland bog. Ash fragments are scattered throughout a half-meter thickness of peat, but are most abundant at these levels. The relative stratigraphic position of the ash layers is similar to that of most peat profiles in northern Washington, suggesting that the source of the ash was the same volcanic action. According to geologists, the most probable source is Glacier Peak in the Cascades of northern Washington.

In the Mt. Constitution bog, fibrous peat occurs close to the bottom underlain by only a thin stratum of sand and silt resting directly on bedrock. This denotes that the proximity of the original pond to the summit of the mountain prevented the erosion of considerable sand and silt into it, which is often the case in Pacific Northwest bogs. The presence of pollen in these lowest levels, however, indicates that forest invasion of adjacent areas began soon after glacial retreat. The Killebrew Lake bog has a much greater thickness of silt and clay underlying the organic peat. In preparation of the peat for microscopic analysis, the potassium hydrate method was employed. From 100 to 200 pollen grains were identified from each horizon. In identification of the winged conifer pollen, the size range method was used (Hansen 1941a, 1941b, 1941c). The tables showing the percentages of conifer pollen and the number of non-significant pollen grains of herbs, grasses, and deciduous trees are omitted because of the unusual scarcity of the latter. Those species recorded as 1.5 per cent or less are shown on the diagram as 1 per cent.

FORESTS OF THE SAN JUAN ISLANDS

The San Juan Islands lie within the hemlock–cedar climax formation of the Coast Forest (Weaver & Clements 1938). Certain factors of the environment, however, are apparently unfavorable for western hemlock and western red cedar (*Thuja plicata*) to thrive as the principal dominants. These islands are also within the Humid Transition life area (Piper 1906). Forest type maps (1936) show that the San Juan Islands are forested largely with second-growth Douglas fir and subalpine and noncommercial types. Mt. Con-

stitution is forested chiefly with lodgepole pine (*Pinus contorta*), with some Douglas fir (*Pseudotsuga taxifolia*) and western hemlock, and scattered specimens of western white pine (*Pinus monticola*) and lowland white fir (*Abies grandis*). The hills adjacent to the Killebrew Lake bog are forested with second-growth Douglas fir, and some hemlock, lowland white fir, western red cedar, Sitka spruce, and western white pine. The most common broadleaf species are largeleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and cottonwood (*Populus trichocarpa*). In dry exposed areas on the south slopes, Oregon white oak (*Quercus garryana*) occurs, while the presence of prickly pear (*Opuntia fragilis*) reflects the dryness of the summers.

In the hemlock–cedar formation of the Puget Lowland of western Washington, Douglas fir persists as subclimax and the chief dominant because of recurring fire during the past (Munger 1940). Over much of the area designated as being forested with this association, however, the environment is unfavorable for hemlock and cedar. In some of these areas Douglas fir thrives as the chief dominant even though fire does not occur. It is suggested that the climate is too dry for hemlock to supplant Douglas fir in the course of normal, uninterrupted forest succession (Munger 1940). The east slope of the Coast Range and the Willamette Valley of western Oregon are examples of such regions. Not only is hemlock practically absent at the present time, but pollen profiles from these areas reveal that hemlock has played only a minor role during all or most of the post-Pleistocene (Hansen 1941a, 1942a). Insufficient rainfall is perhaps the main factor inhibiting hemlock from superseding Douglas fir, even in the absence of fire, but the edaphic and topographic conditions may also exercise some control. The annual precipitation in the Willamette Valley is greater than in parts of the Puget Sound region, where hemlock does replace Douglas fir in normal forest succession. The summer precipitation, however, is slightly less and may be the limiting factor in preventing hemlock from invading and assuming predominance. A lower humidity and greater amount of evaporation during the growing season may also be contributing factors. On Orcas Island, then, it seems probable that the annual rainfall, which is slightly less than in the Puget Sound region, and the dry summers are responsible for the comparative absence of hemlock from the forest complex. On the higher parts of the island, the rocky terrain is undoubtedly an additional factor instrumental in its scarcity.

POSTGLACIAL FOREST SUCCESSION

In both areas lodgepole pine was the predominant species when the lowest pollen-bearing sediments were deposited. In the montane bog it is recorded as 71 per cent (fig. 1), and in the Killebrew Lake bog as 69 per cent (fig. 2). The initial postglacial invasion of lodgepole pine in these areas is

consistent with that of many other regions of the Pacific Northwest (Hansen 1938, 1939a, 1939b, 1940a, 1940b, 1941a, 1942a). The trend of lodgepole pine is very different in the two profiles. In the Mt. Constitution bog, lodgepole pine increases from the bottom to 90 per cent at 8 meters, the highest proportion to which it is recorded in any bog thus far studied. It shows a general decrease from this maximum to the surface, fluctuating between 85 per cent at 7.25 meters and 44 per cent at 1 meter, its lowest proportion of the profile. It then increases to 60 per cent at the top. In the Killebrew Lake profile, lodgepole pine diminishes sharply from the bottom to only 7 per cent at 6.5 meters, and from this horizon upward, it fluctuates between 12 and 4 per cent. It is recorded as 6 per cent at the surface. Western white pine is next most abundantly represented, at the bottom and is recorded as 20 and 15 per cent in the montane and lowland bogs respectively (figs. 1, 2). In the Puget Lowland of western Washington, white pine was also one of the predominant pioneer invaders. It diminishes slightly upward from the bottom, but it remains generally constant throughout both profiles, fluctuating between 12 and 1 per cent in the montane bog, and 14 and 1 per cent in the other.

Douglas fir also differs in its successional trends as recorded in the two profiles. In the Mt. Constitution bog, it is recorded as 3 per cent at the bottom, and fluctuates between this and nothing to 6.5 meters (fig. 1). It is then recorded as slowly increasing upward in the profile, reaching its maximum proportion of 30 per cent at 1 meter, and then declining to 15 per cent at the top. In the Killebrew bog, Douglas fir is recorded as 7 per cent at the lowest level, and then increases sharply to its maximum of 67 per cent at 5 meters (fig. 2). It shows a slight decline from this horizon to the surface, where it is represented by 52 per cent of the conifer pollen present.

In the montane bog, western hemlock exhibits somewhat the same general trend as Douglas fir, but it does not reach such high proportions as low in the profile (fig. 1). Its maximum is 30 per cent at 2 meters, and it then diminishes to 17 per cent at the uppermost level. In the lowland bog, hemlock is recorded more abundantly, as is Douglas fir (fig. 2). It increases lower in the profile and attains proportions of 20 per cent at 7.5, 6.5, 4.75, and 3.75 meters, and then declines and remains constant to the top where it is represented by 14 per cent. This species does not reach higher proportions in the Killebrew bog, but it is more consistently represented by greater proportions throughout the profile than in the montane bog.

Other forest trees recorded in appreciable proportions are Sitka spruce and fir. Spruce is represented more abundantly and consistently in the lowland bog (figs. 1, 2). Here its greatest proportion is 9 per cent at the bottom; in the montane bog it attains 7 per cent at 7 meters. This is consistent, because spruce thrives better near the ocean than at higher elevations farther

inland. Fir pollen is listed under the genus only, since the pollen of all species except lowland white fir is only sporadically present. The other species whose pollen was noted are noble fir (*Abies nobilis*), silver fir (*A. amabilis*), and alpine fir (*A. lasiocarpa*). None of these species was noted on Orcas Island, although they may have existed there in the past. Possible sources of their pollen are the other San Juan Islands, Vancouver Island, or the Olympic Peninsula, because of the prevailing westerly winds. Silver and alpine fir are common in the Olympic Mountains, but the occurrence of noble

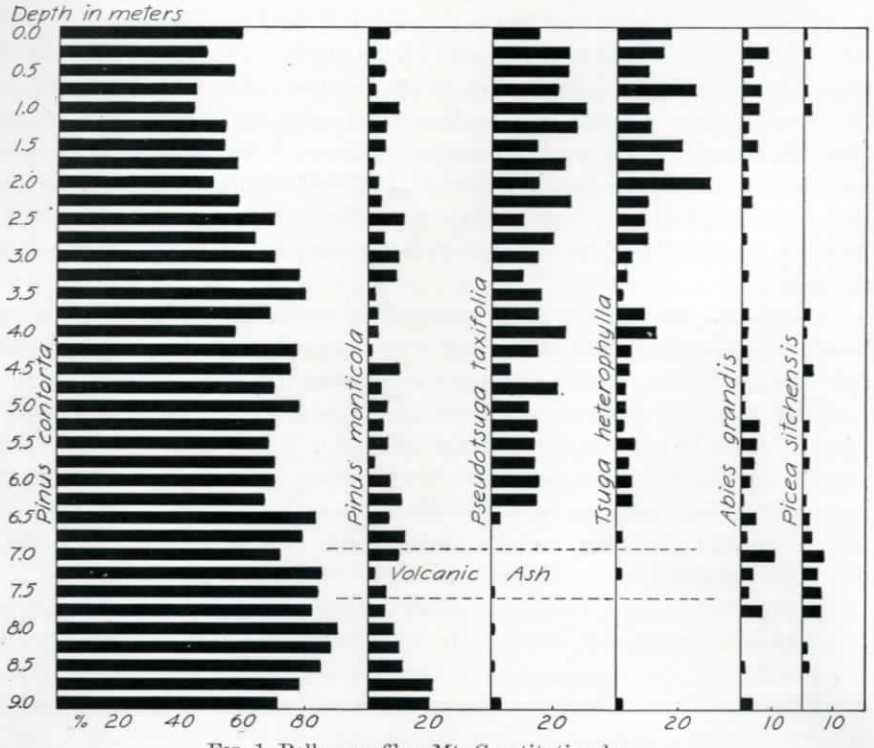

FIG. 1. Pollen profiles. Mt. Constitution bog.

fir is not certain. Noble fir was reported by Sudworth (1908), but Jones (1936) in an extensive study of the flora of the Olympic Peninsula, was unable to find it. This does not exclude the possibility of its existence in the past, and pollen of this species was present in the upper levels of the profiles. A pollen study of a bog on the west side of the Olympic Peninsula also reveals the presence of noble fir pollen, but not in the uppermost level (Hansen 1941d). Fir pollen is more consistently abundant in the Killebrew Lake bog, which is logical because lowland white fir thrives best in low, damp areas. The greatest proportion attained by fir pollen is 16 per cent at 7.25 meters

and at the surface in the lowland bog (fig. 2), whereas in the montane peat deposit it reaches a maximum of 11 per cent at 7 meters and is not present at all horizons (fig. 1). Mountain hemlock (*Tsuga mertensiana*) is sporadically represented in both profiles. Pollen of this species may have come from Vancouver Island or the Olympic Mountains, although it also may have

FIG. 2. Pollen profiles. Lake Killebrew bog.

existed in the San Juan Islands earlier in post-Pleistocene time. Broadleaf trees represented by their pollen are red alder and largeleaf maple, both of which are more abundantly recorded in the Killebrew Lake bog. Sedge pollen increases and yellow pondlily pollen diminishes in abundance upward in both profiles, marking the progress of hydrarch plant suuccession in the bog.

INTERPRETATION OF THE POLLEN PROFILES

The trend of postglacial forest succession in the lowland area of Orcas Island, as portrayed by the pollen profiles of the Killebrew Lake bog, is somewhat similar to that of the Puget Sound region (Hansen 1938, 1940a, 1941a). Pollen analyses of peat deposits there reveal that lodgepole pine was the pioneer postglacial invader and was rapidly supplanted by Douglas fir.

Western hemlock increased more gradually than Douglas fir, but eventually superseded the latter and remained slightly predominant until the advent of white man. In areas adjacent to Killebrew Lake, however, hemlock was never so abundant as in the Puget Sound region, and Douglas fir has maintained a wide degree of predominance since it superseded lodgepole pine. This substantiates the theory that the lack of moisture, particularly in dry summers, on Orcas Island, has prevented hemlock from reaching proportions similar to those in the Puget Sound region. The importance of abundant moisture for the development of hemlock is further corroborated by its predominance in post-Pleistocene forest succession along the Oregon Coast, where the annual precipitation varies from 70 to over 100 inches (Hansen 1941c).

On the summit of Mt. Constitution the thin soil mantle has probably been as important as moisture in controlling forest succession. In fact the rocky terrain, causing rapid run-off, tends to accentuate the dearth of available water for tree growth. Glacial scour left little soil and only a thin layer of residual soil has developed since deglaciation. The much greater intolerance of lodgepole pine for shade than Douglas fir and hemlock, has been compensated for by the edaphic conditions unfavorable for the latter two species. Lodgepole pine has consequently been able to successfully compete with these species. That lodgepole pine is able to thrive under edaphic conditions adverse for other species is shown by its pioneer invasion of areas formerly covered by Pleistocene glaciers in Washington, young sand dunes on the Oregon Coast, climax bogs, pumice mantles in central Oregon, burns, and other edaphically disturbed regions (Hansen 1941c, 1942b, 1942c).

There is little or no evidence for post-Pleistocene climatic trends in the forest succession as portrayed by the pollen profiles. The low proportion of hemlock pollen throughout both profiles in itself, however, denote that it has been too dry for its development to predominance, such as occurred in the Puget Sound region. The rather local representation of the surrounding forests in each respective bog, raises the question as to the size of an area that is represented by its tree pollen in a bog. The small size of the island, restricting the source of the pollen, may tend to accentuate this degree of localization.

SUMMARY

Pollen analyses of two peat deposits on Orcas Island, Washington, reveal different trends of post-Pleistocene forest succession in their respective adjacent areas. In both bogs, lodgepole pine is recorded as having been the predominant, pioneer, postglacial invader. In areas surrounding the montane bog, lodgepole pine maintained predominance throughout the postglacial period to the present. The existing forests are composed chiefly of lodgepole pine. In areas adjacent to the other bog, near sea level, lodgepole

pine was early replaced by Douglas fir which remained predominant during the rest of the post-Pleistocene. The San Juan Islands are located within the hemlock–cedar climax, but hemlock neither superseded nor became nearly so abundant as Douglas fir during the postglacial. This was probably due to the low summer precipitation and the unfavorable edaphic conditions for hemlock. There is little evidence for climatic trends, and it is probable that the ocean has served to maintain an equable climate during postglacial time.

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