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POSTGLACIAL FORESTS IN THE YUKON TERRITORY AND ALASKA*

HENRY P. HANSEN

ABSTRACT. Pollen analysis of peat sections from 74 sites of organic sedimentation in the Yukon Territory and Alaska reveals a record of the forests that have existed within range of pollen dispersal for all or most of the time since this region was freed of the last glacier. Sections along the Alaska Highway in the Yukon indicate that lodgepole pine (*Pinus contorta latifolia*) has been abundant during the time represented and predominant over spruce throughout most of the sections as far as milepost 931, about 15 miles northwest of Whitehorse. The present range of lodgepole pine does not extend far beyond this point, indicating that its postglacial range has not differed significantly from its present range. The early appearance of pine pollen in these sections substantiates theories and evidence that pine persisted in unglaciated areas in west-central Yukon during the Wisconsin glacial age.

From milepost 931 to the Yukon-Alaska border, and throughout interior Alaska, spruce has been the predominant forest tree, and in most sections it is recorded to nearly 100 per cent. In the Fairbanks and Anchorage regions white birch (*Betula papyrifera* vars.) is significantly represented, while aspen (*Populus tremuloides*), very abundant at present, is not represented in the sections because its pollen is poorly preserved.

Climatic trends are not clearly expressed, although in the Yukon Territory sections, the general increase of lodgepole from bottom to top suggests amelioration of climate in more recent time. Chronology is likewise indefinite. Radiocarbon dating of post-Wisconsin peat in the Anchorage area suggests an accumulation rate of 600 years per foot, which when applied to a section of this study near Anchorage, about 7 meters deep, indicates an age of more than 13,000 years. Another radiocarbon date for peat on the Kenai Peninsula indicates a depositional rate of about 800 years per foot which, when applied to the Anchorage section, denotes an age of over 18,000 years. The author believes that on the average the sections from interior Alaska and in the Yukon Territory represent an age up to 5000 years, while the deeper sections near the coast are somewhat older.

INTRODUCTION

DURING the latter part of the summer of 1950, 75 peat sections were obtained from muskegs, bogs, swamps, and other sites of organic sedimentation in Alaska, the Yukon Territory, and British Columbia (fig. 1). The pollen profiles

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and other data derived from these sedimentary columns present a general picture of the forests that have existed in this vast region since the last glaciation, as well as some indication of climatic trends during the period represented. The pollen record as interred in these sections with that of 65 others along the Alaska Highway in British Columbia and farther south in Alberta provides a tentative history of the postglacial forests and climatic trends for western Canada and Alaska. Although this record is based upon only 140 sections taken along the principal highways, the relatively small number of forest tree species and the rather consistent and homogeneous structure and composition of the forests should permit a fairly representative picture of most of the region as indicated by the pollen profiles. Also the results of this study so far have presented to the author information and data which suggest how the problem should be continued on both more intensive and extensive scales.

Because this is a preliminary study and covers as much of the region in a general way as possible under the time limitation, the collection of sedimentary columns has been confined to sites largely adjacent to the main highways. Secondary highways are few and often impassable after rain, which occurs all too often during the late summer. As more side roads are constructed, the author hopes to continue with the problem.

LOCATION AND CHARACTERISTICS OF THE SEDIMENTATION SITES

A transect of 36 sections was obtained along the Alaska Highway from the Yukon-British Columbia border to the Alaska-Yukon boundary, a distance of almost 600 miles (table 1). Five of these columns were taken in British Columbia between mileposts 733 and 786 where the highway swings south of the Yukon border. Two more sections were obtained in the Yukon on the Haines Highway, which connects Haines Junc-

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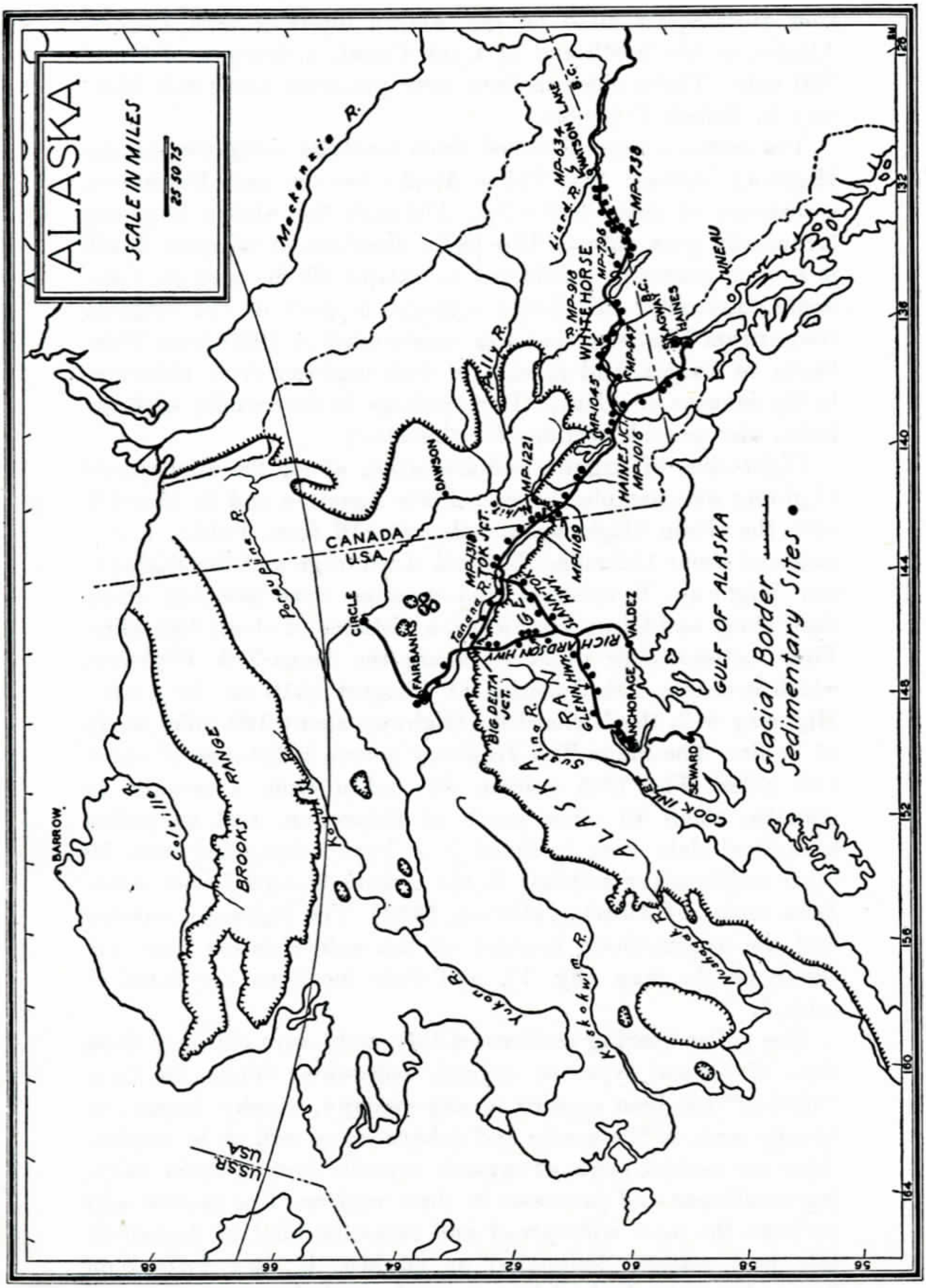

Fig. 1. Generalized map of Alaska and the Yukon. Sites from which peat sections were obtained are shown by dots. Glacial boundaries from map by Capps, 1931. Modified from U. S. G. S. Alaska Map A.

tion at milepost 1016 on the Alaska highway with Haines, Alaska, at the north end of Lynn Canal, a distance of about 160 miles. Three other sections were procured along this highway in British Columbia.

Ten sections were obtained from muskegs along the Alaska Highway between the Yukon-Alaska border and Fairbanks, a distance of about 300 miles. Although the Alaska Highway technically goes only to Big Delta Junction at milepost 1420, it is now generally considered to extend all the way to Fairbanks. Actually, this latter segment is part of the original Richardson Highway that was constructed in 1920 from Fairbanks to Valdez, and it was the first highway from tidewater to the interior of Alaska. Two muskegs in the vicinity of Fairbanks also provide sections for this study.

Eight sites of organic sedimentation along the Richardson Highway were sampled between Delta Junction and its junction with the Glenn Highway at milepost 116 from Valdez, a distance of about 152 miles. Between Anchorage and the Richardson Highway, 9 muskegs and swamps were sampled along the Palmer and Glenn Highways, a distance of about 190 miles. Four sections were procured along the Slana-Tok Highway, which connects Tok Junction at milepost 1318 on the Alaska Highway with the Richardson Highway about 129 miles north of Valdez. The Slana-Tok Highway covers a distance of about 135 miles. The 75th column was taken from a muskeg in Alberta, about 75 miles north of Edmonton, and its pollen analytical data were included in a paper concerned with 10 other sedimentary columns in the Grande Prairie-Lesser Slave Lake region of Alberta (Hansen, 1952). The highways traveled and the approximate location of the sedimentation sites are shown on the map (fig. 1), and their locations are listed in table 1.

The pollen-bearing sections of this study were obtained from sites of several types of organic sediments. While the term "muskeg" has been applied to any swampy, marshy, boggy, or spongy area in the arctic and subarctic, as well as to tundra, there are several types of organic deposits formed under varying conditions and processes in these regions. The typical and perhaps the most widespread and extensive kind of deposit in this vast region, designated as muskeg, is that formed on flat and poorly drained terrain, and which has been built up largely by one or more species of *Sphagnum* and ericaceous shrubs. Sedges also may be associated with the moss and shrubs and consist mostly of cottongrass (*Eriophorum* spp.) and *Carex*. Forbs and grasses also may be abundant although their presence and the species depend upon the amount of moisture present. This type of vegetative cover was apparently developed in the absence of ponded water and without the initial stages of hydrarch succession. This has been possible in a semi-arid region by the growth of *Sphagnum* on the surface in the presence of a high water table held up by permafrost. The accumulating vegetal material served as insulation which prevented the permafrost or seasonal frost table from receding downward in summer. This raised the water table higher, and with the absorbent plant remains acting as a wick, favorable conditions were maintained for continued organic deposition. The absence of pollen or aquatic plants in the lowest sediments as well as in the underlying clay and silt lends credence to this view (Hansen, 1949*a*, 1950*a*). The writer has suggested that the southern limit of muskegs formed by this process may approximate the southern limits of permafrost developed during and after the last glaciation (Hansen, 1952). In fact, it seems hardly possible that muskeg development could have been initiated in a region with an annual precipitation of less than 15 inches without the presence of permafrost except in lakes and ponds. Amelioration of the climate to a degree that would eliminate the permafrost also would possibly result in the extinction of many muskegs formed on flat terrain. Frozen substrata were noted farther south in muskeg than in inorganic substratum along the Alaska Highway, although this may merely emphasize the insulative qualities of the vegetative cover.

Shrubs commonly occurring on this type of muskeg include *Ledum groenlandicum*, *L. palustre decumbens*, *Andromeda polifolia*, *Chamaedaphne calyculata*, *Kalmia polifolia*, *Vaccinium oxycoccus*, *V. uliginosum*, *V. vitis-idaea minus*, *Empetrum nigrum*, *Betula glandulosa*, *Rubus chamaemorus*, and *Salix* spp. The most common tree is black spruce (*Picea mariana*). Tamarack (*Larix laricina*) was noted on bogs and muskegs as far as milepost 688 in the Yukon, and again in the Fairbanks region. An occasional lodgepole pine (*Pinus contorta latifolia*) was noted on muskegs in the Yukon, with an abundance observed on a muskeg at milepost 666. On some of the

TABLE 1

Peat Sections from the Yukon Territory

Miles from Dawson Creek, B. C.	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
634—Watson Lake			
647	5.7	5.6	Lake; marly; pine, spruce, birch, aspen adjacent
655	1.0	1.0	Sedge, ericads; pine, spruce adjacent
664	2.8	2.5	Sedge; pine, tamarack, spruce adjacent
666	4.5	4.2	Muskeg; spruce, pine, tamarack, ericads
681	1.5	1.5	Sedge bog; spruce, tamarack on bog
688	1.5	1.5	Muskeg; spruce, tamarack, pine on bog
699	1.5	1.5	Sedge, ericads, juniper; pine, spruce adjacent
707	1.9	1.5	Muskeg; spruce, ericads; pine adjacent
716	2.0	2.0	Lake; sedge, ericads; pine, spruce adjacent
724	2.0	2.0	Muskeg; spruce, ericads
737—British Columbia	2.9	2.9	Muskeg; spruce, ericads
748	0.7	0.7	Muskeg; burned
759	1.8	1.3	Muskeg; spruce, ericads
770	3.5	3.5	Muskeg; pine, spruce adjacent
779	2.0	2.0	Lake; pine, spruce adjacent
796—Yukon	1.0	0.8	Lake; sedge; pine, spruce adjacent
840	1.7	1.6	Sedge-sphagnum bog; pine adjacent
859	4.9	3.6	Lake; sedge, sphagnum
872	5.5	4.4	Sedge-sphagnum bog; pine, spruce adjacent
899	1.0	0.9	Pond; sedge; pine, spruce
918—Whitehorse			
923	2.0	0.6	Sedge-sphagnum bog
931	0.8	0.4	Muskeg; ericads; spruce, pine adjacent
947	1.4	0.1	Pond; sedge; sandy area

TABLE 1 (cont.)

Peat Sections from the Yukon Territory

Miles from Dawson Creek, B. C.	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
974—Champagne			
986	0.5	0.1	Sedge bog; spruce, aspen adjacent
1009	1.0	0.4	Sedge-hypnum bog; spruce, willow adjacent
1013	1.5	1.1	Pond; sedge; spruce, willow adjacent
1016—Haines Jct.			
1037	0.7*	0.7	Lake; sedge; spruce adjacent
1045	0.7	0.7	Muskeg; spruce, ericads
1102	0.6	0.4	Muskeg; spruce, ericads
1128	0.7	0.6	Sedge; burned
1164	1.0	0.8	Sedge; spruce, ericads
1170	0.52*	0.5	Muskeg; spruce, ericads
1189	0.5	0.4	Lake; spruce, ericads
1192	2.0	1.8	Lake; sedge, spruce, ericads
1200	0.52*	0.4	Muskeg; spruce, ericads
1221	0.52*	0.5	Muskeg; spruce, ericads

*Permafrost

TABLE 2

Peat Sections between Haines Junction, Yukon, and Haines, Alaska

Miles from Haines, Alaska	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
72 B. C.	1.0	0.9	Sphagnum; spruce, juniper
79 B. C.	0.7*	0.6	Sedge-sphagnum; willow; above timberline
84 B. C.	1.0	0.7	Sedge-sphagnum; few spruce on hillsides
103 Yukon	0.52*	0.5	Sedge-sphagnum; willow, spruce scattered
135 Yukon	0.5	0.1	Sedge-sphagnum; spruce adjacent

TABLE 3

Peat Sections along the Alaska Highway from Yukon Border to Fairbanks

Miles from Dawson Creek, B. C.	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
1248	0.52*	0.4	Muskeg; ericads, spruce
1270	0.5*	0.5	Muskeg; ericads, spruce
1297	0.52*	0.52	Muskeg; ericads, spruce
1299	0.52*	0.52	Muskeg; ericads, spruce
1318—Tok Junction			
1336	0.5*	0.5	Muskeg; spruce
1353	0.5*	0.5	Muskeg; spruce, ericads
1387	0.9*	0.9	Muskeg; spruce, ericads
1390	0.6*	0.6	Muskegs; ericads, spruce
1420—Big Delta Junction			
1463	0.5*	0.5	Muskeg; ericads, tamarack, spruce
1488	0.6*	0.5	Muskeg; ericads, tamarack, spruce
1523—Fairbanks (near)	2.0*	1.9	Muskeg; ericads, spruce
Fairbanks (near)	2.3	1.6	Small pond; aquatics, sedge, willow

*Permafrost at lowest level

drier and better-drained muskegs fire may favor an invasion of paper birch (*Betula papyrifera* var.), reindeer moss (*Cladonia* sp.), and hairy cap moss (*Polytrichum* sp.). Bunchberry (*Cornus canadensis*) also seems to be more abundant on burned muskegs. This type of muskeg becomes more shallow northward, and in the Tanana River valley; most of them sampled are about 0.5 meter deep (table 1). Farther south in British Columbia muskegs formed without evidence of an initial aquatic stage may be more than 5.0 meters deep (Hansen, 1949*a*, 1950*a*, 1952). Permafrost or a seasonal frost residuum was encountered in all muskegs sampled between the Yukon-Alaska border and Fairbanks, and southward in the Yukon to milepost 1037. Frost also was noted in muskegs along the Alaska Highway in British Columbia (Hansen, 1950*a*). In muskegs with a frozen substratum it was found that a thicker section of organic sediments could be obtained between the mounds than through them. The larger mounds, in which ice was encountered a foot or so from the surface, may be similar in structure and development to the "palsas" in Labrador described by Wenner (1947), in which almost pure ice occurs in large mounds covered with an insulating layer of *Sphagnum*.

Another type of site from which sections were obtained is the "niggerhead" muskeg which is characterized by tussocks or hummocks of one or more species of cottongrass (*Eriophorum* spp.). The tussocks may be as high as 18 inches from the crown of the roots down to the substratum between the columns of cottongrass roots. Standing water may be present between the hummocks or other plants may grow on the damp substratum between. *Hypnum* spp. frequently occurs between the hummocks, and bog birch and blueberry are also abundant on the "niggerhead" muskeg. The sediments in this type of muskeg were found to be shallow and silty, with little organic matter. Pollen analysis also reveals that little pollen is preserved in sediments accumulated under this type of vegetative cover.

Many of the sedimentary columns were obtained from sites of hydrarch succession that were initiated in lakes, ponds, sloughs, or in valleys with poor drainage. In most cases open water is still present with well-defined concentric zones of vegetation representing various stages of succession. Some support typical bog seres and culminate in Sphagnum-Ericad-black spruce cover. Many of them, however, apparently are progressing toward a sedge-willow-bog birch cover, especially in the Takhini Valley beyond Whitehorse and southeast of Whitehorse in the drier, parkland areas. The lower sediments in these muskegs often consist of marly deposits indicating an abundant source of calcium carbonate in the early aquatic stages of succession. Aquatic plants growing in some of these ponds are encrusted with calcium carbonate. The thickest organic sections were procured from bogs that have developed in ponded water, although in the lower levels pollen is often scarce. Permafrost was not found in sediments that accumulated in lakes, even in areas where it was encountered in the typical muskeg.

TABLE 4

Peat Sections along the Richardson Highway from Big Delta Junction to Glenn Highway

Miles from Fairbanks	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
119	0.6	0.5	Small pond; willow, birch, alder adjacent
126	0.5	0.5	Moss, sedge, on slope
167	1.0	0.5	Sedge, willow, sphagnum, bog birch
192	1.0	0.5	Small lake; spruce, ericads
196	1.5	1.3	Small lake; sedge
210	1.1*	0.7	Muskeg; ericads, bog birch, spruce
225	1.0	0.8	Lake; muskeg, ericads, spruce, bog birch

TABLE 5

Peat Sections between Anchorage and Junction of Glenn and Richardson Highways

Miles from Anchorage	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
Near city airport	0.6	0.5	Muskeg; spruce, bog birch, ericads, sundew, sphagnum
15	6.9	5.2	Lake; floating stage, ericads, white birch, bog birch
26	0.4	0.4	Muskeg; spruce, ericads
28	4.5	2.6	Wet; spruce, ericads, bog birch
88	3.0	2.7	Wet; spruce, ericads, bog birch, buckbean
122	0.6	0.5	Muskeg; spruce, ericads
141	0.5	0.5	Lake; ericads, sedges
151	2.0	1.8	Lake; ericads, sedges, floating stage
158	3.9	3.0	Muskeg; ericads, sedge, bog birch

TABLE 6

Peat Sections along Slana-Tok Highway between Richardson Highway and Tok Junction

Miles from Tok Junction	Total depth of section in m.	Depth of pollen profiles in m.	Characteristics of site
105	0.9	0.3	Lake; ericads, bog birch, willow
95	0.55	0.55	Muskeg; spruce, ericads; dry
65	3.0	1.4	Pond; limnic peat; Hypnum
36	2.0	0.9	Pond; floating stage; willow, alder, bog birch

The three types of sedimentary sites described above represent in general the source of most of the pollen-bearing sediments of this study. Each site differs in physical and floristic detail according to the immediate physiographic and edaphic conditions and the drainage pattern. Inasmuch as the sediments are merely a means to an end, namely, the pollen record interred therein, further detail here is of little significance to the problem at hand.

The thickest section, 6.9 meters, was obtained from a site adjacent to a lake about 15 miles inland from Anchorage. The typology reveals a typical hydrarch succession with the lowest horizons consisting of fine, colloidal, limnic sediments, grading upward into fibrous peat. The submerged and floating stages in the lake are somewhat similar to those in the Puget Lowland of western Washington (Hansen, 1947). No permafrost was encountered, and the section extends down to coarse, impenetrable gravel. In those muskegs where a frozen substratum was present, in most instances the frost table had receded downward during the summer to the inorganic sediments underlying the fibrous peat. In obtaining sections, the permafrost was penetrated at least a decimeter or more. Little or no pollen was noted in those sediments that had been frozen, except in places where they included the lower part of the organic material.

Five muskegs between milepost 1128 in the Yukon and 1270 in Alaska were underlain with pumice, but the source is unknown. Strata of volcanic glass, indiscernible to the naked eye but evident under the microscope, also occur in many of the sections along the Alaska Highway. Two of these ash horizons seem to be chronologically equivalent in the several sections in which they occur (figs. 2-7). One of these volcanic ash strata may have had its source in the St. Elias Range to the southwest. Capps (1916) assigned glass in the Fairbanks region to this source and set the date of the eruption about 1400 years ago. Volcanic glass has been noted by Heusser (1952) in bogs along the southeastern coast of Alaska. In the Sitka region, glass has been assigned to an eruption of Mt. Edgecombe 20 miles distant, and upon the basis of its stratigraphic position and the recorded forest succession has been dated at about 5500 years. Ash in the upper six inches of peat sections along the Alaska Highway in northeastern British Columbia has been ascribed to the eruption of Mt. Katmai in 1912, although Heusser finds no evidence of ash attributable to this source in the muskegs of southeastern Alaska. Kerr (1936) notes that postglacial volcanic activity occurred in mountains 50-60 miles east of Wrangell, possibly 100 years ago. Undoubtedly postglacial volcanic activity has occurred many times in the Coast Range of northern British Columbia and the mountains of Alaska, and it does not seem possible to assign the volcanic glass and pumice that occur in the sedimentary columns to any particular source. They may, however, serve as valuable chronological markers in correlating the recorded forest succession from muskeg to muskeg and from one area to another, when they can be identified.

The Alaska Highway has its southern terminus at Dawson Creek in eastern British Columbia about 12 miles from the Alberta-British Columbia border. It extends north and somewhat west through the rolling plains and the eastern Rocky Mountain foothills to Muskwa near Fort Nelson. It then turns almost due west and cuts through the Rocky Mountains and onto the Liard Plain (Bostock, 1948). The highway then follows up the Liard valley nearly to Watson Lake in the Yukon and continues westward across the Dease Plateau and the northern part of the Cassiar Mountains. On the Teslin Plateau it follows lake and river valleys to Whitehorse, the Takhini Valley and Shakwak Valley northwestward almost to the Yukon-Alaska border.

In the Yukon the Alaska Highway lies within the limits of Wisconsin glaciation, although it has not been determined to what extent the Late-Wisconsin ice covered this region (Flint, 1945, 1947; Denny, 1952). The last 25 miles before the Yukon-Alaska boundary, however, apparently were not covered by Wisconsin ice. Also less than 50 miles to the north of the highway in the Yukon River drainage there is a vast unglaciated region extending nearly 200 miles eastward into the Yukon and reaching northward almost to the Arctic Ocean (fig. 1).

The highway a short distance beyond the Yukon-Alaska border enters the Tanana River valley which it follows to Fairbanks. To the south of the Tanana River is the Alaska Range and to the north lies the interior plateau extending northward to the Brooks Range and drained by the Tanana and Yukon rivers. This area was not glaciated by Wisconsin ice because of low precipitation, and the poorly nurtured glaciers on the north slope of the Alaska Range were unable to flow out upon the plateau (Capps, 1931). Although the muskegs along the highway between the border and Fairbanks lie in an unglaciated region, their sites were undoubtedly modified by glacial meltwater from the Alaska Range which was carried westward by the Tanana River drainage.

The Richardson Highway, south of Big Delta, cuts through the Alaska Range following along in valleys and on tablelands. The Glenn Highway follows westward from its junction with the Richardson between the Talkeetna Mountains to the north and the Chugach Mountains to the south. It then extends down the Matanuska Valley to Palmer, then the Knik River to tidewater and along the Knik Arm of Cook Inlet to Anchorage. The Slana-Tok Highway follows through rugged country between the Wrangell and Mentasta Mountains and then emerges upon a flat terrace in the Tanana River valley for the last 25 miles to Tok Junction on the Alaska Highway. The muskegs and bogs along these highways that provide sedimentary columns for this study lie on sites that were glaciated by the Late Wisconsin ice and modified by meltwater during its recession.

FORESTS ALONG THE ALASKA HIGHWAY IN THE YUKON

The forests along the Alaska Highway in the Yukon Territory are comprised of nine arboreal species. These are white spruce (*Picea glauca*), black spruce (*P. mariana*), alpine fir (*Abies lasiocarpa*) lodgepole pine (*Pinus contorta latifolia*), tamarack (*Larix laricina*), aspen (*Populus tremuloides*), balsam poplar (*P. tacamahacca*), black cottonwood (*P. trichocarpa*), and paper birch (*Betula papyrifera* vars.). Sitka spruce (*Picea sitchensis*) occurs sparingly in southwestern Yukon near the Haines Highway. Phytosociologically only two of these, white spruce and alpine fir, are considered to be permanent or climax species. The others owe their persistence to either immature succession or disturbance such as fire, cutting, landslides, new floodplain deposits, rabbit depredations, and other disrupting factors. Fire, of course, has been by far the most significant and important factor in the persistence of the nonclimax species. It is evident that most of the area along the highway has burned recently or not far in the past. There is every stage of succession in evidence, resulting from the complete destruction of the forest over many square miles to partial destruction and small burns. Lodgepole and aspen have benefited most from fire, while white birch and the poplars may be favored under certain conditions. Tamarack is confined to muskegs and is only locally abundant. Black spruce is also chiefly a muskeg dweller, but the vast extent of the muskeg in this region and its lower susceptibility to fire than the upland forest permit this species to persist indefinitely in the absence of competition. Under the present climate and drainage it seems that the muskegs are permanent and black spruce may be considered as a physiographic climax. White spruce prefers the better-drained slopes and uplands, although it also thrives on floodplains where the soil is light. The poplars also occur on floodplains and sand bars where they may form almost pure stands. An understory of white spruce in the older stands, however, indicates the eventual replacement of the poplars. Paper birch is not abundant and rarely forms anything resembling pure stands. It often invades the drier muskegs after they have been burned, but it is most common on well-drained slopes where fire has occurred in the past; its relation to other species is not clear. Alpine fir is not common adjacent to the highway, but it occurs on the upper slopes and becomes the dominant tree at timberline at about 4000 feet (Halliday, 1937).

Of the nine arboreal species in the Yukon, lodgepole pine and alpine fir are Cordilleran in range. Lodgepole has a vast range, extending from Lower California to central Yukon and from the Pacific Coast eastward to the east slope of the Rocky

Mountains. In Canada it ranges eastward in Alberta to Smith and Edmonton and it also occurs as an outlier in the Cariboo Mountains south of Great Slave Lake (Raup, 1935). Alpine fir also extends eastward to central Alberta (Halliday and Brown, 1943). White and black spruce, balsam poplar, and tamarack are species of the boreal forest that extends in a broad band from the Gulf of St. Lawrence northwestward across Canada to Alaska, with the first three extending southward in the Rocky Mountains. Two other species of the boreal forest, jack pine (*P. banksiana*) and balsam fir (*A. balsamea*) range westward to north central Alberta, the former overlapping the range of lodgepole pine for 200 miles or more (Moss, 1949). Paper birch is also more or less coextensive with the spruces, but it breaks up into several varieties in the northwestern territories and Alaska. It is reasonable to assume that any species with as great a range as lodgepole pine must consist of a large number of biotypes, which is responsible for its wide ecologic amplitude.

The first species observed to drop out northward along the Alaska Highway is tamarack which was last noted in a muskeg at milepost 688, although it may extend farther at points remote from the highway. The only other arboreal species to reach the end of its range along the highway is lodgepole, which was last noted about 25 miles beyond Whitehorse at milepost 945. It is reported to occur as far northwest as Kluane Lake. The only portion of the Alaska Highway between Watson Lake and the Alaska-Yukon border that does not normally support forests is in the Takhini-Dezadeash valleys west of Whitehorse for a distance of about 100 miles. Here the soil is light and in some places sandy, with dune areas in the vicinity of Champagne. The vegetation has a natural parkland appearance, with scattered stands of white spruce, aspen, willow, and open grassy areas with an abundance of forbs. In the Kluane Lake region and westward almost to the Alaska border the forest consists almost entirely of white spruce, although black spruce was again noted in the White River valley and is also common in the Tanana River valley in Alaska.

In general, it can be said that the principal forest mixture or type along the Alaska Highway in the Yukon is white spruce, lodgepole pine, and aspen. Between Watson Lake and Whitehorse, pine forms vast pure stands on the lighter soils and in other areas where fire has been frequent. White spruce usually predominates on the heavier clayey soils in well-drained upland areas, while black spruce usually occupies muskeg on the valley floors, although it may also occur in upland communities of white spruce and pine, especially on northern exposures. It appears that aspen is a fire species that prospers after several frequently recurring fires that first kill the spruce and/or pine and then their reproduction. Aspen, growing faster and sprouting by means of root suckers, thrives until it is replaced first by pine and then by spruce if the fireless interim is sufficiently long.

FORESTS OF ALASKA

Alaska has an area of 586,400 square miles, and its vegetation may be broadly classified as coastal forests, interior forests, and treeless tundra and grassland. The coastal forests of southeastern Alaska cover about 10 per cent, the lightly timbered interior forests about 60 per cent, and the nontimbered tundra perhaps 30 per cent (Heintzelman, 1951). These figures are merely estimates and differ from those of other observers of the region. Within each of these formations there are many localized types because of physiography, soil, climate, and fire.

The coastal forests of southeastern Alaska, from which there are no peat sections for this study, represent an extension of the coastal forests of Oregon, Washington, and British Columbia. These are comprised of Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), lodgepole pine, and silver fir (*Abies amabilis*). In addition, at higher elevations and under favorable conditions at sea level such species as Alaska cedar (*Chamaecyparis nootkatensis*), mountain hemlock (*T. mertensiana*), and alpine fir are present. The northernmost extension of the Coast Forest reaches Cook Inlet, with Sitka spruce ranging slightly farther north than western hemlock and Alaska cedar. Silver fir (*A. amabilis*) occurs at the southern end of the Alaskan coastal forest (Taylor, 1950; Munns, 1938). Broadleaf arboreal species in southeastern Alaska are paper birch (*Betula papyrifera* vars.), red alder (*Alnus rubra*), thinleaf alder (*A. tenuifolia*), Stika alder (*A. sinuata*), Douglas maple (*Acer Douglasii*), and northern black cottonwood (*Populus trichocarpa*). Several species of willows of tree stature are also present.

Since 1750 the valley glaciers in southeastern Alaska have been receding (Lawrence, 1950), affording deglaciated terrain open for invasion by the vegetation of the region. The general trend of succession seems to be initial invasion by alder and willow, and cottonwood, followed by Sitka spruce which largely replaces the less tolerant broadleaf species, with finally a climax of western hemlock and Sitka spruce. Lodgepole seems to be restricted largely to muskegs, while Alaska cedar also occurs in such habitats in addition to its occurrence at timberline with alpine fir and mountain hemlock. Pollen analysis of peat sections from southeastern Alaska has been carried out by Heusser (1952), and the results pertinent to this study will be discussed later.

The interior forests of Alaska are composed of a limited number of arboreal species. These are white and black spruce, paper birch, aspen, balsam poplar, tamarack, and alpine fir. Although maps by Harlow and Harrar (1941) and Munns (1938) show the range of lodgepole as extending into eastern Alaska from the Yukon, Taylor (1950) states that this species does not enter Alaska from the Yukon, and extends northward along the coast to the head of Lynn Canal at Skagway and Glacier Bay. No lodgepole was noted in interior Alaska along the highways, although this, of course, does not preclude its existence in remote areas. Alpine fir likewise is of rare occurrence in interior Alaska but it was noted occasionally along the Slana-Tok Highway between Sinona and Mentasta at higher elevations.

It is generally conceded by botanists, and others who have made observations of the forests in this region, that white spruce is to be considered as the climatic climax dominant, and that in the absence of fire, disease, animal depredations, and other disturbances for several centuries, the upland stands of timber would consist largely of white spruce. This, unfortunately, has not been the case, and it is estimated that during the past half century the average area burned annually has been at least 1,000,000 acres and so not more than 20 per cent of the original white spruce forest remains (Lutz, 1951). The criteria for considering white spruce as the climax species or as the culmination of successional development on the uplands are the facts that it attains greater age than the other boreal species with which it is associated, it is more tolerant of shade, it is less subject to disease and decay at an early age, it more readily germinates and develops on organic substratum, and it grows more rapidly than its associates on the well-drained, upland soils. Severe fires in white spruce stands usually result in its total destruction and succession begins anew with subclimax species. The composition of the new young forest depends upon the species that survive in proximity to the burn. Birch, aspen, and balsam poplar are the usual invaders, although the relative success of these species depends upon the physiographic and edaphic factors. If the organic material in the soil is destroyed, aspen will be favored; whereas if the litter and duff have not been destroyed spruce and birch, if seed is available, will invade and successfully compete with aspen during this early stage. Undisturbed succession, however, will culminate in white spruce and birch, and if continued for a century or more pure spruce will obtain. The muskegs and other poorly drained areas support essentially pure stands of black spruce. Tamarack occurs with black spruce in the valleys of the Tanana, lower Yukon, upper Kuskokwim, and upper Koyukuk rivers. Along the Alaska Highway it first was noted near Big Delta Junction. While black spruce is a seral species of the latter stages of hydrarch succession on muskegs and bogs farther south, it may be considered as a physiographic climax in interior Alaska, because of its evident permanence. Black spruce readily reproduces vegetatively by layering. The permanency of black spruce is further assured by the absence of fire on the wet muskegs, whence seed is provided for the adjacent burned areas. Thus black spruce has been gradually invading uplands following fire in white spruce. Once established in these areas it has the advantage of serotinous cones, which remain closed and are retained for several years on the trees. Following fire the cones are opened and the seeds dispersed in great quantities so that a black spruce stand may often regenerate to black spruce. This process is similar to that of lodgepole in the Rocky Mountains and Douglas fir in parts of the Pacific Northwest which are maintained through frequently recurring fires. Repeated severe burning may cause reversion from black spruce to earlier stages consisting of alder, dwarf birch, and willow.

One of the important basic factors in forest distribution and composition in interior Alaska as well as in the Yukon is permafrost. The interaction between permafrost, slope, exposure, soil texture and fire plays a critical role in determining the vegetative cover. Destruction of the litter and duff may also lower the permafrost table, permitting trees with deeper root systems to thrive. Elimination of the organic material in the soil and lowering of the permafrost table may also lower the water table and the drier conditions may encourage less mesophytic species. Aspen is particularly favored under these conditions because it prefers a mineral soil for germination, deep and well-drained light soils, and south slopes where it simulates the climax situation. Absence of white spruce in the understory may indicate that the permafrost table is several feet below the surface and the soil too dry (Stoeckler, 1949). The ability of aspen to sprout from roots after a fire also favors its persistence even under less favorable conditions.

Balsam poplar prefers deep, moist, light soils and occurs chiefly on newly formed floodplains and river bars, although it also invades the uplands where mineral soil is exposed. It has a deeper root system than white spruce and its presence indicates a permafrost table several feet below the surface. Birch germinates best on mineral soil, but it can grow under a wide range of moisture conditions. It has a shallow root system but prefers deeper soil than does white spruce. Although it invades burned areas with spruce, it is much less tolerant and in time is replaced by spruce.

The mosaic of forest types in the interior of Alaska is not well understood, but it seems obvious that the thermal regime of the soil as influenced by slope, exposure, drainage, depth and structure of soil, and fire in relation to the ecological requirements of the trees is one of the more significant controlling factors.

POSTGLACIAL FORESTS

In considering the postglacial forests as portrayed by the pollen record for the time represented by the pollen-bearing columns, the usual sources of error inherent in pollen analysis should be kept in mind. Perhaps the most significant in the region of this study is the evident failure of aspen and cottonwood pollen grains to be preserved in the sediments. These species, especially the former, have undoubtedly been important in forest succession, particularly in relation to fire. Although it seems evident that fire has been far more extensive and destructive during the past half century than perhaps during the

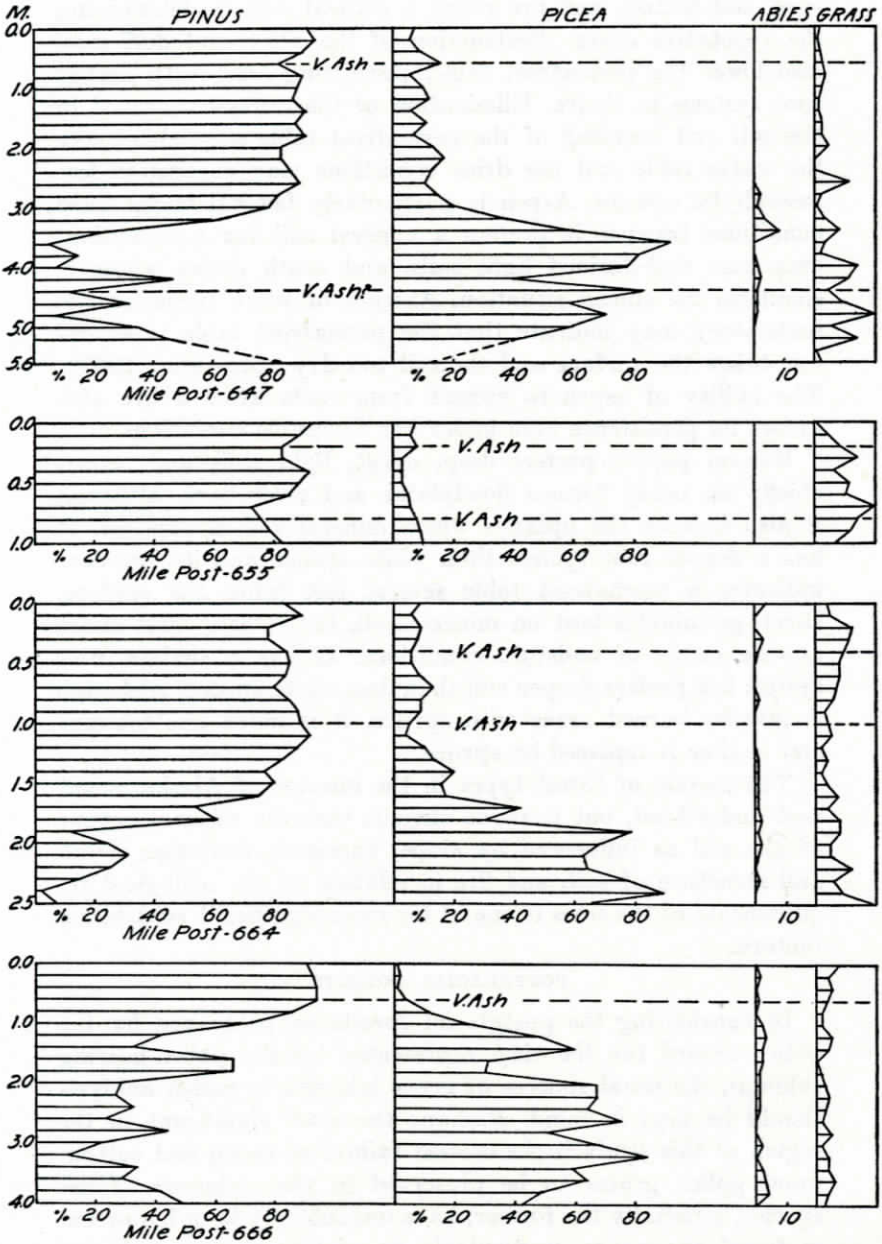

Fig. 2. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 647 to 666.

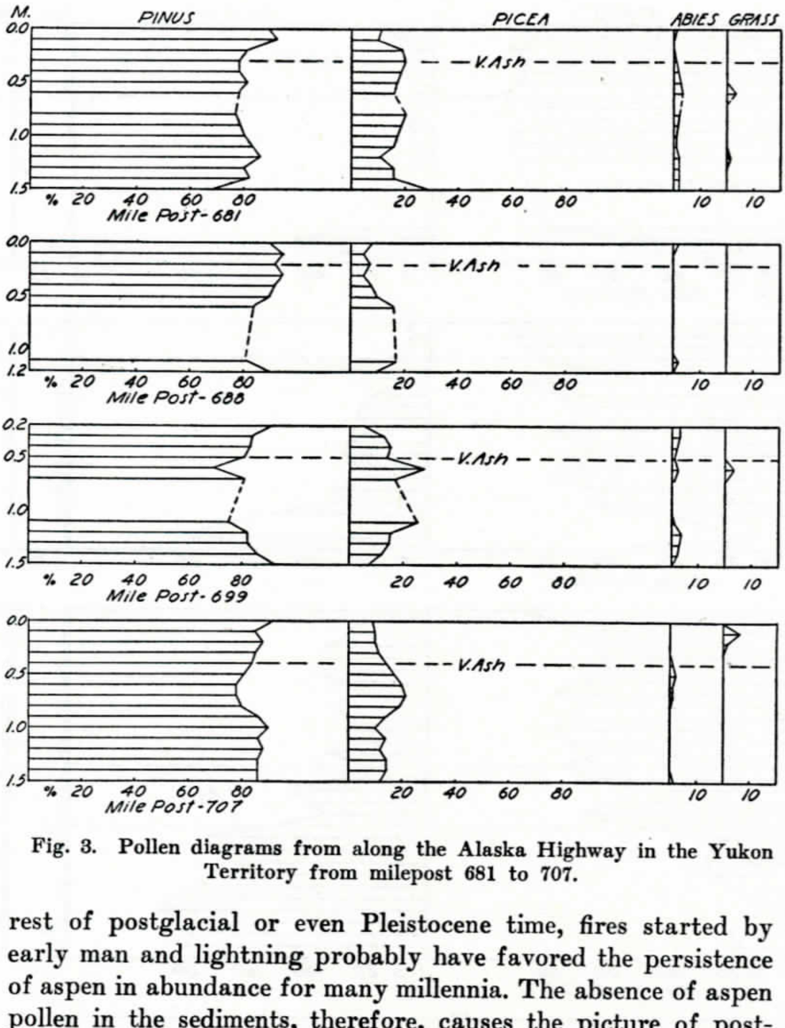

Fig. 3. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 681 to 707.

rest of postglacial or even Pleistocene time, fires started by early man and lightning probably have favored the persistence of aspen in abundance for many millennia. The absence of aspen pollen in the sediments, therefore, causes the picture of postglacial forests to be incomplete and also results in the overrepresentation of those species that are recorded. Thus most of the pollen profiles from Alaska, especially in the interior, reveal nearly 100 per cent of spruce. Although these pollen profiles may seem to be of no significance, they reveal whether or not certain species such as lodgepole pine and alpine fir ever have existed in interior Alaska during the Postglacial.

Lodgepole is recorded as having been important in postglacial forest succession northwestward to milepost 931 in the

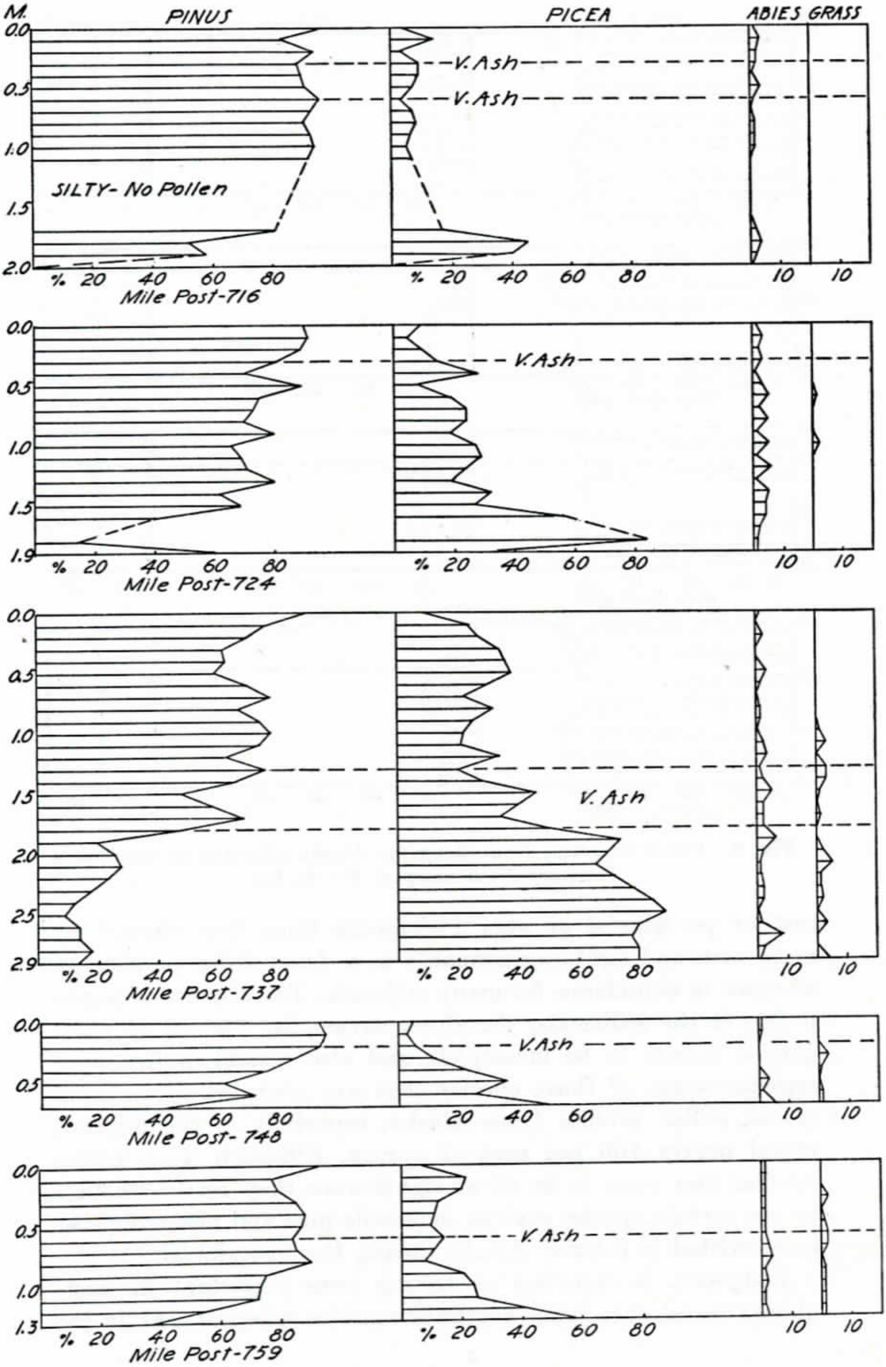

Fig. 4. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 716 to 759.

Yukon. This section is located about 15 miles within the northwestern limits of lodgepole as noted along the highway. Lodgepole is also appreciably represented in sections along the Haines Highway, the pollen of which undoubtedly was carried eastward from the coastal area of southeastern Alaska. The record of lodgepole does not become progressively weaker northwestward toward the end of its range as one might expect. Rather it is strongly represented in the section at milepost 931, beyond which it abruptly ceases to be recorded appreciably in any part of the column (figs. 2-6). In the first 22 sections along the highway there are two general patterns of lodgepole-spruce relationships exhibited. The more common is a general increase of lodgepole from low proportions at the bottom to 60 per cent or more, and in some cases to 80 per cent, in the middle third of the profile and maintenance of this preponderance to the top (figs. 2, 4, 5). In two instances lodgepole supersedes spruce at the bottom and then declines before it attains its strong predominance in the upper half or two-thirds (fig. 2). This deviation may represent an earlier stage not recorded in the other sections as it is expressed in only two of the deeper sections, 5.6 and 4.0 meters at mileposts 647 and 666 respectively. Another section, 4.0 meters, at milepost 872 exhibits an increase of pine to 90 per cent or more in the upper third (fig. 6). The other pattern reveals lodgepole as strongly predominant throughout the column, with proportions of mostly 75 per cent or more from bottom to top. The profiles of spruce are almost the exact converse of those of pine, except in those sections where grass is appreciably represented. Alpine fir is represented consistently but in low proportions throughout most of the sections. The maximum of this species is only 10 per cent at milepost 872 (fig. 6). Spruce pollen profiles are based upon both black and white spruce, which reflect the influence of the forest on the muskeg and adjacent poorly drained areas. This is partially offset by the occurrence of black spruce in uplands where repeated conflagration has destroyed the white spruce forests so that seed source of this species is too far removed for its immediate reinvasion. The occurrence of black spruce on the muskeg may be compensated for by a limited amount of pine also thereon, and the latter's greater pollen production. This is evinced by the overwhelming preponderance of lodgepole pine in most of the sections, espe-

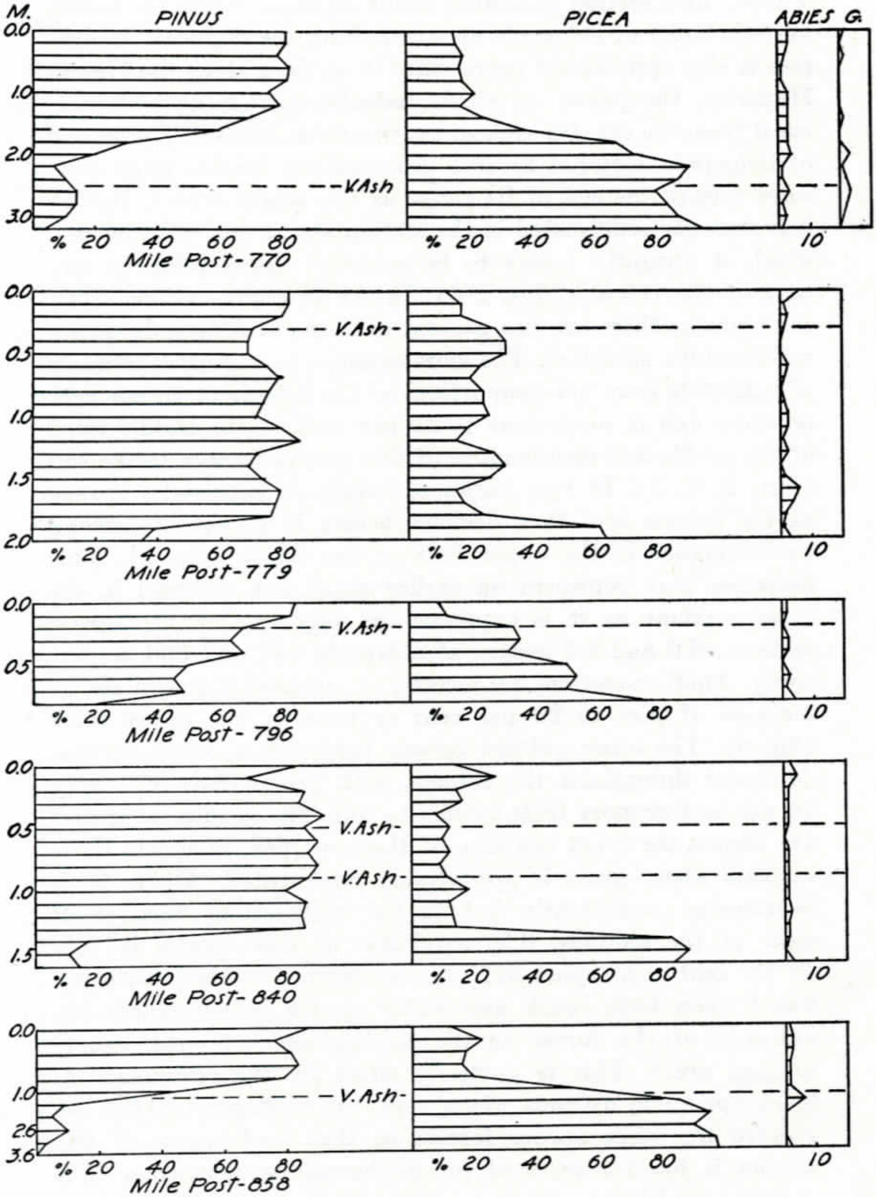

Fig. 5. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 770 to 858.

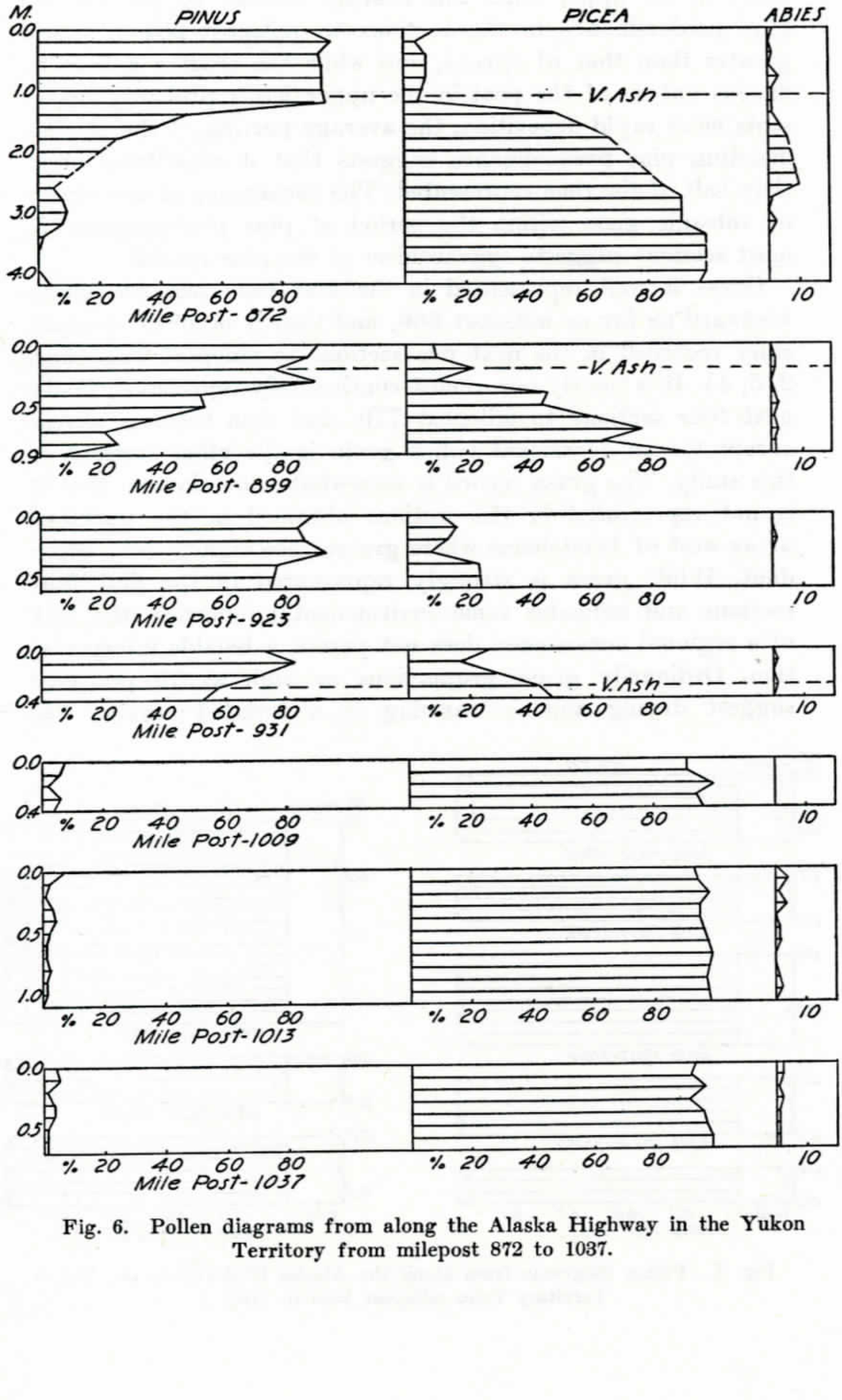

Fig. 6. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 872 to 1037.

cially in the upper half. The average number of horizons of pine predominance in the sections to milepost 931 is much greater than that of spruce, and while the coarser and more fibrous nature of the peat in the upper levels probably represents more rapid deposition, the average portion of the profiles denoting pine predominance suggests that it constitutes more than half of the time represented. The occurrence of two strata of volcanic glass within the period of pine predominance in most sections suggests synchronism of the pine record.

Grass is well represented in the first four sections northwestward as far as milepost 666, and then it becomes sporadically recorded in the next five sections to milepost 724 (figs. 2, 3, 4). It is poorly but almost continuously represented in the next four sections to milepost 770, and then becomes absent except for an occasional pollen grain in the other sections of this study. The grass record is somewhat anomalous in that it is not represented in the sections obtained in the parkland areas west of Whitehorse where grasses are significantly abundant. While grass is strongly represented in the first four sections and indicates some environmental influence, the lack of a regional consistency does not permit a tenable interpretation. Ordinarily grass proportions as high as 15 per cent suggest drying and/or warming in a forested region. The

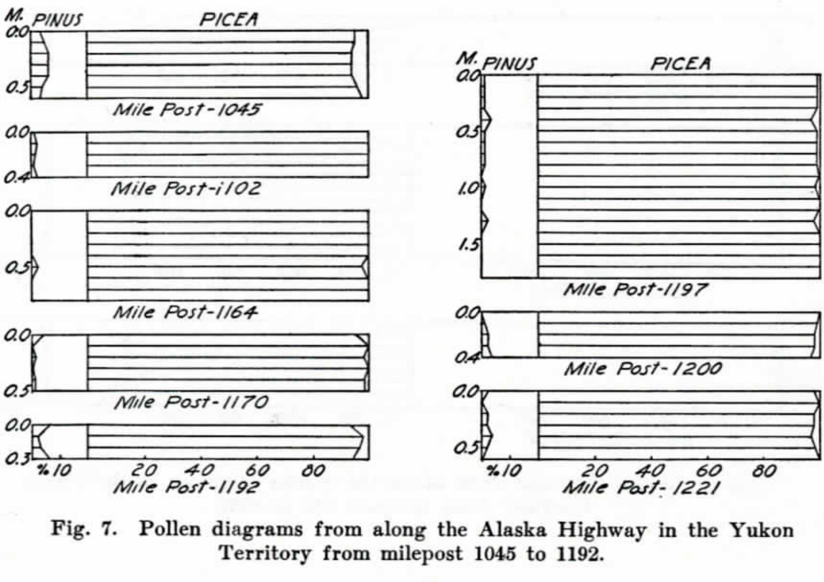

Fig. 7. Pollen diagrams from along the Alaska Highway in the Yukon Territory from milepost 1045 to 1192.

muskegs from which the sections were obtained did not support grasses and most of them surrounded open water. The adjacent areas likewise do not support grasslands. Uplands remote from the site of the sediments were not observed, however, and grass pollen may have come from such areas. There does not seem to be any correlation of the grass profiles with those of pine and spruce, especially in relation to fire in recent time which has apparently favored pine and aspen. In fact, most profiles reveal absence or decline of grass in the upper levels.

Sedimentary columns obtained from sites beyond milepost 931 show an abrupt drop in the pine proportions to only a few per cent (figs. 6, 7). Pine is well represented in five sections taken between Haines Junction at milepost 1016 and Haines, Alaska. Three of the thicker sections reveal pine proportions ranging from 1 to 42 per cent, with an average of over 20 per cent (fig. 8). The forests at this elevation are sparse and no pine was noted, so its pollen must have been carried up and inland from the coastal forests. Western hemlock is also appreciably represented in these columns, which with the presence of some mountain hemlock pollen further indicates the effect of winds moving inland from the coast during the period of anthesis. Alpine fir, which becomes absent in the profiles at milepost 1037, is sparingly represented in some of these sections. Some of the spruce pollen is undoubtedly Sitka spruce from the coast and the few scattered trees along the highway.

Pollen profiles from 17 sedimentary columns along the Alaska Highway in northeastern British Columbia from Dawson Creek

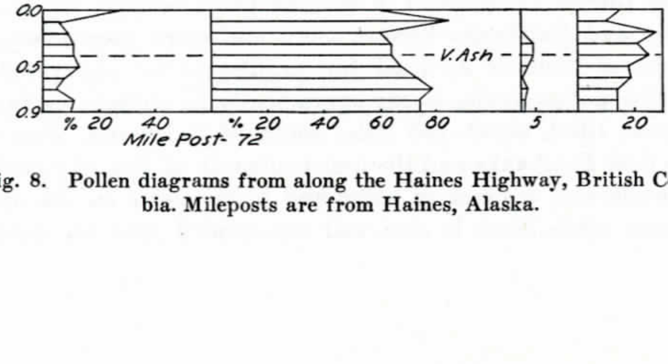

Fig. 8. Pollen diagrams from along the Haines Highway, British Columbia. Mileposts are from Haines, Alaska.

to Watson Lake reveal trends of forest succession both similar to and different from those of this study (Hansen, 1950*a*). In six of these sections spruce is predominant throughout, and pine in only three. Similarity of trends is expressed by pine expansion in the upper levels to supersede spruce at the top in 10 columns. In general spruce has apparently been more abundant along the first 600 miles of the Alaska Highway in British Columbia than in the Yukon to milepost 1009. In a 6.6-meter section at milepost 253, spruce is recorded to 80 per cent or more throughout its entire profile. Still farther south and east in the Grande Prairie-Lesser Slave Lake region, spruce and pine are more nearly equally represented in most of 11 sections, although pine increases in the upper horizons to supersede spruce in all of them (Hansen, 1952). Still farther south in the vicinity of Edmonton and near the southern limits of spruce and pine in central Alberta, pollen profiles from seven muskegs show pine predominance at the bottom in six of the sections and throughout generally (Hansen, 1949*a*). An increase in pine at the top in six of the profiles is consistent with its record in most sections to milepost 931, suggesting the influence of fire since the advent of white man, perhaps further favored by a drier climate during the past 200 years. West of Edmonton and nearer the Rocky Mountains a similar pattern for pine is shown in three out of four profiles (Hansen, 1949*b*). In general, spruce becomes more consistently predominant in the lowest pollen-bearing level progressively northwestward and persists in preponderance longer, but in more recent time lodgepole pine has expanded over the region represented in the pollen profiles because of more favorable conditions in the past few centuries. Why its record should so abruptly become absent beyond milepost 931 is difficult to explain unless this transition zone also constitutes the southern limits of permafrost which is slowly moving northward in response to a warming climate.

The forests as recorded in sections taken between the Yukon border and Fairbanks become more and more preponderantly spruce, so there is no need for profiles to be illustrated. A few pine pollen grains occur sporadically in sections as far as milepost 1390, about 135 miles south of Fairbanks. Two sections near Fairbanks and the first two south of this city contain a considerable amount of alder and birch pollen in the upper horizons while birch is also well represented near the bottom.

Much of the birch pollen is probably from paper birch on uplands while some is from bog birch on the muskeg. Dwarf birch may also be represented as this species is common on oft-burned areas where the arboreal cover has been entirely depleted. Volcanic glass occurs in the upper two decimeters of sediments, and another layer is also present near the bottom in most of these sections.

In the four sections procured along the Slana-Tok Highway southwest of Tok Junction, spruce is recorded to practically 100 per cent throughout the pollen-bearing strata. Only two pollen grains of pine and one of fir were noted. The thickest section, 3.0 meters, which was taken from the border of a pond in a deep depression, reveals pollen only to 1.6 meters, while the sediments down to 2.5 meters consist of colloidal limnic peat of largely organic matter. The absence of tree pollen suggests that forests did not exist in the region when these sediments were laid down. The adjacent hillsides support some birch, and yet very little birch pollen was noted. In all sections volcanic glass occurs in the upper two decimeters and again near the bottom, as in sections along the Alaska Highway between the Yukon border and Fairbanks.

Sedimentary columns taken from eight sites along the Richardson Highway south of Big Delta Junction to the Glenn Highway reveal that spruce is recorded to 100 per cent throughout their pollen-bearing strata. A single pine pollen grain was observed in the uppermost level of a section taken about 19 miles south of Delta Junction. Two sections taken in this area show an abundance of alder and birch pollen throughout and some willow and sedge pollen at a few of the horizons. That much of the adjacent area is covered with alder and dwarf birch explains the source of the pollen. A section taken from a willow-sedge muskeg on Isabella Pass, at an elevation of about 3200 feet, has little pollen throughout the silty sediments but spruce is recorded to 100 per cent at all levels. In the other sections, the last of which was taken about 122 miles south of Big Delta Junction, the few pollen grains of mountain hemlock noted probably were carried inland from the coast. In most columns along the Richardson Highway the lower sediments are composed largely of silt, and there is little or no pollen present in the lowest 2-4 decimeters so as to suggest the absence of forests in adjacent areas when they were deposited.

Nine sections along the Palmer-Glenn Highway, a distance of about 190 miles, reveal a preponderance of spruce in those from higher elevations inland, while in those situated in the lowlands within 30 miles of Anchorage birch is strongly represented (fig. 9). The presence of paper birch on the adjacent slopes accounts for the abundance of its pollen in the upper levels, and it can be presumed that birch has been an important component of these forests during most of the time represented by the sediments. In the thickest section of this study, 6.9 meters, about 15 miles east of Anchorage, birch shows a stronger

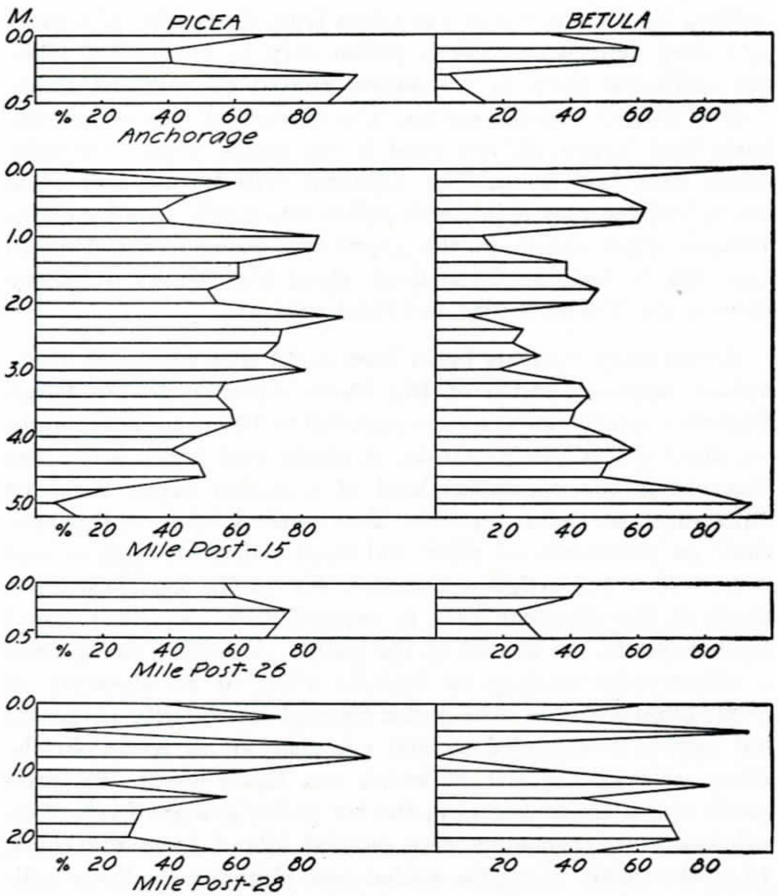

Fig. 9. Pollen diagrams from along the Palmer-Glenn Highway, Alaska. Mileposts are from Anchorage.

average representation than does spruce. Although organic limnic peat extends almost to the bottom, little or no tree pollen is present below 5.2 meters, so as to suggest that forests did not invade the region for some time after the initiation of the sediments. Birch is poorly represented at higher elevations in the Matanuska Valley and on the tableland between the Talkeetna and Chugach mountains. The five sections between mileposts 88 and 158 were taken from swampy lake margins at elevations of 2500 feet. Spruce is recorded to practically 100 per cent in all of these columns, while occasional pollen grains of pine and mountain hemlock undoubtedly were carried inland from the coast. A 3.9-meter section at milepost 158 lacks tree pollen in the lower 0.9 meter, suggesting the absence of forests within range of pollen dispersal for some time after deposition had begun.

POSTGLACIAL CHRONOLOGY AND CLIMATE

The term "postglacial" is used rather loosely here in that it refers to the time since each sedimentary site was freed of ice and the pollen-bearing sediments began to accumulate. Obviously the time that sedimentation began must have varied from site to site, or at least in the several regions represented. Also the time when vegetation first appeared within range of pollen dispersal to each respective site may have varied considerably. Inasmuch as the glacial chronology of Alaska and of the Yukon Territory is poorly defined and there is evidence that neither all of Alaska nor the Yukon was glaciated during Wisconsin time, the usage of "postglacial" does not imply post-Mankato or post-Late Wisconsin as it usually does farther south in Canada and the United States. It seems probable, however, that the sections described in this study are composed of sediments that have accumulated since the glacial retreat late in the Wisconsin age.

In general the depth of the muskegs developed under non-aquatic conditions decreases with an increase in latitude. This reflects the less favorable growing conditions for the principal peat-forming plants, caused by the shorter growing season. Terraces of stratified silt and sand 200 feet above the present level of the Tanana River indicate the height of the river during deglaciation, and peat sections obtained from sites at this or lower elevations are necessarily postglacial (Brooks, 1900). The vast unglaciated area of interior Alaska provides the possibility of continuous peat deposition since a time before retreat of the late Wisconsin glaciers in the Alaska Range to the south and the Brooks Range to the north. Inasmuch as muskeg grades into tundra northward and both types of vegetative cover result in organic deposition, it is conceivable that on sites beyond and above the direct and indirect physiographic effects of glaciation on this interior plateau, peat deposition may have been initiated and continued regardless of glacial conditions in the mountain ranges. There is no reason to assume that the climate during the Wisconsin glaciation was necessarily more severe than it is today on the Arctic plain north of the Brooks Range which supports luxuriant tundra vegetation. The persistence of plants in unglaciated refugia in the Yukon and Alaska as pointed out by Hultén (1937) supports this view. In fact, it has been suggested that the climate of Alaska was warmer than normal during the ice age and at no time colder than the present (Pauly, 1952). The abundance of vegetal remains, including trees, and strata of interglacial peat in the mucks and silts in the Fairbanks region, as well as in other parts of Alaska (Taber, 1943; Tuck, 1940), would indicate that with each glacial age the vegetation of interior Alaska and other ice-free areas in the Yukon, British Columbia, and Alberta was not entirely obliterated. It is hardly conceivable that during each interglacial age vegetation migrated from beyond the southern limits of glaciation on the continent all the way back to interior Alaska and west-central Yukon. The abundance of lodgepole pine pollen in the lowest levels of peat sections in northeastern British Columbia and western Alberta causes the author to believe that late during the Wisconsin glaciation there were ice-free areas that supported forests of lodgepole and spruce (Hansen, 1949*a*, 1949*b*, 1950*a*, 1952). The position of the "Altamont" (Mankato) moraine, 70 miles east of Edmonton, further supports this evidence (Bretz, 1943).

The author does not presume, however, that any of the peat sections of this study antedate the beginning of the final recession of the Late Wisconsin glacier in this region. As stated above, the sections from the Tanana River valley are too close to the river to believe that the terrain upon which they lie was undisturbed or not indirectly modified by late Wisconsin glaciation in the Alaska Range not far to the south (Capps, 1931). The other sections were taken from sites that were either overrun by ice and/or modified by meltwater. Many of the peat deposits have accumulated in standing water that was ponded by glaciofluvial processes resulting directly from deglaciation. The author does believe, upon the basis of the evidence, that the ages of the pollen-bearing sections do differ considerably. It is interesting and significant that in sections along the Alaska Highway in the Yukon and Alaska the shallower muskegs contain forest tree pollen in the lowest horizons and even in the upper part of the inorganic silt, while in the deeper sections that have been formed in ponds and lakes, tree pollen is largely or entirely absent in the lower portions of the columns, although aquatic plant pollen may occur almost to the bottom. The two thickest sections in the Yukon, 4.9 and 5.5 meters at mileposts 859 and 872 respectively, have more than a meter of the lowest portions devoid of tree pollen. Likewise, two sections along the Slana-Tok Highway, 3.0 and 2.0 deep, reveal only 1.6 and 0.9 meters respectively of tree pollen-bearing sediments. The same is true along the Palmer-Glenn Highway east of Anchorage, where the thickest section of this study, 6.9 meters, contains arboreal pollen down only to 5.2 meters, while a column 4.5 meters thick contains tree pollen only to the 2.6 meter horizon. The presence of nonarboreal pollen denotes that the accumulating sediments were receptive to and favorable for the preservation of pollen, while the absence of tree pollen suggests that forests were absent within range of pollen dispersal for some time after sedimentation began. Apparently conditions were favorable for the existence of plants in the region. Pollen from forests that may have existed in the unglaciated interior may have been prevented from reaching these sites because of prevailing westerly winds.

In the typical muskeg the presence of ericad and spruce pollen down to the underlying inorganic material suggests that forests and other vegetation were in existence when organic deposition in these muskegs began. In a few muskegs on flat terrain without early aquatic stages, spruce pollen does not occur all the way to the bottom. This also denotes the absence of forests in adjacent areas unless winds prevented pollen from reaching the site of the sediments. The age then of the lowest pollen-bearing sediments is uncertain.

Rate of peat deposition in this region must be exceedingly slow because of the rigorous climate and the short growing season. The thickness of the typical muskeg deposit increases southeastward along the Alaska Highway and southward still farther to the vicinity of Edmonton, Alberta, which is the approximate limit in Alberta of what the author considers to be true muskeg (Hansen, 1949*a*, 1949*b*, 1950*a*, 1952). In the latter region the muskeg depth above the residual blue clay formed by gleization of waterlogged glacial drift averages about 3 meters as compared to the average of 0.5 meter depth of muskegs between the Yukon border and Fairbanks (table 1). The thickest section obtained from a muskeg along the Alaska Highway is 7.0 meters at milepost 253 south of Fort Nelson (Hansen, 1950*a*). It would seem that the rate of deposition under the conditions at this latitude is much slower than farther south where the climate is more favorable, although the relative ages of the muskegs in the two regions must be considered.

Several yardsticks may be used in estimating the age of the peat sections of this study based upon data derived directly from peat in this region. Capps (1931) studied the relationships between the development of adventitious roots of spruce and progressive rise of the permafrost table in a living *Sphagnum* moss deposit resting on fresh till about eight miles beyond the terminum of Russell Glacier. This site is located in an exposure cut by the White River near the Yukon-Alaska border. Calculations based upon annual ring counts indicate that the peat has accumulated at a rate of one foot in 200 years, which when applied to the 39-foot thick deposit denotes an age of about 7800 years. This rate applied to the muskegs in the Tanana River valley would indicate an age of only a few hundred years. It is possible that the White River deposit represents optimum conditions for muskeg development, as it can be readily demonstrated that the rate of peat accumulation may vary as much as 9 to 1 in a single region (Hansen, 1947). This rate applied to the thickest section of this study, 15 miles east of Anchorage, would imply an age of about 4600 years. While the White River peat site undoubtedly was covered by late Wisconsin ice, the cutting of a gorge 70 feet or more deep may have confined its meltwater to the gorge, thereby preventing disturbance of the peat site early in postglacial time, while in the Tanana River valley disturbance of the present muskeg sites by meltwater for a much longer time may be reflected in the shallower muskegs. A similar interpretation may be applied to the deeper sections of this study that have developed in valleys carrying meltwater from Wisconsin glaciers.

A second chronological yardstick available is the radiocarbon date of peat from the Anchorage area. A sample of peat from the lower foot of an 8-foot exposure at the north end of the Anchorage International Airport has been dated at about 5000 years (Kulp, Feely, and Tryon, 1951). This figure implies an accumulation rate of more than 600 years per foot, which when applied to the thickest section of this study near Anchorage denotes an age of more than 13,000 years. Another radiocarbon date of significance is that of about 3800 years for peat at a depth of five feet, near Boulder Point, Kenai Peninsula (Kulp, et al., 1952). Peat accumulation here probably has occurred under climatic conditions somewhat similar to those in the Anchorage area. The rate of about 800 years per foot would indicate almost 18,000 years for the deep section near Anchorage. Climatic conditions for peat accumulation would seem to be more favorable today in the Anchorage region than in the interior. Further study of the White River peat exposure, including radiocarbon techniques and pollen analysis, would be extremely significant in that it would provide a valuable index for the chronology of postglacial time in Alaska and the Yukon. Another radiocarbon date of significance is that of 14,300 $\pm$ 600 years determined from lignitic peat exposed along the Eagle River north of Anchorage, which is believed to be overlain by Late Wisconsin till, and appears to have been deposited during the Cary-Mankato interglacial. This figure and Capps' computations suggest that the sites represented were deglaciated as early as or earlier than the northern Lake States as denoted by radiocarbon dates of peat and wood from that region (Flint and Deevey, 1951). It becomes very evident that a series of carbon-14 dates for Alaska peats is essential for better approximation of their ages and application to the forest record in this region. Heusser (1952), in a pollen and stratigraphic study of 17 peat sections in southeastern Alaska from Ketchikan to Juneau, sets a date of about 8000 years for the older and deeper muskegs. These muskegs vary in depth from a few decimeters to 6 meters.

There seems to be little or no evidence for climatic trends in the pollen profiles, except perhaps a general amelioration throughout the time represented. This is expressed by a rapid expansion of lodgepole to its maximum in many of the Yukon sections, although some of them reveal a preponderance of pine throughout. The thickness of the peat through which lodgepole is predominantly recorded after attaining its maximum varies considerably. At milepost 647 it is recorded to 80 per cent or more in the upper 3 meters of a 5.6-meter section, while in other thick sections it is preponderantly recorded in only the upper few decimeters. This difference can be assumed to be caused by local fluctuations in the relative abundance of spruce and pine as well as a variation in the rate of peat deposition. The occurrence of two volcanic glass layers within the period of pine predominance, however, indicates general synchronism in the several profiles. In many sections a slight increase in pine in the upper decimeter or two may reflect the influence of fire since the advent of white man. It is not believed that the warmer and drier climate of the past 200 years as indicated by glacial retreat in southeastern Alaska and dated by dendrochronological studies is reflected by this pine increase (Lawrence, 1950). The upper decimeter of pine increase probably constitutes less than 200 years, while the total period of pine maximum is much greater than 200 years. The sections in Alaska do not manifest climatic trends and apparently the postglacial climate has not been sufficiently warm to favor migration of pine into the interior. While the author believes that most of the deeper pollen-bearing sediments extend back to the postglacial thermal maximum so well shown elsewhere, there seems to be no evidence that the influence of this warm, dry interval extended this far north. The abundance of birch in the Anchorage region may reflect both fire and the absence of perennially frozen ground (Taber, 1943).

The pollen assemblages of this study indicate that the present range of lodgepole pine does not differ significantly from that during any of the time represented by the pollen profiles. The presence of appreciable pine pollen in the lowest levels of the Yukon sections denotes that pine was prevalent in the region when the earliest pollen-bearing sediments were deposited, and that it probably persisted during the late Wisconsin glaciation in refugia not far removed from the sites of those sediments. It may have migrated northwestward from ice-free areas in western Alberta and/or northeastern British Columbia or from refugia in west-central Yukon. The former hypothesis is supported by the lodgepole pine pollen record in muskegs in Alberta and British Columbia (Hansen, 1950*a*, 1952). The absence of pine wood or other macroscopic remains of this species in the Pleistocene mucks and silts in the Fairbanks region suggests that it did not migrate into interior Alaska during Pleistocene time (Chaney and Mason, 1936). The occurrence of a few pine pollen grains observed in a preliminary study of these sediments by the author may mean merely the same as their occurrence in the postglacial sediments of this study, namely, that pine pollen was carried into the area from distant sites. The early postglacial appearance of lodgepole pine in coastal southeastern Alaska as expressed by Heusser's studies may have resulted from its migration down the Stikine River valley from interior British Columbia, or over White Pass from the Bennett Lake area into the Lynn Canal drainage basin. A northward coastal migration of lodgepole from centers of its persistence south of the glacial border in Washington seems less probable.

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Oregon State College
Corvallis, Oregon